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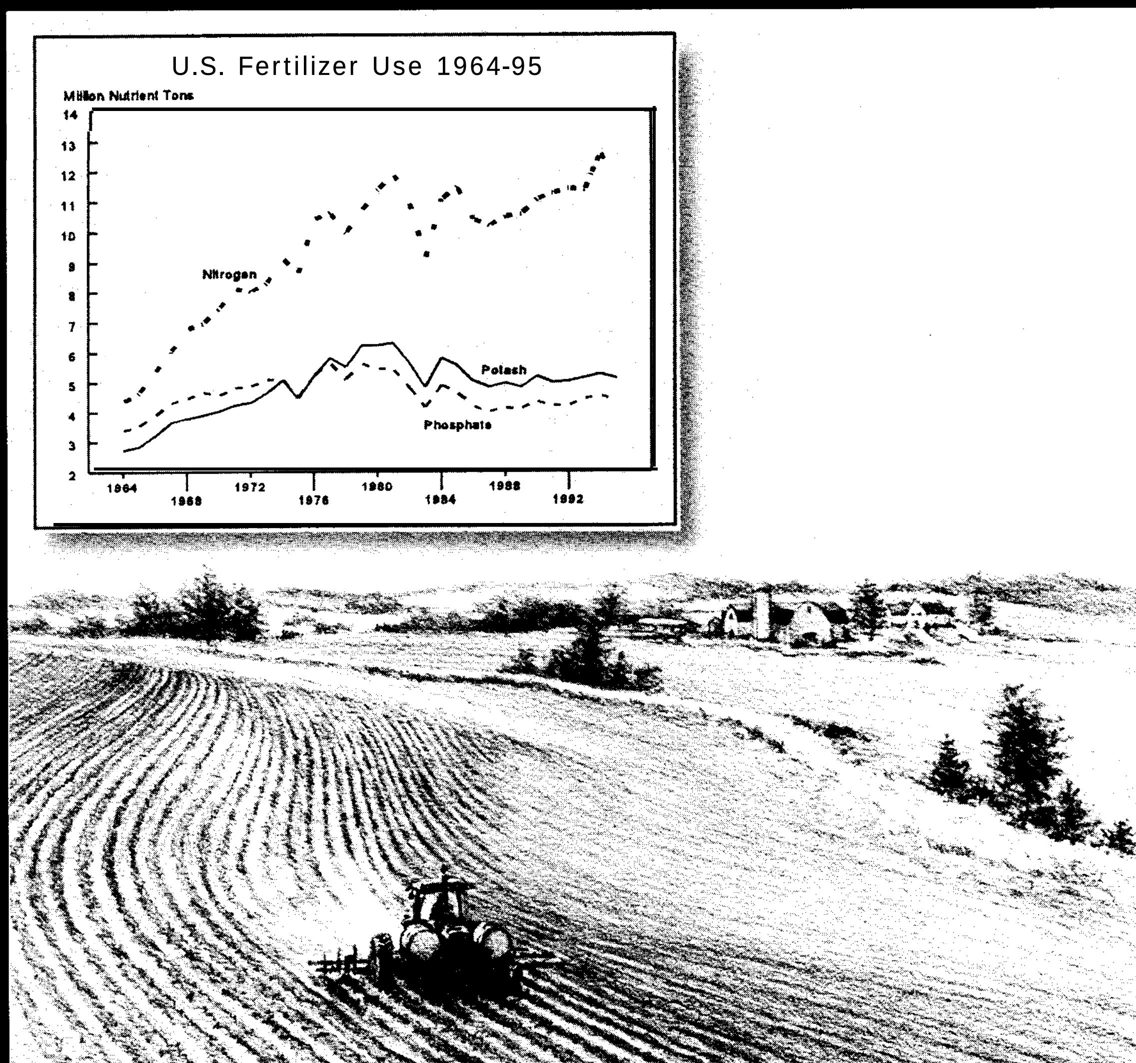
# Background Report on Fertilizer Use, Contaminants and Regulations



January, 1999

# BACKGROUND REPORT ON FERTILIZER USE, CONTAMINANTS AND REGULATIONS

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## DISCLAIMER

## CONTRIBUTING ORGANIZATIONS

This study was funded and managed by the U.S. Environmental Protection Agency. The data collection and analyses were conducted by Battelle Memorial Institute under contract to the Environmental Protection Agency. Each organization's responsibilities are listed below.

### Battelle Memorial Institute (Battelle)

Battelle was responsible for identifying and incorporating the results of relevant studies, obtaining and managing relevant information and databases, contacting individuals within the fertilizer community for insight into relevant issues, compiling information, carrying out the data analysis, and preparing the report. The Battelle Task Managers were Marcie Francis and Marcia Nishioka. Laura Brackney, Bruce Buxton, Jyothi Nagaraja, and Greg Stark were key contributors to the report.

### U.S. Environmental Protection Agency (EPA)

The Environmental Protection Agency was responsible for providing objectives of the data analysis, reviewing the developed methodology, contributing to the development of conclusions, reviewing draft versions of the report, and managing the peer review and publication of the report. The EPA Work Assignment Managers were Janet Remmers and Todd Holderman. The EPA Project Manager was Sineta Wooten. David Fagan of the Office of Solid Waste was a key contributor and reviewer.

## EXECUTIVE SUMMARY

The Environmental Protection Agency (EPA) is studying the issue of heavy metals and other non-nutritive constituents (also referred to as contaminants) in fertilizers and liming materials (referred to as fertilizers hereafter). The purpose of this report is to provide background information on fertilizer use, consumption patterns, composition and regulations. This information is gathered and presented here for fertilizers from natural mineral sources and those that are derived from industrial by-products. The data for heavy metals in fertilizers compiled here are used to provide estimates of the rates at which these metals may be added to agricultural soils from standard agronomic practices. The additions of heavy metals to agricultural soil are discussed in terms of federal and international regulations.

This report is provided as a source of information. It is not intended as a risk-assessment for contaminants in fertilizer, nor does it address the introduction of these materials into plants, the food chain for humans, and the greater ecosystem. Although some discussion is given here to biosolids (sewage sludge) and its regulations, and other organic fertilizers, such information is limited. The focus of this report is on inorganic fertilizers and their application to agricultural lands. Discussion related to fertilizer usage on public lands, range lands, and residential lawns and gardens is limited for this reason. In addition, some information is presented on the use of recycled industrial by-products as fertilizers; however, an in-depth investigation of these recycling practices was beyond the scope of this study.

More than 54 million tons (110 billion pounds) of commercial fertilizers and liming materials of all kinds were consumed in the United States in the year ending June 30, 1996 (AAPFCO, 1997a). Primary nutrients (N, P, K) accounted for 91% of this total; liming materials accounted for about 4%, and organic fertilizers accounted for 1% of the total. Approximately 5% of the total (2.7 million tons) was due to secondary nutrient fertilizers (calcium, magnesium, sulfur) and micronutrients. States with the highest fertilizer consumption were the agricultural states in the corn belt and California. Florida (1.6 million tons) and Texas (1.6 million tons) consumed the most multiple nutrient fertilizers while Illinois (1.9 million tons of nitrogen (N), 0.8 million tons of phosphate ($P_2O_5$) and 1.0 million tons of potash ($K_2O$) fertilizers) consumed the most single-nutrient N, P, and K fertilizers. North Carolina consumed most of the organic fertilizers and liming materials (0.2 million tons organic fertilizer, 0. 9 million tons liming fertilizer), while California consumed most of the secondary and micronutrient fertilizers (1.6 million tons).

The potato crop was the most fertilized (100% of acres receive N, P and K fertilizers) and had one of the highest fertilizer application rates for all primary nutrient fertilizers (average application rates of 195 lbs/acre N, 173 lbs per acre $P_2O_5$ and 139 lbs/acre $K_2O$) but represented fewer acres planted (0.8 million acres) than other field crops except tobacco. If consideration were given to the number of acres planted, corn (70 million acres) represented the crop with the highest fertilizer use, though not the highest application rate per acre (average application rates of 133 lbs/acre N, 57 lbs/acre $P_2O_5$ and 79 lbs/acre $K_2O$). The fruits and vegetables with the highest fertilizer application rates were watermelon in Arizona (N), bell peppers in California ($P_2O_5$) and fresh tomatoes in Florida ($K_2O$). The two states with the highest total consumption of non-farm fertilizer were Florida (0.4 million tons) and California (0.32 million tons). Multiple nutrient, organic and miscellaneous fertilizers were used in higher percentages on non-farm land than other fertilizers. Non-farm fertilizer use included applications to residential, recreational and public property.

Soils naturally contain trace levels (ppb to ppm) of heavy metals. For example, median concentrations of metals in U.S. soils are 0.2 mg/kg cadmium, 11 mg/kg lead, and 18.2 mg/kg nickel. There are, however, considerable variations in these metal concentrations by geographic region and soil type.

Several studies have measured heavy metals in mineral ores and the resulting fertilizers. Natural rock phosphate ore contains zinc ranging from 0.2 to 576 mg/kg and measurable amounts of cadmium, lead, nickel and copper. These metals can also be found in the NPK fertilizers that are produced from natural ores. For example, the State of Washington Department of Ecology reports the ranges of metal concentrations for a sample of 21 diverse NPK fertilizers with cadmium levels being <0.1-145 mg/kg, lead levels being <0.4-21 mg/kg, and nickel levels being <0.2-195 mg/kg. Measurements of other NPK fertilizers by other authors generally fall within this same range of values. A few studies have also measured arsenic, chromium and mercury in NPK fertilizers.

Organic and biosolid fertilizers may also have measurable concentrations of heavy metals. One study of 6 organic fertilizers (Raven and Loeppert;1997) reported measureable levels for heavy metals such as arsenic, cadmium, chromium, lead and mercury. According to these authors, "Trace metal concentrations generally decreased in the following sample order: rock phosphate > sewage sludge > commercial phosphate fertilizers > organic amendments and liming materials > commercial $K_2O$ fertilizers > commercial N fertilizers". Whether or not fertilizers add significant amounts of metals to soil depends upon several factors including the existing soil metal concentration, the concentration of trace metals in the fertilizer and the fertilizer application rate.

Since some industrial wastes contain substances which can be used, or converted for use, in fertilizers, industrial waste recycling is encouraged in the U.S., if done so in a safe manner. The concern is that the wastes may also contain potentially hazardous constituents that provide no nutritive value to the plant and introduce these constituents into the greater ecosystem. No specific regulations exist requiring fertilizer producers to list non-nutritive constituents on fertilizer labels, so it is difficult to quickly ascertain the levels of heavy metals (and other chemicals) in fertilizers. Chemicals such as radionuclides and persistent organics (e.g., chlorinated dibenzodioxins/furans) are in this category. Several studies have shown that heavy metals are present in the parts per million (mg/kg) range, and occasionally as high as parts per thousand, in fertilizers produced from recycled industrial by-products.

Industrial wastes may be used in the manufacture of fertilizers, provided that such use constitutes legitimate beneficial recycling, and that the concentrations of hazardous constituents in the resulting fertilizers do not exceed the treatment standards specified for the wastes (40 CFR 266.20). No other federal standards apply specifically to fertilizer composition. State regulations require nutrient composition labeling of fertilizers.

Most states regulate fertilizer composition, but generally only for the plant nutrients. State fertilizer laws generally require product registration and/or licensing and efficacy testing to assure that statements made on the label are correct. Most fertilizer regulations also include general statements about product adulteration and a prohibition against including any product that is harmful to plants, animals, humans or the environment. At this time, only two states (Washington and Texas) have regulations that establish specific limits on heavy metal contaminants, and testing and labeling requirements.

RCRA regulations generally encourage waste minimization and recycling. Examples of hazardous wastes that can be recycled into fertilizer ingredients (usually micronutrient fertilizers) include wood ash, K061wastes (emission control dust/sludge from the primary production of steel in electrical furnaces), brass foundry dusts and tire ash. The Occupational Safety and Health Administration (OSHA) in its hazard communication standard requires employers to include in Material Safety Data Sheets (MSDS) information on any product component present at 1% or greater (0.1% for carcinogens). Thus, if certain metals are present in sufficient quantity in fertilizer products, there exists a mechanism for communicating information on hazardous metal content.

Internationally, the Canadian Fertilizers Act (1993) and Fertilizers Regulations contain specific limits for heavy metals that apply to all fertilizer products. The Canadian Food Inspection Agency originally developed these limits for biosolids applied to land, but these standards now apply to all fertilizers. The Canadian standards are not risk-based, but were instead developed with the objective of “no significant degradation” of soils above background concentrations of metals. Japan regulates industrial waste incinerator ash application to land and has limits for metals and organic chemicals. Additionally, Australia and several European countries limit cadmium in phosphate fertilizers.

The U.S. EPA, states and foreign countries regulate biosolids application to land. The U.S. EPA (40 CFR 503) sets limits for heavy metals in biosolids in the product and on the soil following application. Several states have more stringent metal limits for biosolids application to land. Many foreign countries also have limits for heavy metals in biosolids and for soil. The European Union (EU) has set standards for its member countries, but individual countries may have more stringent regulations. The EU biosolids standards, in units of mg/kg of sludge product, are generally lower than those of the U.S. ceiling concentrations for land applications but are similar to the U.S. monthly average concentrations for application to agricultural land.

This report includes a characterization of the addition of heavy metals to agricultural soils from application of fertilizers which contain heavy metals. The calculations used here are designed to provide an estimate of the yearly incremental additions of metals to soils following diverse types of fertilizer applications. These incremental increases are then used to estimate the years required to double average background levels of metals in soil from yearly applications. These yearly additions of metals to the soil are then compared to the U.S. biosolids annual pollutant loading rates and the Canadian Fertilizers Act limits.

Fertilizer products are compared in this report with respect to the amount of nine heavy metals the product would add to soil, assuming a single application of the product per year. This is termed the yearly soil addition rate of a metal (or "yearly addition of metal X", see Index of Terms). The yearly soil addition rate of a metal is the concentration of that heavy metal in the product per desired nutrient ingredient multiplied by the nutrient application rate, with all appropriate conversion factors applied. For those fertilizer products with lower nutrient content, a proportionally greater amount of the undesirable heavy metal will be added to the land in achieving a consistent nutrient application rate. Therefore, a fertilizer product may contribute high levels of heavy metals to soil when the heavy metal concentration in the product is high and/or when the desired plant nutrient is at a low level in the product.

For this report, the yearly addition of each metal was calculated for each individual product at three nutrient application rates- an average nutrient application rate, a high rate and at the maximum application rate recorded for this nutrient. An extended appendix of this report (Appendix G) contains the yearly soil addition rate of each metal in each product when applied at these three nutrient application rates. The aggregate of these individual yearly addition rates, then, produced the average soil metal addition rate for a fertilizer product category (e.g., $P_2O_5$ fertilizers) at the three different nutrient application rates. This aggregate is termed the product average yearly addition of metal X (see Index of Terms). This summary includes discussions of the yearly addition of metals in terms of both the individual product giving the highest yearly soil addition of a specific metal, and in terms of the product average yearly addition rates for metals.

The calculations performed here showed that the product average yearly addition rates of metals to soil would not exceed the U.S. biosolids annual pollutant loading rates for any fertilizer category evaluated. This finding applied to both natural ore-derived fertilizers and industrial by-product derived fertilizers.

The calculations also showed that the product average yearly addition rates of metals to soil rarely exceeded the annualized Canadian Fertilizers Act limits for metals additions. The particular instances when the product average addition rate of metal to soil exceeded the Canadian limits were found in the following combinations of heavy metal and fertilizer categories, and this occurred only at the maximum nutrient application rate:

Arsenic in: liming materials ($CaCO_3$ applied at 15,000 lbs/acre once every 3 years)
iron fertilizers (iron applied at 30 lbs/acre every year)

The Canadian standards for metals additions to soil were exceeded more frequently for **individual** fertilizer products, and were exceeded for metals other than arsenic. A total of 38 cases were identified where a particular heavy metal in an identified individual fertilizer product would exceed Canadian fertilizer standards when applied at the maximum nutrient application rate. These cases included:

Cadmium in: NPK fertilizers applied for $P_2O_5$ content [10 products of 91evaluated exceeded limits; 10 of 91]
Phosphate fertilizers [1 of 61]
Liming materials [3 of 10]
Zinc fertilizers [3 of 22]

| | |
|---|---|
| Lead in : | NPK fertilizers applied for $P_2O_5$ content [4 of 91]<br>Liming materials [2 of 10]<br>Zinc fertilizers [6 of 63]<br>Iron fertilizers [1 of 3] |
| Arsenic in: | NPK fertilizers applied for $P_2O_5$ content [1 of 84]<br>Liming materials [3 of 10]<br>Iron fertilizers [1 of 3] |
| Mercury in: | Liming materials [1 of 8] |
| Nickel in: | Liming materials [1 of 8] |
| Zinc in: | NPK fertilizers applied for N content [1 of 49] |

Of the products listed above, 18 exceeded Canadian standards at the high nutrient application rate, and 8 exceeded the standards at the average nutrient application rate. Data were gathered here on 345 fertilizer products. A total of 1389 combinations of fertilizer product and metal at three application rates (total of 4167 data points) were compared with Canadian standards. (Data on an additional 537 combinations of unregulated heavy metals in products were also gathered). Since some products exceeded standards in more than one metal, the number of individual products exceeding the standards for at least one metal is greater than 2.7% (38 of 1389), but less than 11% (38 of 345).

Figure ES-1 identifies those fertilizer categories where the product average yearly addition rate of a metal is likely to double the average level of that metal in background US soils in 45 or fewer years, when the nutrient is applied at either the average (open box) or maximum (closed box) application rate. Similarly, this figure also identifies those instances where at least one individual product within a category exists that may double the average background level in 45 or fewer years, when the nutrient is applied at either the average (open circle) or maximum (closed circle) application rate. These scenarios assume yearly applications, with exception of lime, which is applied once every three years. For example, the product average application rate of cadmium (Cd) from either NPK-P fertilizers (NPK fertilzers applied for $P_2O_5$ content) or from $P_2O_5$ fertilizers will double the average background Cd soil level in 45 or fewer years when either the average or maximum nutrient ($P_2O_5$) application rate is used every year. In addition, there were individual NPK-N, NPK-P and $P_2O_5$ products identified that would double background soil Cd levels in 45 or fewer years if applied each year. There were no potash ($K_2O$), gypsum, manganese (Mn), or boron (B) fertilizer products identified that would double the indicated soil metals levels in 45 or fewer years. In contrast, liming materials were identified that might double the soil levels of all nine metals with consistent use (application once every three years) within a 45 year time frame.

In the process of preparing this report, and performing the above mentioned calculations, it was necessary to make a number of assumptions and simplifications to arrive at the contaminant levels in the soil following fertilizer application.

The simplifying assumptions that were made, and implications thereof, include:

- Metal additions to the soil were based on application of a single fertilizer type, and a single crop per year. In fact, many different fertilizers and liming materials may be

## Products That Double Average U.S. Soil Background Level of Indicated Metal in 45 or Fewer Years

| Fertilizer Products | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Primary Nutrients | | | | | | | | | |
| NPK-N | ■○● | ○● | | | | | | ○● | ● |
| NPK-P | ❑■○● | ○● | ● | | | | | ● | ● |
| $P_2O_5$ | ❑■○● | | | | | | | ● | |
| $K_2O$ | | | | | | | | | |
| Secondary Nutrients | | | | | | | | | |
| Gypsum | | | | | | | | | |
| Sulfur | ■○● | | | | | | | | |
| Soil pH Adjustment | | | | | | | | | |
| Lime | ■○● | ■○● | ■○● | ● | ■○● | ● | ● | ■○● | ■○● |
| Sulfur | ○● | | | | | | | | |
| Micronutrients | | | | | | | | | |
| Zn | ■○● | ■○● | | | | | | | |
| Fe | ■○● | ❑■○● | ■○● | | | | | | |
| Mn | | | | | | | | | |
| B | | | | | | | | | |

PPT/Nishioka/47-1

- ❑ Product average yearly addition rate of metal to soil with nutrient applied at average application rate
- ■ Product average yearly addition rate of metal to soil with nutrient applied at maximum application rate
- ○ Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at average application rate
- ● Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at maximum application rate

applied to a field in a growing season. The concomitant addition of heavy metals from all sources was not assessed here.

- To simplify calculations, soil type and chemical nature, plant uptake, leaching and erosion and other removal mechanisms were not considered in these calculations. All input of heavy metals was assumed to remain with the soil, and is therefore presumed to be an overestimate of soil metals levels over a long time period.

- Calculations of heavy metal additions to soil from fertilizers were based on all available data. The representativeness of this data set with respect to all fertilizers is not known. There has been as yet no systematic investigation of all fertilizer types, or an investigation of the percentage of recycled industrial waste products with substantial levels of heavy metals in the fertilizer market.

- Fertilizer application rates for agricultural crops were the only ones considered here. No attempt was made to capture the metals additions to residential and public lands, because of a lack of information on application rates. Preliminary data on heavy metals in home garden fertilizers suggest that significant amounts of metals may be added to home gardens from use of some of these products.

- In only a few instances was the origin (e.g., natural ore or industrial by-product) of the fertilizer product known. Although it may be instructive to compare heavy metal additions to soil from natural ores and products from industrial waste, such an exercise could not be undertaken on the basis of the available data.

While the following list is not inclusive, some of the data gaps that may require further study include:

- Nationally-representative micronutrient application rates. Aggregate average application rates for micronutrients and liming materials by state, treated acres and crop type have not been assembled, as has been done for N, P and K fertilizer.

- Regional variability in concomitant use of NPK, micronutrient and liming materials on the same field. Statewide use data for each fertilizer type are available, but the overlap in application by crop has not been compiled. Some areas of the U.S. may receive higher input of heavy metals from fertilizers due to the combination of crop type and existing soil conditions.

- Contribution of fertilizer products derived from industrial wastes to total fertilizer market. While sources of most industrial waste-derived fertilizers are fairly well known, the market share of these products in the total fertilizer market is not known.

- Statistically valid, nationally representative metal contaminant levels of all fertilizer types. While researchers have measured contaminant levels in fertilizers, these studies tend to represent either a single product type and/or products found in a specific state.

- Levels of other contaminants such as radionuclides and persistent organic chemicals in fertilizers and liming materials. Compared with the data on heavy metals in fertilizers, relatively little information exists on the levels of organic pollutants in fertilizers. Such organics could include dioxins, PCBs, pesticides and PAHs.

- The environmental fate of chemical additions to soil. This issue has been studied primarily for cadmium and lead, and most often under controlled laboratory or field conditions. All potential contaminants, soil types and crops have not been addressed. In addition, the fate of metals added to the soil as a result of fertilizer addition to non-agricultural land (e.g., range land and residential land) has not been adequately studied.

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## Index of Terms

Cement Kiln Dust (CKD) - A by-product from the manufacturing of cement. Contains 4% to 12.8% of potash ($K_2O$) and averages 30% Ca. Used primarily as a liming material. High content of calcium oxide produces equilibrium pH in suspension of about 12. (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Contaminant- A constituent or component of a fertilizer that is not part of the guaranteed analysis and/or 1) is not a macronutrient (primary or secondary), 2) is not a micronutrient, 3) is not required for plant nutrition (e.g., Cd, Pb, As, Hg, radionuclides, dioxins), and 4) may be essential for some plants (and humans) at low levels or in one oxidation state but toxic at higher levels or in a different oxidation state (e.g., Cr, Ni, V, Cu, Zn). Contaminant constituents are present naturally in inorganic fertilizer ores and in industrial by-products reprocessed for fertilizers.

Diammonium Phosphate (DAP) - A type of NPK fertilizer. The fertilizer grade of DAP $(NH_4)_2HPO_4$ is made from wet-process phosphoric acid and ammonia and has a grade of 18-46-0. DAP has an economic advantage over monoammonium phosphate (MAP) because the same amount of acid reacts with twice as much ammonia. Substantial quantities of crystalline DAP are produced as by-products from the iron and steel industry (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Fertilizer - A substance that contains one or more recognized plant nutrients that is specially designed to be used for its plant nutrient content and is claimed to promote plant growth. A fertilizer material is a fertilizer which either:

A. Contains important quantities of no more than one of the primary plant nutrients: nitrogen (N), phosphorus (P), and potassium (K), or

B. Has 85% or more of its plant nutrient content present in the form of a single chemical compound, or

C. Is derived from a plant or animal residue or by-product or natural material deposit which has been processed in such a way that its content of plant nutrients has not been materially changed except by purification and concentration (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Filler - A substance added to fertilizer materials to provide bulk, prevent caking, or serve some purpose other than providing essential plant nutrients. (Source-Fertilizer Dictionary, Farm Chemicals Handbook '97)

Guaranteed Analysis - The minimum percentage of plant nutrients claimed in a fertilizer that is found on the fertilizer label (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Gypsum - A product consisting chiefly of calcium sulfate with combined water ($CaSO_4 \cdot 2H_2O$) and is incapable of neutralizing soil acidity. Occurs in large deposits of soft crystalline rock and as sand. A granulated form has been developed for application to soil (for growing peanuts and other crops) as a calcium source or sulfur source either by itself or in a blend of other fertilizers. In irrigated agriculture it is used to increase permeability of soils (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Heavy Metals - Certain metals, such as arsenic, cadmium, lead, mercury, and nickel, may be present in varying concentrations in naturally occurring ores or in industrial by-products which contain plant nutrients and are processed for fertilizers (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Industrial By-Product - Waste materials from various industrial processes which contain plant nutrients. These products may be converted into fertilizer materials, depending upon their physical condition and on their content of possibly undesirable contaminants. Some by-products are hazardous waste, others are not. (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Inorganic Fertilizer - A fertilizer material which does not have carbon as the essential component of its basic chemical structure (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

$K_2O$- Potash or potassium oxide. Not used as a fertilizer *per se*, but the chemical term used as the basic measure of potassium (K) content in diverse potassium fertilizers such as potassium chloride, potassium sulfate, potassium nitrate and potassium thiosulfate.

K061 Waste - Emission control dust/sludge from the primary production of steel in electric furnaces (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Liming Materials - A product whose calcium and magnesium compounds are capable of neutralizing soil acidity (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Macronutrients - Nutrients that plants require for growth in relatively large amounts. Includes both primary and secondary nutrients. Primary nutrients are nitrogen, phosphorus, and potassium. Secondary nutrients are calcium, magnesium, and sulfur (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Micronutrients - Nutrients essential for normal growth of plants that are required relatively small amounts. Micronutrients include boron, chlorine, cobalt, copper, iron, manganese, molybdenum, sodium and zinc. (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Monoammonium Phosphate (MAP) - An important NPK fertilizer ($NH_4H_2PO_4$) whose production and use has increased steadily over the past several years. Granular product, made with wet-process acid, has a grade of about 10-53-0. Some by-product MAP made with furnace acid has a grade of 12-61-0 and is used mainly in production of liquid fertilizers. Nongranular (powder) MAP is used in formulations for granular NP and NPK fertilizers, which it can react with additional ammonia and aid granulation (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Muriate of Potash (MP) - A potash salt containing 48% to 62% soluble potash ($K_2O$) , chiefly as chloride. Also known as commercial potassium chloride (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

N- Nitrogen, essential element for plant growth. Not used as a fertilizer *per se*, but the chemical term used as the basic measure of nitrogen content in diverse fertilizers such as nitrates, ammonium salts, liquid ammonium, urea, and natural organics.

Organic Fertilizer - A material that contains carbon and one or more elements besides hydrogen and oxygen that are required for plant growth (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

$P_2O_5$- Phosphorus oxide. Not used as a fertilizer *per se*, but the chemical term used as the basic measure of phosphorus (P) content in diverse phosphate fertilizers such as calcium phosphates, ammonium phosphates, polyphosphates and superphosphates.

Phosphogypsum - Calcium sulfate ($CaSO_4{\cdot}2H_2O$) that is the dried by-product from the manufacturing of phosphoric acid, see gypsum. (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

ppb- parts per billion. Unit of concentration equal to ng/g or ug/kg.

ppm- parts per million. Unit of concentration equal to ug/g or mg/kg.

Product Average Yearly Addition: Also product average yearly addition of metal X (e.g., Cd); product average yearly soil addition rate of metal X. The average amount of metal X that will be added to agricultural soil from all products of a specific fertilizer category. The product average yearly addition is obtained by calculation: the sum of the yearly addition rates of metal X in product type Y (e.g., $P_2O_5$ fertilizers) at nutrient application rate Z (e.g., average nutrient application rate), divided by the number of products of that category evaluated. Product average yearly addition is determined for three different nutrient application rates- average, high and maximum.

Soil Amendments - Any substance that is added to soil (other than the substances used primarily as fertilizer) that is thought to improve the physical characteristics of the soil, such as porosity to water and air. Soil amendments do not include commerical fertilizers, agricultuural liming materials, unmanipulated animal manures, unmanipulated vegetable manures, pesticides, and other materials exempted by regulation but can contain important fertilizer elements (Source: Fertilizer Dictionary, Farm Chemicals Handbook).

Yearly Addition: Also yearly addition of metal X (e.g., Cd); yearly soil addition rate of metal X. The amount of metal X that is added to agricultural soil from the application of a specific fertilizer product. Assumes one application of the product fertilizer in the year. The yearly addition value is obtained by calculation as follows: the concentration of that specific heavy metal in the fertiizer product per desired nutrient ingredient, multiplied by the nutrient application rate, with all appropriate conversion factors applied.  Yearly addition is calculated with three different nutrient application rates- average, high and maximum.

# BACKGROUND REPORT ON FERTILIZER USE, CONTAMINANTS AND REGULATIONS

## 1.0 INTRODUCTION

The Environmental Protection Agency (EPA) is studying the issue of heavy metals and other non-nutritive constituents (also referred to as contaminants) in fertilizers and liming materials. The purpose of this report is to provide background information on fertilizer use, consumption patterns, composition and regulations. This information is gathered and presented here for fertilizers from natural mineral sources and those that are derived from industrial by-products. The data for heavy metals in fertilizers compiled here are used to provide estimate of the rates at which these metals may be added to agricultural soils from standard agronomic practices. The addition of heavy metals to agricultural soil are discussed in terms of federal and international regulations.

Some industrial by-products contain chemicals which provide plant nutrients. The recycling of these materials conserves resources and minimizes waste, but at the same time may result in fertilizer products that contain chemicals unnecessary for plant growth and development. Examples of such chemicals are heavy metals such as lead and cadmium, radionuclides chemicals and persistent organics such as chlorinated dioxins. Concern has been raised that potentially hazardous constituents of recycled wastes, as well as naturally occurring heavy metals in ores used for fertilizers, might be taken up by plants and ingested by humans or animals in quantities that could be harmful to health. Additional concerns about use of fertilizer products include risks to farmers and their families, damage to soil fertility, and dispersion into groundwater and air.

States regulate label statements made about the plant nutrients (macronutrients: nitrogen, phosphate, potash; secondary nutrients and micronutrients) in fertilizers, but, in general, do not regulate other constituents that may be present as a result of the preparation of these products. Existing EPA Resource Conservation and Recovery Act (RCRA) regulations allow with certain restrictions the recycling of industrial wastes in the interest of minimizing waste that would ultimately end up in landfills or require additional treatment. EPA and the U.S. Department of Agriculture (USDA) also encourage the recycling of agricultural and municipal wastes. These wastes may contain heavy metals (e.g. arsenic, lead and cadmium) and persistent organic compounds (e.g. dioxins and furans) in addition to the beneficial chemicals which are being recycled into plant nutrient products. Biosolids (sewage sludge) are regulated in the U.S. when these products are applied to the land (EPA Part 503 Rule). EPA Part 266.20, "Recyclable Materials Used in a Manner Constituting Disposal," requires that fertilizers containing recycled hazardous materials meet specific treatment standards.

This report is a compilation of existing information on inorganic fertilizers and liming agents. The use and content of other types of materials used in agriculture, such as manures and other biosolid materials, was not addressed in this study.

Section 2 of this report provides an overview of the use of fertilizer in the United States, including including total consumption rates for various fertilizer types by state, for agricultural and non-agricultural use, and for specific crop types. This section also presents a brief profile of the U.S. fertilizer industry, and a discussion of the types of recycled industrial wastes and secondary materials that can be used in fertilizer manufacture.

Section 3 provides information on classification of fertilizers, and presents data on concentrations of heavy metals and other contaminants by fertilizer type, as well as data from a number of studies on soil metal concentrations.

Section 4 is a summary discussion of regulations and guidelines for fertilizers that have been developed in the United States and other countries. This section also outlines regulations for biosolids that are applied to land.

Section 5 combines data on the application rates for different fertilizer types with the data on contaminant levels, to estimate the amounts of metals that may be added to soils from fertilizer usage. These data are compared with regulatory standards and benchmarks, and to background soil concentrations of metals.

## 1.1 PEER REVIEW PROCESS

This report was reviewed independently by members of a peer review panel. The panel consisted of a diverse group of researchers and policy professionals in government, industry, and environmental advocacy who, together, had considerable knowledge on all subject areas addressed in this report. The members of this panel and their affiliations were:

Darlene H. Blair, Canadian Food Inspection Agency
Sally Brown, US Department of Agriculture- Agricultural Research Service
Stan Daberkow, US Department of Agriculture
Jacqueline Savitz, Environmental Working Group
James Skillen, The Fertilizer Institute
Steven Wong, California Department of Food and Agriculture.

The peer reviewers were invited to provide both general comments and specific suggestions concerning the report.

The majority of the peer reviewer comments can be divided into five main subject areas. These subject areas include:

- purpose of the report,
- definition of terms,
- use of benchmark standards for comparison of products,
- potential fertilizer problems beyond heavy metals in agricultural products, and
- technical issues related to clarity of discussion of calculation methods, and the role of lime and gypsum in the fertilizer industry.

The purpose of the report was not well understood by the reviewers, so that several reviewers requested analyses, data collection, evaluation of EPA's next steps, and/or assessment of EPA's policy position. These requests covered areas that far exceeded the scope and intended purpose of the report. As a result of such reviewer comments, the executive summary and the introduction were modified significantly to emphasize that this report is an information source, and contains a compilation of available data on fertilizer composition, application rates, and applicable regulations, and provides a calculated estimate of the possible soil metal accumulations that may occur over time with repeated applications of fertilizer products. The report was not designed as an exposure assessment or risk assessment, either ecological or human. EPA's next steps and policy position were not addressed as this would go beyond the scope and intent of this report, and would logically be communicated to the public at a later time.

Terms that were used in the peer reviewed version of the report (e.g., contaminant, hazardous waste) were viewed as significantly ambiguous to several reviewers so as to require clarification and/or modification. Several reviewers suggested that a glossary of terms be added at the beginning of the document, and this suggestion was implemented. The glossary covers standard fertilizer terms and their abbreviations (e.g., DAP, diammonium phosphate), as well as terms which may connote different things to different groups if not explicitly defined (e.g., industrial by-product). A consistent set of terms was then applied to the entire document, and these terms were chosen as "neutral" in their connotations. For example, the term "heavy metal contaminant" was replaced with "heavy metal constituent" because heavy metals such as zinc and copper can be used as a nutrient in some circumstances and viewed as an undesirable component in other instances. In addition, because of negative connotations to the word "hazardous waste", especially as applied to materials that are legitimately reprocessed as fertilizer materials or feedstocks, this term was replaced with "industrial by-product" in the report.

Several reviewers questioned the appropriateness of the benchmark standards that were employed in the evaluation of diverse fertilizer products. In particular, reviewers questioned the use of heavy metals limits set in the Canadian Fertilizers Act and Regulations, and the calculation of years required to double soil metal background levels with repeated yearly additions of a given product. As documented in the report, the Canadian standards were not established through a formal risk assessment, but were instead determined from the best estimates of leading scientists in various fields as levels associated with no adverse effect to plants, animals or land over the long term. These limits are being adopted by states and AAPFCO at this time, in lieu of formal risk assessments, so that they constitute a useful and consistent point of reference for comparisons. The report also characterizes fertilizer products with respect to the length of time required for their consistent applications to double the average background US soil metals levels. Although the doubling of soil metal levels may not be associated with any known risk, these calculations help to put products, application rates and fertilizer constituent levels in the perspective of a measurable change to soils.

Due to the concern that recycled industrial by-products may have hazardous constituents other than the heavy metals, the report was expanded to include discussions of other undesirable components of fertilizers. In this section, attention was given specifically to dioxins/furans and radionuclides. Some peripheral comments also noted the potential for pesticides, PAHs, and PCBs to be present in industrial wastes, but organic constituents were not a primary focus of this report.  Similarly, questions were raised about fertilizers other than those applied in production agriculture, specifically those used in the home-and-garden arena.  Because data were readily available from several sources on concentrations of heavy metals in home-and-garden fertilizers, these data were included in the report.  However, because application rates for these products are so varied among consumers, no attempt was made to estimate soil additions of metals from these products.

Several comments made by reviewers suggested that there was some confusion about what constituted an average fertilizer product.  For this reason, there is a definition of average product in the text, an expanded discussion of the calculation method, and examples that show the manner in which both the percentage of the active nutrient ingredient and the individual product heavy metal concentrations contribute to the soil addition rate.  As a result of these comments, text in both the executive summary and Section 5 has been augmented by figures which provide a rapid perspective on product types that may require additional scrutiny due to exceedances of Canadian standards or relatively short time of use before soil background metals levels are potentially doubled.  These figures provide an excellent perspective for final conclusions of the report.

EPA has established a public record for the peer review of this report under administrative record AR-208 , “Background Report on Fertilizer Use”. The record is available in the TSCA Nonconfidential Information Center, which is open from noon to 4 PM Eastern time Monday through Friday, except legal holidays.  The TSCA Nonconfidential information Center is located in Room NE-B607, Northeast Mall, 401 M Street SW, Washington, DC.

## 2.0 FERTILIZER USE AND INDUSTRY CHARACTERIZATION

This section provides an introduction to the fertilizer industry in the United States. Fertilizers are defined in the first subsection. Fertilizer consumption in the U.S. is described in the second subsection. That subsection includes information on tons of fertilizers consumed by types of fertilizer for individual states and regions of the country. Fertilizer use on agricultural crops is provided, both amount consumed and application rates. In addition, fertilizer consumption is broken down into that used for agriculture and other uses in the third and fourth subsections. The final subsection provides an overview of the fertilizer industry describing the market structure, production volumes and size distribution of producing firms.

This section addresses the questions:

- What constitutes a fertilizer and a liming material?
- How much fertilizer is used in the U.S.?
- How much of various kinds of fertilizers and micronutrients are used in the U.S.?
- How do the states and regions of the country differ in fertilizer use?
- What crops use the most of specific fertilizer types?
- What is known about non-farm fertilizer use?
- How is fertilizer made?
- What is known about the fertilizer industry in terms of production, revenue and employment?

### 2.1. DEFINITION OF FERTILIZER AND LIMING MATERIAL

**Fertilizer** is defined as "any substance containing one or more recognized plant nutrient(s) which is used for its plant nutrient content and which is designed for use or claimed to have value in promoting plant growth" (Association of American Plant Food Control Officials - AAPFCO, 1997b). A **fertilizer material** is a fertilizer which either

(a) "Contains important quantities of no more than one of the primary plant nutrients: nitrogen (N), phosphorus (P) and potassium (K), or
(b) Has 85% or more of its plant nutrient content present in the form of a single chemical compound, or
(c) Is derived from a plant or animal residue or by-product or natural material deposit which has been processed in such a way that its content of plant nutrients has not been materially changed except by purification and concentration." (AAPFCO)

Fertilizers may be composed of multiple fertilizer materials. In addition, fertilizers may contain additives which "alter transformation in the soil, maintain good physical condition, reduce corrosiveness and serve some purpose other than providing plant nutrients" (Meister, R.T., 1997) and micronutrients. Primary nutrients are defined by the AAPFCO as nitrogen (N), available phosphate ($P_2O_5$) and soluble potash ($K_2O$). The AAPFCO defines secondary and micronutrients as "those other than the primary nutrients that are essential for the normal growth of plants and that may need to be added to the growth medium. Secondary plant nutrients shall include calcium, magnesium and sulfur; micro plant nutrients shall include boron, chlorine, cobalt, copper, iron, manganese, molybdenum, sodium and zinc."  Calcium (liming materials and gypsum), magnesium (from dolomite limestone) and sulfur (in the form of inorganic sulfates and sulfur in organic matter) are used to aid in fruit and leaf development and leaf color.  More detailed descriptions of the composition of fertilizers are provided in Section 3.

A **liming material** is defined as "a product whose calcium and magnesium compounds are capable of neutralizing soil acidity" (AAPFCO, 1997b).

## 2.2. FERTILIZER CONSUMPTION IN THE U.S.

Both the AAPFCO and USDA collect information on fertilizer use in the United States. The Economic Research Service (ERS) and National Agricultural Statistics Service (NASS) of USDA and State Statistical Offices (SSO's) collect information on chemical use in agriculture, including information on crops treated, acreage and costs.  The AAPFCO, an organization of officials, examiners, and researchers in North America charged with regulating fertilizer materials and enforcing laws applied thereto, collects information on commercial fertilizers consumed in North America, Hawaii, and Puerto Rico.  Information provided in this chapter on fertilizer use has been abstracted from both sources and several ancillary sources.  The AAPFCO uses the term "consumption" for their fertilizer statistics.  Consumption, for the AAPFCO, means data submitted by fertilizer control offices on sales or shipments for farm and non-farm use.  The USDA data record fertilizer application to agricultural land, which is a more specific definition of use.  Because there are no data on fertilizer stockpiling by the consumer, use and consumption are used interchangeably in this report.

The AAPFCO reports that more than 54 million tons (110 billion lbs) of commercial fertilizers of all kinds were consumed in the United States in the year ending June 30, 1996. Primary nutrients (N, P, K) accounted for 91% of this total; liming materials accounted for about 4%, and organic fertilizers accounted for 1% of the total.  Approximately 5% of the total (2.7 million tons) was due to secondary nutrients and micronutrients.  Table 2-1 summarizes the U.S. tonnage use of the different fertilizer types.  The zinc and iron micronutrient fertilizers, which have come under scrutiny lately as industrial waste by-products with heavy metal content, comprise about 0.1% of the total tonnage of fertilizers consumed.

Table 2-2 summarizes the use of fertilizers in different regions of the United States.  The largest single category of fertilizers consumed in 1996 was the nitrogen materials (23 million tons) and the smallest category is natural organic materials (0.57 million tons), which includes compost, manure and sewage sludge.  The West North Central region (13 million tons) and the New England Region (0.4 million tons) are the areas consuming the most and least fertilizer in the continental United States, respectively.  These consumption values are totals and are not adjusted for the amount of agricultural land in each region.  The AAPFCO statistics presented in Table 2-2 differ slightly from those presented in Commercial Fertilizers 1996 (AAPFCO and the Fertilizer Institute (TFI), 1997) because this table was prepared from electronic files obtained from the AAPFCO.  Because of the inclusion of liming materials in these tables and some minor differences in the definition of multiple nutrient fertilizers and "other" fertilizer groupings, these fertilizer consumption values differ slightly from those presented in Commercial Fertilizers 1996.

**Table 2-1. Total Fertilizer (Tons) Consumed in the United States in 1996[a]**

| Fertilizer Type | Tons | % of Total |
|---|---|---|
| Nitrogen | 23,412,475 | 38 |
| Multiple Nutrient | 19,049,707 | 31 |
| Phosphate | 7,204,054 | 12 |
| Potash | 5,988,338 | 10 |
| Secondary/Micronutrient | 2,743,287 | 4.5 |
| [gypsum | ~50%][b] | [2.3] |
| [other | ~25%][b] | [1.1] |
| [zinc | ~1.5%][b] | [0.07] |
| [iron | ~1%][b] | [0.05] |
| Lime | 2,219,922 | 3.6 |
| Organic | 571,575 | 0.9 |

a) Source: AAPFCO Electronic Database; see expanded form in Table 2-2 see footnote a, Table 2-2.

b) Selected data; percentage of the secondary/micronutrient total due to indicated type.

Appendix A contains fertilizer consumption for individual states and Puerto Rico, grouped into the regions of the country shown in Table 2-2 (pp. 8-14). These data are abstracted from AAPFCO data files for the year ending June 30, 1996. There are nine states with total fertilizer consumption over 2 million tons. These states are, in order of increasing fertilizer consumption: Florida, Minnesota, Ohio, Nebraska, North Carolina, Texas, Iowa, Illinois and California. Table 2-3 below shows the fertilizer consumption (tons) of the top two states by fertilizer category. Texas and Florida consume the most multiple nutrient fertilizers, while Illinois consumes the most single nutrient nitrogen, phosphate and potash fertilizers. North Carolina consumes the most organic fertilizers and liming materials, while California consumes the most secondary nutrient and micronutrient fertilizers.

**Table 2-3. Top States Consuming Fertilizers by Fertilizer Type, 1996[a]**

| Fertilizer Type[b] | Top State and Tons Consumed | Second Top State and Tons Consumed |
|---|---|---|
| **Multiple Nutrient** | TX - 1,622,103 | FL - 1,562,946 |
| **Nitrogen** | IL - 1,920,268 | IA - 1,819,846 |
| **Phosphate** | IL - 832,904 | IA - 647,541 |
| **Potash** | IL - 979,455 | IA - 699,879 |
| **Organic** | NC - 194,265 | CA - 78,781 |
| **Secondary Nutrient and Micronutrients** | CA - 1,596,796 | NC - 145,651 |
| **Liming Materials** | NC - 947,126 | CA - 621,915 |

a) See Appendix A for more details

b) Source: AAPFCO Database, 1997

# Table 2-2. Total Fertilizer (Tons) Consumed in the United States and Regions in 1996

| Description | New England | Middle Atlantic | South Atlantic | East North Central | West North Central | East South Central | West South Central | Mountain | Pacific | Alaska Hawaii Puerto Rico | United States and Puerto Rico |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | | | |
| N-P-K | 238,837 | 906,139 | 3,497,228 | 1,341,258 | 613,608 | 737,119 | 1,595,897 | 59,972 | 1,336,439 | 114,217 | 10,440,715 |
| N-P | 17,756 | 180,851 | 259,164 | 1,636,291 | 2,773,728 | 444,812 | 755,069 | 628,283 | 452,600 | 6,912 | 7,155,466 |
| N-K | 7,326 | 44,111 | 526,711 | 56,458 | 16,323 | 41,300 | 119,429 | 4,495 | 35,408 | 1,572 | 853,133 |
| P-K | 1,982 | 27,157 | 145,734 | 149,290 | 6,260 | 45,620 | 222,927 | 22 | 1,386 | 13 | 600,392 |
| TOTAL | 265,902 | 1,158,258 | 4,428,838 | 3,183,297 | 3,409,920 | 1,268,851 | 2,693,322 | 692,773 | 1,825,832 | 122,714 | 19,049,707 |
| **NITROGEN FERTILIZERS** | | | | | | | | | | | |
| Ammonium Nitrate | 3,347 | 21,810 | 182,906 | 78,787 | 442,273 | 504,232 | 379,706 | 308,154 | 177,368 | 147 | 2,098,730 |
| Ammonium Nitrate Solution | 0 | 1 | 3,714 | 203 | 0 | 228 | 34 | 50 | 70,064 | 0 | 74,294 |
| Ammonium Nitrate-limestone Mixtures | 2 | 5 | 397 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 404 |
| Ammonium Nitrate-sulfate | 0 | 1,167 | 12,697 | 4,404 | 39 | 890 | 2,227 | 7,592 | 2,490 | 0 | 31,505 |
| Ammonium Polysulfide | 0 | 1 | 3,622 | 335 | 115 | 420 | 51 | 10,137 | 25,047 | 0 | 39,728 |
| Ammonium Sulfate | 1,258 | 45,536 | 101,076 | 108,605 | 102,906 | 28,612 | 155,272 | 138,843 | 350,869 | 17,021 | 1,049,999 |
| Ammonium Sulfate Solution | 0 | 507 | 672 | 141,415 | 19,765 | 0 | 231 | 22 | 318 | 0 | 162,930 |
| Ammoniumsulfate-nitrate | 0 | 802 | 1,260 | 22,446 | 1,287 | 210 | 7,001 | 1,709 | 1,005 | 0 | 35,720 |
| Ammoniumsulfate-urea | 0 | 25 | 469 | 114 | 0 | 0 | 2,183 | 0 | 0 | 0 | 2,790 |
| Ammonium Thiosulfate | 5 | 3,239 | 1,415 | 15,055 | 98,942 | 7,992 | 21,867 | 28,426 | 60,101 | 0 | 237,042 |
| Anhydrous Ammonia | 2 | 16,535 | 22,453 | 1,020,310 | 2,713,026 | 96,978 | 405,354 | 290,472 | 265,361 | 0 | 4,830,490 |
| Aqua Ammonia | 0 | 424 | 600 | 12,047 | 3,386 | 273 | 0 | 8,871 | 349,061 | 0 | 374,662 |
| Calcium Ammonium Nitrate | 9 | 77 | 354 | 1,231 | 854 | 32 | 454 | 982 | 176,673 | 0 | 180,665 |
| Calcium Cyanamide | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 248 | 0 | 252 |
| Calcium Nitrate | 1,052 | 3,486 | 20,076 | 47,795 | 1,742 | 769 | 495 | 3,634 | 112,688 | 0 | 191,737 |
| Calcium Nitrate-urea | 0 | 27 | 1,495 | 311 | 612 | 0 | 1,934 | 87 | 0 | 0 | 4,465 |

## Table 2-2. (Continued)

| Description | New England | Middle Atlantic | South Atlantic | East North Central | West North Central | East South Central | West South Central | Mountain | Pacific | Alaska Hawaii Puerto Rico | United States and Puerto Rico |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ferrous Ammonium Sulfate | 17 | 78 | 242 | 155 | 66 | 1,664 | 0 | 43 | 1,805 | 0 | 4,070 |
| Magnesium Nitrate | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Nitric Acid | 23 | 9 | 991 | 1,346 | 747 | 1 | 170 | 212 | 0 | 0 | 3,500 |
| Nitrogen Solution 28% | 762 | 40,384 | 22,849 | 2,137,611 | 1,604,399 | 103,271 | 323,376 | 26,268 | 18,442 | 0 | 4,277,361 |
| Nitrogen Solution 30% | 1 | 220,452 | 772,531 | 5,367 | 8,670 | 16,629 | 45,082 | 423 | 16 | 0 | 1,069,172 |
| Nitrogen Solution 32% | 3,108 | 32,407 | 38,814 | 228,594 | 1,072,964 | 252,530 | 862,560 | 443,132 | 793,919 | 18,236 | 3,746,263 |
| Nitrogen Solution < 28% | 101 | 42,211 | 232,379 | 139,808 | 21,593 | 17,511 | 31,077 | 53,999 | 17,920 | 0 | 556,600 |
| Nitrogen Solution > 32% | 0 | 210 | 1,960 | 857 | 6,432 | 918 | 6,187 | 23 | 967 | 0 | 17,555 |
| Sodium Nitrate | 340 | 409 | 18,948 | 1,443 | 42 | 5,339 | 3,268 | 95 | 1,718 | 0 | 31,602 |
| Sulfur Coated Urea | 6 | 429 | 246 | 1,473 | 1,104 | 56 | 465 | 426 | 1,989 | 8 | 6,202 |
| Urea | 13,437 | 95,224 | 83,617 | 514,168 | 1,403,713 | 295,787 | 852,280 | 377,587 | 266,480 | 9,713 | 3,912,007 |
| Urea Solution | 0 | 0 | 301 | 0 | 1,277 | 281 | 0 | 63 | 8,437 | 0 | 10,359 |
| Urea-formaldehyde | 1,857 | 12,218 | 12,929 | 8,553 | 4,463 | 3,240 | 15,504 | 88 | 4,260 | 1 | 63,114 |
| Zinc Ammonium Sulfate Solution | 0 | 0 | 319 | 2 | 5,691 | 546 | 0 | 72 | 0 | 0 | 6,631 |
| Zinc Manganese Ammonium Sulfate | 0 | 3 | 75 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 92 |
| Other | 3,389 | 10,448 | 68,387 | 76,305 | 31,253 | 68,180 | 83,512 | 17,618 | 33,441 | 1 | 392,534 |
| TOTAL | 28,715 | 548,128 | 1,607,798 | 4,568,739 | 7,547,376 | 1,406,587 | 3,200,289 | 1,719,029 | 2,740,687 | 45,127 | 23,412,475 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | | | |
| Ammonium Metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8,284 | 0 | 8,284 |
| Ammonium Phosphate | 1 | 911 | 4 | 38 | 17,228 | 98 | 296 | 238 | 468 | 3,215 | 22,498 |
| Ammonium Phosphate Nitrate | 0 | 0 | 1 | 1 | 1,238 | 5 | 15 | 0 | 2,512 | 0 | 3,772 |
| Ammonium Phosphate Sulfate | 0 | 121 | 24 | 494 | 3,388 | 0 | 7,827 | 76,593 | 98,945 | 0 | 187,391 |
| Ammonium Polyphosphate | 61 | 446 | 6 | 132 | 52,123 | 57 | 0 | 0 | 3,706 | 0 | 56,533 |
| Basic Lime Phosphate | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37 |

## Table 2-2. (Continued)

| Description | New England | Middle Atlantic | South Atlantic | East North Central | West North Central | East South Central | West South Central | Mountain | Pacific | Alaska Hawaii Puerto Rico | United States and Puerto Rico |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Basic Slag | 0 | 0 | 2,988 | 0 | 0 | 2,143 | 0 | 0 | 0 | 0 | 5,131 |
| Bonemeal, Raw | 76 | 59 | 40 | 35 | 0 | 0 | 2 | 1 | 82 | 0 | 294 |
| Bonemeal, Steamed | 214 | 155 | 178 | 136 | 26 | 12 | 2 | 17 | 374 | 0 | 1,113 |
| Bone, Precipitated | 0 | 0 | 0 | 0 | 2 | 0 | 5 | 284 | 0 | 0 | 292 |
| Calcium Metaphosphate | 0 | 0 | 115 | 0 | 253 | 1,825 | 25 | 0 | 0 | 0 | 2,218 |
| Colloidal Phosphate (Soft Phosphate) | 4 | 45 | 499 | 196 | 142 | 128 | 28 | 0 | 6 | 0 | 1,047 |
| Diammonium Phosphate | 5,886 | 45,610 | 112,709 | 1,128,423 | 1,617,708 | 403,834 | 213,220 | 129,627 | 36,480 | 615 | 3,694,109 |
| Limestone, Phosphatic | 0 | 0 | 45 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 68 |
| Liquid Ammonium Polyphosphate | 1,965 | 23,525 | 89,524 | 277,089 | 486,662 | 19,340 | 137,368 | 64,905 | 122,073 | 3,081 | 1,225,533 |
| Magnesium Phosphate | 0 | 41 | 43 | 40 | 990 | 48 | 149 | 25 | 3 | 0 | 1,340 |
| Mono Ammonium Phosphate | 2,538 | 39,846 | 4,256 | 153,501 | 528,150 | 8,077 | 47,462 | 350,713 | 165,720 | 1 | 1,300,264 |
| Nitric Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,394 | 0 | 2,394 |
| Phosphate Rock | 10 | 6 | 24 | 632 | 335 | 31 | 150 | 1,416 | 2,869 | 11 | 5,483 |
| Phosphoric Acid | 0 | 2,319 | 3,203 | 577 | 4,802 | 1 | 291 | 9,933 | 15,155 | 0 | 36,280 |
| Precipitated Phosphate | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 1,187 | 0 | 6 | 1,216 |
| Super Phosphate, Enriched | 8 | 42 | 86 | 35 | 89 | 28 | 3 | 56 | 556 | 0 | 902 |
| Super Phosphate, Normal | 146 | 1,201 | 2,667 | 12,666 | 8,978 | 520 | 4 | 3,785 | 473 | 159 | 30,599 |
| Super Phosphate, Triple | 697 | 17,110 | 28,658 | 198,374 | 91,090 | 50,095 | 25,240 | 19,932 | 11,950 | 432 | 443,577 |
| Super Phosphoric Acid | 0 | 0 | 2,219 | 2 | 10,430 | 0 | 893 | 18,323 | 12,577 | 0 | 44,444 |
| Other | 151 | 3,466 | 17,579 | 92,606 | 3,732 | 1,613 | 4,635 | 2,583 | 2,868 | 0 | 129,235 |
| TOTAL | 11,794 | 134,904 | 264,890 | 1,864,977 | 2,827,389 | 487,856 | 437,613 | 679,617 | 487,496 | 7,519 | 7,204,054 |
| **POTASH FERTILIZERS** | | | | | | | | | | | |
| Lime-potash Mixtures | 46 | 5,568 | 220 | 1,587 | 30 | 88 | 1 | 543 | 0 | 0 | 8,084 |
| Manure Salts | 0 | 0 | 504 | 464 | 1,179 | 0 | 18 | 1,530 | 0 | 0 | 3,694 |

## Table 2-2. (Continued)

| Description | New England | Middle Atlantic | South Atlantic | East North Central | West North Central | East South Central | West South Central | Mountain | Pacific | Alaska Hawaii Puerto Rico | United States and Puerto Rico |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Muriate of Potash 60%(Pot. Chloride) | 8,063 | 120,740 | 192,919 | 1,787,204 | 1,488,714 | 504,059 | 140,414 | 104,454 | 149,085 | 592 | 4,496,243 |
| Muriate of Potash 62% | 720 | 13,243 | 12,943 | 676,455 | 196,174 | 23,565 | 4,094 | 6,009 | 10,990 | 0 | 944,192 |
| Potash Suspensions | 62 | 2,752 | 179 | 0 | 0 | 183 | 0 | 0 | 7,091 | 0 | 10,267 |
| Potassium Carbonate | 28 | 77 | 295 | 153 | 292 | 0 | 77 | 442 | 25 | 0 | 1,389 |
| Potassium Nitrate | 362 | 10,126 | 26,616 | 2,100 | 200 | 2,853 | 1,176 | 2,740 | 23,528 | 179 | 69,880 |
| Potassium Sulfate | 224 | 2,743 | 17,695 | 10,152 | 1,857 | 42,255 | 5,811 | 4,708 | 55,555 | 1,173 | 142,173 |
| Potassium-magnesium Sulfate | 1,488 | 3,796 | 17,017 | 19,574 | 39,898 | 9,336 | 7,874 | 5,813 | 30,301 | 0 | 135,098 |
| Potassium-meta Phosphate | 4 | 173 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 177 |
| Potassium-sodium Nitrate | 1 | 141 | 18,418 | 37 | 23 | 224 | 0 | 1 | 0 | 0 | 18,845 |
| Other | 778 | 14,242 | 37,071 | 26,676 | 11,338 | 10,887 | 10,518 | 19,325 | 11,098 | 16,328 | 158,260 |
| TOTAL | 11,777 | 173,602 | 323,878 | 2,524,402 | 1,739,704 | 593,448 | 169,983 | 145,598 | 287,672 | 18,272 | 5,988,338 |
| **ORGANIC FERTILIZERS** | | | | | | | | | | | |
| Blood, Dried | 37 | 20 | 196 | 124 | 172 | 3 | 1 | 1 | 1,770 | 0 | 2,324 |
| Castor Pomace | 0 | 0 | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| Cocoa Shell Meal | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| Compost | 14,509 | 15,195 | 20,863 | 3,974 | 492 | 0 | 0 | 8,793 | 948 | 0 | 64,774 |
| Cottonseed Meal | 6 | 0 | 40 | 0 | 0 | 27 | 0 | 0 | 72 | 0 | 144 |
| Fish Scrap | 48 | 0 | 18 | 12 | 0 | 989 | 0 | 0 | 377 | 0 | 1,443 |
| Guano | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 6 |
| Manure | 820 | 13,060 | 57,307 | 4,947 | 2,293 | 6,830 | 4,891 | 8,653 | 17,470 | 0 | 116,271 |
| Peat | 0 | 93 | 8,461 | 26,690 | 0 | 2,338 | 0 | 395 | 0 | 0 | 37,977 |
| Sewage Sludge, Activated | 1,241 | 6,618 | 10,760 | 0 | 523 | 241 | 0 | 97 | 0 | 0 | 19,480 |
| Sewage Sludge, Digested | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| Sewage Sludge, Heat Dried | 0 | 127 | 0 | 2,472 | 8 | 0 | 0 | 12,510 | 0 | 0 | 15,116 |
| Sewage Sludge, Other | 86 | 4,038 | 259 | 0 | 0 | 0 | 44 | 0 | 77,169 | 0 | 81,595 |

## Table 2-2. (Continued)

| Description | New England | Middle Atlantic | South Atlantic | East North Central | West North Central | East South Central | West South Central | Mountain | Pacific | Alaska Hawaii Puerto Rico | United States and Puerto Rico |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Soybean Meal | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Tankage, Animal | 0 | 0 | 0 | 37 | 0 | 0 | 0 | 202 | 0 | 0 | 239 |
| Tankage, Process | 0 | 0 | 83 | 281 | 61 | 154 | 0 | 0 | 371 | 0 | 949 |
| Other | 28 | 7,837 | 187,427 | 10,597 | 2,869 | 9,763 | 102 | 1,055 | 11,544 | 11 | 231,234 |
| TOTAL | 16,775 | 46,988 | 285,434 | 49,135 | 6,418 | 20,343 | 5,038 | 31,706 | 109,728 | 11 | 571,575 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | | | |
| Aluminum Sulfate | 421 | 37 | 16 | 1 | 0 | 441 | 3 | 6 | 138 | 0 | 1,063 |
| Borax | 123 | 800 | 1,895 | 1,462 | 2,339 | 3,690 | 11,617 | 72 | 4,279 | 0 | 26,276 |
| Calcium Chelate | 4 | 82 | 227 | 9,026 | 47 | 0 | 0 | 1 | 0 | 3,751 | 13,138 |
| Calcium Chloride | 0 | 393 | 38 | 1,331 | 4,988 | 9 | 0 | 0 | 0 | 0 | 6,759 |
| Calcium Sulfate (Hydrous) | 0 | 0 | 13 | 1,804 | 190 | 0 | 0 | 0 | 179 | 0 | 2,186 |
| Cobalt Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| Copper Chelate | 0 | 2 | 58 | 49 | 74 | 0 | 0 | 2 | 25 | 0 | 211 |
| Copper Compound | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 582 | 0 | 589 |
| Copper Oxide, Black | 0 | 0 | 0 | 36 | 53 | 0 | 0 | 0 | 0 | 0 | 89 |
| Copper Sulfate | 2 | 440 | 217 | 42 | 240 | 6 | 0 | 367 | 89 | 0 | 1,403 |
| Epsom Salt(magnesium Sulfate) | 10 | 57 | 874 | 72 | 1 | 16 | 1 | 82 | 1,265 | 219 | 2,596 |
| Ferric Oxide | 0 | 0 | 2 | 0 | 1,482 | 255 | 0 | 0 | 1 | 0 | 1,740 |
| Ferric Sulfate | 0 | 51 | 0 | 0 | 37 | 0 | 0 | 516 | 4,073 | 0 | 4,677 |
| Ferrous Sulfate | 6 | 22 | 1,745 | 0 | 421 | 25 | 0 | 1,421 | 1,159 | 0 | 4,799 |
| Gypsum (Calcium Sulfate) | 488 | 1,835 | 334,400 | 20,838 | 8,576 | 1,160 | 44 | 37,569 | 1,205,581 | 0 | 1,610,491 |
| Iron Chelate | 51 | 187 | 629 | 286 | 636 | 45 | 9 | 368 | 162 | 0 | 2,372 |
| Iron Compound | 7 | 61 | 216 | 5 | 32 | 16 | 0 | 27 | 7,020 | 0 | 7,383 |
| Lime Sulfur Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 716 | 3 | 0 | 719 |
| Magnesia (Magnesium Oxide) | 11 | 339 | 266 | 56 | 196 | 74 | 1 | 0 | 0 | 247 | 1,190 |
| Magnesium Chelate | 0 | 11 | 23 | 0 | 7 | 7 | 12 | 416 | 35 | 0 | 509 |
| Manganese Agstone | 0 | 0 | 0 | 1 | 19 | 0 | 0 | 0 | 0 | 0 | 20 |

## Table 2-2. (Continued)

| Description | New England | Middle Atlantic | South Atlantic | East North Central | West North Central | East South Central | West South Central | Mountain | Pacific | Alaska Hawaii Puerto Rico | United States and Puerto Rico |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese Chelate | 0 | 23 | 119 | 1 | 82 | 10 | 0 | 1 | 105 | 0 | 342 |
| Manganese Oxide | 4 | 11 | 39 | 3 | 54 | 21 | 0 | 4 | 71 | 0 | 206 |
| Manganese Slag | 0 | 0 | 160 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 160 |
| Manganese Sulfate | 9 | 191 | 3,376 | 75 | 387 | 15 | 0 | 73 | 293 | 0 | 4,419 |
| Manganese Oxide | 0 | 0 | 0 | 73 | 3 | 3 | 0 | 0 | 0 | 2 | 81 |
| Potting Soil | 0 | 373 | 28,530 | 0 | 0 | 2 | 0 | 44 | 0 | 0 | 28,950 |
| Sodium Molybdate | 0 | 0 | 0 | 9 | 1 | 200 | 0 | 0 | 23 | 0 | 234 |
| Soil Additive | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 4 |
| Soil Amendment | 20,035 | 72 | 5,036 | 0 | 60 | 0 | 3 | 339 | 316 | 0 | 25,861 |
| Soil Conditioner | 0 | 7,135 | 415 | 11,601 | 1,202 | 0 | 0 | 10,817 | 0 | 0 | 31,171 |
| Sulfur | 79 | 1,090 | 2,273 | 4,959 | 14,323 | 4,100 | 630 | 26,254 | 66,638 | 137 | 120,484 |
| Sulfuric Acid | 0 | 0 | 0 | 0 | 1,248 | 2 | 0 | 15,015 | 118,100 | 0 | 134,365 |
| Zinc Chelate | 2 | 95 | 83 | 3 | 2,955 | 61 | 646 | 4,989 | 790 | 0 | 9,623 |
| Zinc Oxide | 0 | 367 | 120 | 673 | 4,849 | 359 | 63 | 243 | 1,482 | 0 | 8,158 |
| Zinc Oxysulfate | 0 | 72 | 22 | 331 | 39 | 114 | 0 | 0 | 35 | 0 | 612 |
| Zinc Sulfate | 20 | 298 | 34 | 206 | 12,645 | 186 | 141 | 1,526 | 3,499 | 15 | 18,569 |
| Zinc Sulfate Solution | 0 | 0 | 0 | 0 | 1,883 | 0 | 144 | 17 | 0 | 0 | 2,044 |
| Other | 48 | 1,112 | 117,038 | 30,415 | 21,327 | 12,206 | 139,236 | 15,947 | 332,384 | 81 | 669,793 |
| TOTAL | 21,319 | 15,156 | 497,872 | 83,357 | 80,395 | 23,024 | 152,549 | 116,835 | 1,748,327 | 4,451 | 2,743,287 |
| **LIMING MATERIALS** | | | | | | | | | | | |
| Calcitic Lime (75% Neutral) | 13,558 | 0 | 25,124 | 437 | 0 | 0 | 2,953 | 0 | 0 | 8,696 | 50,768 |
| Calcium Hydroxide (Hydrate) | 24 | 0 | 231 | 5 | 2 | 41 | 0 | 0 | 1,964 | 0 | 2,267 |
| Calcium Oxide (Burnt) | 0 | 0 | 186 | 0 | 0 | 0 | 0 | 0 | 0 | 96 | 282 |
| Dolomitic & Calcitic Blend (Pelletized) | 0 | 0 | 890 | 1,114 | 0 | 148 | 0 | 0 | 0 | 0 | 2,152 |
| Dolomitic Lime (75% Neutral) | 11,877 | 10 | 111,863 | 2 | 0 | 1,319 | 174 | 1 | 0 | 0 | 125,247 |
| Lime Suspensions | 0 | 228 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 228 |

## Table 2-2. (Continued)

| Description | New England | Middle Atlantic | South Atlantic | East North Central | West North Central | East South Central | West South Central | Mountain | Pacific | Alaska Hawaii Puerto Rico | United States and Puerto Rico |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-lime Filler (Water, Sand, Etc.) | 0 | 92 | 7 | 1,097 | 0 | 0 | 0 | 0 | 0 | 0 | 1,196 |
| Standard Calcite | 8,988 | 9,469 | 973,331 | 0 | 5,259 | 22,226 | 0 | 564 | 160,751 | 180 | 1,180,768 |
| Standard Dolomite | 7,306 | 34 | 36,224 | 0 | 0 | 56 | 27 | 0 | 34,432 | 0 | 78,079 |
| Other | 10,270 | 9,872 | 35,824 | 20,145 | 65 | 1,828 | 115 | 37 | 700,781 | 0 | 778,936 |
| TOTAL | 52,022 | 19,704 | 1,183,681 | 22,800 | 5,327 | 25,618 | 3,268 | 602 | 897,928 | 8,972 | 2,219,922 |
| **TOTAL ALL FERTILIZERS** | | | | | | | | | | | |
| GRAND TOTAL[b] | 380,487 | 1,931,326 | 8,209,554 | 10,696,555 | 12,905,624 | 3,380,801 | 6,249,756 | 2,729,707 | 7,537,010 | 199,975 | 54,220,796 |

a) Notes: Data in this table were compiled from the electronic database provided by the AAPFCO and may differ slightly from those published in Commercial Fertilizers 1996 by the AAPFCO and TFI.

Regions are:
East North Central - IN, IL, MI, OH, WI
East South Central - KY, AL, MS, TN
West North Central - KS, IA, MN, MO, NB, ND, SD
West South Central - LA, AR, OK, TX
New England - CN, ME, MA, NH, NY, RI, VT
Middle Atlantic - DE, MD, NJ, PA, WV
South Atlantic - FL, GA, NC, SC, VA
Mountain - AZ, CO, ID, MT, NM, NV, UT, WY
Pacific - AK, CA, HI, OR, WA

The term "Other" in this table refers to unspecified fertilizer types. For example, Other under Nitrogen Fertilizers refers to nitrogen-containing fertilizer products not previously specified in the listed nitrogen fertilizers.

b) Grand totals are less than sum of the category totals, because some multinutrient fertilizers are also included in other fertilizer categories.

## 2.3. AGRICULTURAL FERTILIZER USE

The USDA ERS-NASS data presented in this section come from the most recent surveys of field, fruit and vegetable crops. These surveys, the sampling methodology, coverage and data collection are described in the USDA, ERS Agricultural Resources and Environmental Indicators, 1996-1997 Appendix: Agricultural Resource Surveys and Data (1997).

Fruit and vegetable data were abstracted from the Chemical Use Surveys that were initially funded under the 1989 President's Food Safety Initiative. These surveys are conducted by NASS "using personal enumeration of a stratified systematic sample of growers who produce at least one acre of the targeted crops." The information collected on fertilizer use, acreage planted and application rates are survey data for the major crop producing states and do not represent the totality of farms in the U.S. raising these crops. Surveys are conducted in odd numbered years for fruit (latest available survey performed in 1995, reported in 1996) and even numbered years for vegetable crops (latest available survey performed in 1994, reported in 1995; the 1996 survey did not collect fertilizer data).

The latest field crop usage data, covering 70 to 90% of the total U.S. crop, are from the Agricultural Resources Management Survey (ARMS) of 1996 which combines the former Cropping Practices Surveys with the Farm Costs and Returns Survey. This survey has three phases. Phase II, conducted in the autumn, collects data on agricultural production practices, resource and input use and production. In this survey, "a multi-frame, stratified sampling procedure is used. Results are weighted and aggregated to develop state, regional and national estimates." The ARMS collects additional information on a selected field crop in certain years. For example, in 1996 the ARMS collected data on tobacco.

### 2.3.1 Field Crops

The USDA, ERS, NASS (1997) collected data on selected field crops in the major states with approximately eighty percent of the U.S. acreage for these crops. Table 2-4 shows the number of acres planted, the total amount of N, P ($P_2O_5$) and K ($K_2O$) fertilizers applied and N, P and K application rates for these field crops (note that in this section on fertilizer use, P refers to phosphate fertilizers, not phosphorus, and K refers to potash, not potassium). Potatoes have the highest average application rates for nitrogen fertilizers (195 lbs/acre) and phosphate fertilizers (173 lbs/acre), while application rates of potash are highest on tobacco (203 lbs/acre). Potatoes and tobacco, however, each have fewer than 1 million acres planted. More acres are planted with corn (approximately 70 million acres) than any other crop in the U.S., and the application rates are 133 lbs/acre N, 57 lbs/acre $P_2O_5$ and 79 lbs/acre $K_2O$. Thus, in terms of total applied fertilizer, acreage in corn, in the aggregate, receives the most fertilizer.

Information on lime, sulfur, manure and micronutrient use is available only from previous USDA surveys. The USDA, ERS, Cropping Practices Survey field crop data for crop year 1994 and 1995 (USDA, AREI, May, 1996) report some information on these fertilizers and soil amendments. Table 2-5 shows the number of field crop acres receiving nutrients and application rates for sulfur and lime for 1994 and 1995. Almost 60 percent of the potato acreage receives sulfur and micronutrient fertilizers, and this is a much greater percentage than any of the other field crops. Application rate for sulfur on potatoes is also much higher than other field crops (82 lbs/acre for potatoes compared to 11-13 lbs/acre for other field crops). Six percent of potato acreage receives lime, and while this is higher than other crops, it is only slightly higher. Fourteen percent of the corn acreage in 1995 received manure treatments. All other crops had fewer acres treated with manure.

**Table 2-4. Fertilizer Use on Field Crops in 1996, Totals for All States[a]**

| Crop | Acres Planted (thousands of acres) | Total Applied (million lbs/year) (Percent of Acres Treated) | | | Application Rate Per Crop Year (lbs/acre) Average and Range[b] | | |
|---|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ |
| **Corn** | 70,250 | 9,089.0 (98%) | 3,416.7 (85%) | 4,076.1 (73%) | 133 79-170 | 57 34-87 | 79 22-116 |
| **Upland Cotton** | 11,915 | 917.7 (77%) | 316.0 (55%) | 373.1 (43%) | 100 74-175 | 48 38-83 | 73 21-106 |
| **Fall Potatoes** | 797 | 154.0 (99%) | 134.4 (97%) | 98.9 (90%) | 195 84-285 | 173 78-198 | 139 105-204 |
| **Soybeans** | 50,050 | 184.3 (15%) | 605.4 (25%) | 1,151.5 (27%) | 24 12-40 | 49 42-56 | 85 17-102 |
| **Flue-cured Tobacco** | 415 | 36.4 (99%) | 38.0 (99%) | 83.6 (99%) | 88 80-108 | 93 67-116 | 203 172-284 |
| **Winter Wheat** | 28,520 | 1,494.8 (86%) | 438.2 (51%) | 53.0 (6%) | 61 41-115 | 30 20-53 | 29 17-40 |
| **Durum Wheat** | 3,000 | 168.6 (93%) | 50.9 (73%) | 4.9 (8%) | 60 na[c] | 23 na | 21 na |
| **Other Spring Wheat** | 16,350 | 983.4 (89%) | 399.1 (79%) | 83.4 (24%) | 67 50-91 | 31 23-37 | 21 9-28 |

a) Source: USDA, ERS, NASS, 1997
b) Averages are state weighted averages. Ranges are the minimum and maximum reported for all states reporting
c) Only one state reported data for this crop, no range can be calculated

Appendix B (Table B-1) presents corn, cotton, potato, soybean, tobacco, and wheat data for primary plant nutrient use (N, $P_2O_5$ and $K_2O$), fertilizer (total N, $P_2O_5$ and $K_2O$) and fertilizer application rates from the most recent USDA survey. The Agricultural Resources Management Survey was conducted in the fall of 1996 (USDA, NASS, ERS, September, 1997). In 1996, the survey covered the major field crop producing states with data from 63 percent (potatoes) to 88 percent (corn) of all U.S. acreage for these field crops. Corn is the field crop with the most acres planted (70 million) and the most nitrogen (9 billion pounds), phosphate (3 billion pounds) and potash (4 billion pounds) fertilizers consumed. Ninety-nine percent of the tobacco crop (0.4 million acres) and greater than ninety percent of the potato crop (0.8 million acres) is fertilized with N, $P_2O_5$ and $K_2O$ fertilizers. Less than 30% of the soybean crop (50 million acres) receives application of these primary nutrients.

### 2.3.2 Fruits and Vegetables

In addition to field crops, the USDA, ERS, NASS collects information on fertilizer usage on fruit and vegetable crops (USDA, ERS, NASS, 1997b and USDA, ERS, NASS, 1996). Appendix B, Tables B-2 and B-3 present information on acres planted, total N, P, and K applied and the application rates per crop year for fruits (1995) and vegetables (1994) in selected states.

**Table 2-5. Percent of Acres Receiving Various Nutrients and Application Rates, Selected Field Crops in Major Producing States[a]**

| | Percent of Acres Receiving Nutrients | | | | Application Rates | |
|---|---|---|---|---|---|---|
| Year | Manure | Sulfur | Lime | Micro-nutrients | Sulfur (lbs/acre) | Lime (tons/acre) |
| Corn for Grain (10 States, 55,850,000 acres)[b] | | | | | | |
| 1994 | 16 | 10 | 5 | 11 | 12 | 1.7 |
| 1995 | 14 | NA[c] | NA | NA | NA[c] | NA |
| Cotton (6 States, 11, 650,000 acres) | | | | | | |
| 1994 | 3 | 20 | 4 | 20 | 13 | 1.1 |
| 1995 | 3 | NA | NA | NA | NA | NA |
| Fall Potatoes (11 States, 1,147,000 acres) | | | | | | |
| 1994 | 2 | 58 | 6 | 59 | 82 | 0.9 |
| 1995 | 2 | NA | NA | NA | NA | NA |
| Soybeans, Northern (7 States, 41,700,000 acres) | | | | | | |
| 1994 | 8 | 2 | 4 | 3 | 13 | 1.8 |
| 1995 | 5 | NA | NA | NA | NA | NA |
| Soybeans, Southern (7 States, 10,140,000 acres) | | | | | | |
| 1994 (AR only) | 2 | 1 | 4 | 2 | NA | 1.3 |
| 1995 | 2 | NA | NA | NA | NA | NA |
| All Wheat (15 States, 52,965,000 acres) | | | | | | |
| 1994 | 3 | 10 | 1 | 2 | 11 | 1.7 |
| 1995 | 3 | NA | NA | NA | NA | NA |

a) Source: USDA, ERS Cropping Practices Survey Data. Application rates not available for manure and micronutrients. Information on secondary and micronutrients was not collected in the 1996 survey.
b) Acreage reported is for 1995, Source: USDA, AREI Report Number 2, May, 1996.
c) NA = Not Available.

It should be noted that the application rates presented in these tables are per crop year and may represent multiple applications at lower rates.

There is considerable information in the fruit and vegetable tables in Appendix B. These data are summarized in Tables 2-6 and 2-7. These tables show the acres planted, the total pounds of N, $P_2O_5$ and $K_2O$ fertilizers applied and the application rates per crop year for vegetable and fruit crops. When more than one state was included in the USDA surveys for a specific crop, the total acreage and pounds of fertilizer applied are presented. Average and ranges of fertilizer application rates are shown for the producing states. In some cases only a single producing state was included in the survey, and the values shown in the table are for only that state.

### Table 2-6. Fertilizer Use on Vegetable Crops for Crop Year 1994[a]

| | | | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) Average and Range[b] | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State or Total[c]** | **Acres Planted** | **N** | **$P_2O_5$** | **$K_2O$** | **N** | **$P_2O_5$** | **$K_2O$** |
| **Asparagus** | Total | 80,650 | 7,226 | 1,191 | 3,504 | 100<br>64-136 | 57<br>44-101 | 110<br>50-145 |
| **Beans, Lima (fresh)** | GA | 6,500 | 654 | 364 | 565 | 101 | 56 | 87 |
| **Beans, Lima (processing)** | Total[d] | 33,500 | 1,704 | 959 | 834 | 68 | 61 | 71 |
| **Beans, Snap (fresh)** | Total | 71,300 | 5,471 | 4,954 | 6,498 | 85<br>39-101 | 88<br>47-104 | 115<br>46-132 |
| **Beans, Snap (processing)** | Total | 173,400 | 10,695 | 10,192 | 10,354 | 64<br>35-154 | 64<br>40-128 | 68<br>51-101 |
| **Broccoli** | Total | 110,900 | 21,772 | 9,087 | 4,345 | 206<br>92-247 | 109<br>88-159 | 62<br>8-131 |
| **Cabbage (fresh)** | Total | 69,900 | 11,658 | 6,910 | 9,724 | 167<br>117-258 | 106<br>86-149 | 163<br>18-272 |
| **Cabbage (processing)** | Total | 5,600 | 733 | 525 | 1,145 | 126<br>106-146 | 94<br>93-96 | 198<br>173-224 |
| **Carrots** | Total | 100,700 | 18,347 | 14,954 | 8,983 | 182<br>24-234 | 166<br>31-200 | 110<br>17-340 |
| **Cauliflower** | Total | 53,850 | 11,474 | 5,239 | 2,382 | 230<br>101-315 | 121<br>85-236 | 69<br>25-159 |
| **Celery** | Total | 35,900 | 9,119 | 7,037 | 9,055 | 240<br>134-317 | 195<br>126-228 | 292<br>207-417 |
| **Corn, Sweet (fresh)** | Total | 163,900 | 22,557 | 11,899 | 20,528 | 125<br>95-274 | 81<br>40-129 | 137<br>66-216 |
| **Corn, Sweet (processing)** | Total | 503,400 | 69,084 | 28,476 | 35,912 | 135<br>86-227 | 63<br>47-134 | 85<br>77-98 |
| **Cucumbers (fresh)** | Total | 51,400 | 6,025 | 3,950 | 5,985 | 115<br>81-139 | 89<br>47-137 | 115<br>28-156 |
| **Cucumbers (processing)** | Total | 82,600 | 7,866 | 4,809 | 7,472 | 94<br>61-155 | 60<br>40-147 | 100<br>55-123 |
| **Eggplant** | Total | 3,500 | 442 | 346 | 456 | 133<br>121-153 | 130<br>124-137 | 140<br>120-168 |
| **Lettuce, Head** | Total | 191,000 | 45,953 | 27,196 | 5,898 | 262<br>93-357 | 190<br>84-252 | 77<br>73-124 |
| **Lettuce, Other** | Total | 60,120 | 9,459 | 5,706 | 2,325 | 194<br>75-335 | 134<br>34-237 | 71<br>71-75 |
| **Cantaloupe** | Total | 97,700 | 9,781 | 5,870 | 2,341 | 104<br>80-170 | 93<br>79-103 | 41<br>9-124 |

## Table 2-6. (Continued)

| | | | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) Average and Range[b] | | |
|---|---|---|---|---|---|---|---|---|
| **Honeydew Melon** | Total | 25,700 | 2,184 | 2,101 | 444 | 83<br>59-206 | 96<br>68-192 | 58<br>41-119 |
| **Watermelon** | Total | 166,000 | 19,347 | 13,676 | 15,806 | 120<br>61-414 | 94<br>51-163 | 119<br>46-182 |
| **Onions, Dry** | Total | 127,800 | 24,798 | 16,721 | 11,479 | 186<br>107-269 | 137<br>73-217 | 139<br>16-266 |
| **Peas, Green (processing)** | Total | 280,800 | 6,920 | 10,225 | 13,555 | 30<br>24-42 | 55<br>40-108 | 73<br>40-110 |
| **Peppers, Bell** | Total | 61,000 | 14,440 | 9,098 | 13,961 | 239<br>95-320 | 189<br>69-405 | 263<br>50-393 |
| **Spinach (fresh)** | Total | 10,700 | 1,344 | 801 | 558 | 149<br>116-159 | 97<br>90-114 | 79<br>24-126 |
| **Spinach (processing)** | TX | 8,600 | 882 | 834 | 127 | 103 | 97 | 30 |
| **Strawberries** | Total | 45,800 | 6,548 | 3,891 | 95 | 153<br>43-199 | 95<br>49-144 | 116<br>30-156 |
| **Tomatoes (fresh)** | Total | 103,900 | 24,584 | 14,632 | 31,030 | 264<br>83-311 | 174<br>64-201 | 408<br>65-534 |
| **Tomatoes (processing)** | Total | 322,600 | 51,561 | 30,905 | 7,941 | 163<br>91-164 | 103<br>103-110 | 49<br>40-289 |

a) Source: USDA, NASS, ERS, 1997, See Appendix B for detailed tables of fertilizer use for vegetable-producing states. Note that no fertilizer data were collected in 1996. The fertilizer data are from the 1994 crop year.

b) Average application rates and ranges are provided if more than one producing state was included in the survey.

c) If more than one state was included in the survey, vegetable totals for all states are presented. If only one state producing the vegetable was included in the survey the state is shown in this column.

d) Data not provided for individual states.

## Table 2-7. Fertilizer Use on Fruit Crops for Crop Year 1995[a]

| | | | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) Average and Range[b] | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State or Total[c]** | **Acres Planted** | **N** | **$P_2O_5$** | **$K_2O$** | **N** | **$P_2O_5$** | **$K_2O$** |
| **Oranges** | Total | 753,800 | 122,017 | 15,576 | 101,430 | 164<br>119-179 | 43<br>42-46 | 177<br>61-182 |
| **Grapefruit** | Total | 145,700 | 18,123 | 5,822 | 18,502 | 128<br>102-132 | 56<br>54-81 | 146<br>55-147 |
| **Lemons** | CA | 45,700 | 5,492 | 202 | 314 | 128 | 41 | 26 |
| **Limes** | FL | 1,900 | 262 | 71 | 281 | 149 | 61 | 160 |
| **Tangelos** | FL | 12,400 | 2,095 | 551 | 2,106 | 170 | 65 | 172 |
| **Tangerines** | Total | 28,600 | 4,492 | 584 | 3,951 | 159<br>88-191 | 34<br>33-38 | 185<br>44-197 |
| **Temples** | FL | 6,800 | 1,067 | 132 | 1,110 | 157 | 40 | 172 |
| **Apples** | Total | 340,300 | 16,329 | 4,314 | 8,146 | 62<br>35-75 | 34<br>28-60 | 54<br>24-75 |
| **Apricots** | CA | 19,800 | 1,213 | 604 | 574 | 92 | 101 | 96 |
| **Avocados** | Total | 73,000 | 8,707 | 2,125 | 2,731 | 124<br>120-171 | 71<br>68-71 | 74<br>55-185 |
| **Blueberries** | Total | 29,750 | 2,004 | 790 | 1,314 | 72<br>54-138 | 42<br>29-69 | 55<br>43-66 |
| **Blackberries** | OR | 4,900 | 409 | 361 | 353 | 86 | 78 | 76 |
| **Raspberries** | Total | 11,100 | 941 | 1,141 | 1,111 | 87<br>82-91 | 106<br>89-121 | 103<br>80-123 |
| **Cherries, Sweet** | Total | 45,000 | 3,116 | 531 | 990 | 82<br>73-97 | 35<br>31-42 | 61<br>34-85 |
| **Cherries, Tart** | Total | 37,100 | 2,362 | 343 | 1,368 | 74<br>26-84 | 40<br>17-55 | 74<br>23-90 |
| **Dates** | CA | 5,500 | 409 | 113 | NA[d] | 99 | 92 | NA |
| **Figs** | CA | 15,000 | 783 | 137 | 225 | 81 | 46 | 55 |
| **Grapes** | Total | 740,600 | 41,684 | 11,570 | 32,165 | 67<br>27-117 | 55<br>32-89 | 107<br>43-151 |
| **Kiwifruit** | CA | 6,600 | 427 | 41 | 128 | 77 | 57 | 102 |
| **Nectarines** | CA | 32,400 | 3,398 | 892 | 1,550 | 114 | 54 | 92 |
| **Olives** | CA | 33,700 | 1,884 | 83 | 124 | 72 | 44 | 51 |
| **Peaches** | Total | 131,800 | 9,797 | 2,013 | 5,969 | 84<br>29-109 | 38<br>27-50 | 76<br>31-124 |

a) Source: USDA, NASS, ERS, 1996, See Appendix B for detailed tables of fertilizer use for fruit-producing states.

b) Average application rates and ranges are provided if more than one producing state was included in the survey

c) If more than one state was included in the survey, fruit totals for all states are presented. If only one state producing the fruit was included in the survey the state is shown in this column.

d) NA = insufficient reports to publish data for usage

Fruit and vegetable crops with the highest average application rates (lbs/acre) per crop year are fresh tomatoes (N: 264 lbs/acre and $K_2O$: 408 lbs/acre) and celery ($P_2O_5$: 195 lbs/acre). Most acreage is planted with processing sweet corn, tomatoes and green peas. State-specific data are presented in Appendix B. Crops with the highest application rates for nitrogen fertilizers are watermelon, head lettuce and other lettuce in Arizona. Crops with the highest application rates for phosphate fertilizers are processing cucumbers in North Carolina, bell peppers in California and head lettuce in Arizona. Crops with the highest application rate of potash fertilizers are fresh tomatoes, celery and bell peppers in Florida.

## 2.4. NON-AGRICULTURAL FERTILIZER USE

In addition to the fertilizer consumption by state and fertilizer type, the AAPFCO database (AAPFCO, 1997a) contains estimates of the farm and non-farm consumption data. Table 2-8 summarizes these data for the states, and Appendix C contains the farm and non-farm consumption (tons) for each of the individual fertilizer types. Several states have no recorded non-farm consumption, therefore no non-farm percentages were reported (i.e. the farm use was coded as 1 and non-farm use was coded as 2, and there were no 2s). Farm and non-farm use data were not reported for the states of Arkansas, Iowa, Kentucky, Ohio and Texas (i.e., the field for the variable “use” was blank). Non-farm uses include application around residences, golf courses, other recreational fields, cemeteries and public property.

Over 2,650,000 tons of fertilizer was used on non-agricultural land according to those states reporting data to the AAPFCO. This represents approximately 6% of the total fertilizer use defined as farm and non-farm. The states with the highest non-farm consumption of fertilizers are Florida (393,012 tons) and California (320,367 tons). The states with greater than 30% non-farm fertilizer use are New Jersey (124,661 tons), Nevada (12,408 tons) and Vermont (11,904 tons).

The types of fertilizers used on farm and non-farm land differ. Table 2-9 shows the farm and non-farm consumption of various fertilizer types for the states with the highest consumption in terms of non-farm percent or total tons, as described in the previous paragraph. Detailed information for all states is provided in Appendix C. Multiple nutrient, and organic fertilizers are used in higher percentages on non-farm land than other fertilizers, particularly the single nutrient N, $P_2O_5$ and $K_2O$ fertilizers.

## 2.5 U.S. FERTILIZER INDUSTRY PROFILE

Information in this section has been abstracted from an EPA report (The U.S. Fertilizer Industry: A Profile, U.S. EPA, Economics, Exposure and Technology Division, OPPT, November, 1997). Details of the production process, industry definition, domestic production, imports and exports, firms in the fertilizer industry and market structure may be found in that report.

Nitrogen fertilizers are derived from synthetic ammonia that is produced from natural gas. Approximately one-third of nitrogen fertilizer is applied as anhydrous ammonia (soil injection).

**Table 2-8. Comparison of Fertilizer Consumption by Farm and Non-Farm Use in 1996[a]**

| State | Farm (tons) | Non-farm (tons) | % Non-farm |
|---|---|---|---|
| NJ | 206,895 | 124,661 | 37.60 |
| VT | 24,252 | 11,904 | 32.92 |
| NV | 28,130 | 12,408 | 30.61 |
| MD | 330,382 | 109,242 | 24.85 |
| FL | 1,730,243 | 393,012 | 18.51 |
| WV | 39,117 | 8,885 | 18.51 |
| NY | 342,631 | 73,735 | 17.71 |
| UT | 97,331 | 19,868 | 16.95 |
| VA | 745,966 | 129,208 | 14.76 |
| PA | 487,229 | 82,103 | 14.42 |
| WA | 1,061,442 | 143,746 | 11.93 |
| MI | 1,140,332 | 124,526 | 9.85 |
| ME | 140,869 | 13,526 | 8.76 |
| SC | 605,744 | 43,284 | 6.67 |
| TN | 837,492 | 54,736 | 6.13 |
| CA | 5,209,585 | 320,367 | 5.79 |
| MS | 827,853 | 47,792 | 5.46 |
| DE | 121,175 | 5,271 | 4.17 |
| OK | 774,463 | 29,165 | 3.63 |
| LA | 857,526 | 27,563 | 3.11 |
| WI | 1,217,874 | 38,609 | 3.07 |
| IN | 1,935,735 | 57,049 | 2.86 |
| AZ | 352,987 | 10,342 | 2.85 |
| MO | 1,658,295 | 43,428 | 2.55 |
| IL | 3,886,719 | 77,319 | 1.95 |
| WY | 252,150 | 3,942 | 1.54 |
| NC[b] | 1,816,998 | 28,386 | 1.54 |
| OR | 791,874 | 9,995 | 1.25 |
| NM | 154,604 | 1,024 | 0.66 |
| CO | 362,185 | 2,106 | 0.58 |
| MA | 104,137 | 538 | 0.51 |
| PR | 73,115 | 144 | 0.20 |
| NH | 25,286 | 25 | 0.10 |
| NB | 2,272,742 | 428 | 0.02 |
| AL | 649,449 | 71 | 0.01 |
| KS | 1,674,326 | 11 | 0.00 |
| MN | 2,138,683 | NA[c] | NA |
| ND | 1,109,024 | NA | NA |
| SD | 536,982 | NA | NA |
| RI | 17,718 | NA | NA |

**Table 2-8. (Continued)**

| State | Farm (tons) | Non-farm (tons) | % Non-farm |
|---|---|---|---|
| GA | 1,741,097 | NA | NA |
| ID | 881,219 | NA | NA |
| MT | 551,412 | NA | NA |
| AK | 8,447 | NA | NA |
| HI | 118,269 | NA | NA |
| CT | 42,232 | NA | NA |
| **TOTAL**[d] | 39,982,216 | 2,048,419 | NA |

a) Source: AAPFCO Database, 1997
b) NC also had other use categories; these have been omitted from the table
c) Not available
d) Totals by use may not be accurate since some states did not report data by use

**Table 2-9. Consumption (tons) of Specific Fertilizer Types on Farm and Non-Farm Land for Selected States**[a]

| Fertilizer Type | Use | FL | CA | NJ | VT | NV |
|---|---|---|---|---|---|---|
| Multiple Nutrient | farm | 1,241,508 | 1,162,687 | 155,081 | 15,787 | 6,747 |
| | non-farm | 321,437 | 316,847 | 115,523 | 8,399 | 6,031 |
| | % non-farm | 20.6 | 21.4 | 42.7 | 34.7 | 47.2 |
| N | farm | 168,105 | 1,706,091 | 40,361 | 5,228 | 13,982 |
| | non-farm | 27,661 | 0 | 3,793 | 3,015 | 5,687 |
| | % non-farm | 14.1 | 0.0 | 8.6 | 36.6 | 28.9 |
| $P_2O_5$ | farm | 28,455 | 223,074 | 3,367 | 1,976 | 5,238 |
| | non-farm | 13,647 | 0 | 1,345 | 11 | 1,135 |
| | % non-farm | 32.4 | 0.0 | 28.5 | 0.6 | 17.8 |
| $K_2O$ | farm | 37,349 | 130,149 | 5,385 | 3,079 | 535 |
| | non-farm | 3,378 | 0 | 1,038 | 17 | 46 |
| | % non-farm | 8.3 | 0.0 | 16.2 | 0.5 | 7.9 |
| Organic | farm | 4,487 | 78,781 | 31 | 10 | 2 |
| | non-farm | 11,208 | 0 | 16,160 | 73 | 226 |
| | % non-farm | 71.4 | 0.0 | 99.8 | 88.0 | 99.1 |
| Secondary and micronutrient | farm | 74,735 | 1,593,276 | 5,570 | 54 | 6,423 |
| | non-farm | 16,573 | 3,520 | 2,811 | 413 | 488 |
| | % non-farm | 18.2 | 0.2 | 33.5 | 88.4 | 7.1 |
| Liming | farm | 195,305 | 621,915 | 99 | 0 | 0 |
| | non-farm | 21,054 | 0 | 286 | 29 | 0 |
| | % non-farm | 9.7 | 0.0 | 74.3 | 100.0 | no uses |

**Table 2-8. (Continued)**

a) Source: AAPFCO database, see text for information on how states were selected. Appendix C contains data for all states

Approximately two-thirds of nitrogen fertilizers are ammonium salts and other nitrogen-containing chemicals (see Table 2-1). Phosphate fertilizers are made by treating phosphate rock with sulfuric acid to produce phosphoric acid. Approximately two-thirds of applied phosphorus is in the form of mono- and diammonium phosphate. Phosphate rock deposits are found primarily in Florida, North Carolina and Idaho, and the U.S. is a net exporter of phosphatic fertilizer. Potash ($K_2O$) is derived from marine deposits and brines. Most potash fertilizer (approximately 95%) is in the form of potassium chloride. Potassium sulfate and potassium nitrate are also used on certain crops. The U.S. imports most of its potash from Canada.

The U.S. Census of Manufactures classifies fertilizer industries in the following Standard Industrial Classification Codes (SIC):

2873 Nitrogenous fertilizer materials, this SIC includes
- Establishments that only produce nitrogen fertilizer materials
- Establishments that both manufacture nutrients and prepare fertilizer mixtures

2874 Phosphatic fertilizer materials, this SIC includes
- Establishments that only produce phosphate fertilizer materials
- Establishments that both manufacture nutrients and prepare fertilizer mixtures

2875 Fertilizer mixing only, this SIC includes
- Establishments that only mix raw materials

In addition, producers of other fertilizer materials, such as potassium chloride, will be found in SIC 2819 - Industrial Inorganic Chemicals, not elsewhere classified. Because many fertilizer producers (particularly micronutrient fertilizer producers) are included with the production of inorganic chemicals for all purposes, it is difficult to specifically define industries producing fertilizers. The real value of shipments in 1995 (in 1992 dollars) for SICs 2873, 2874 and 2874 are $3,435.3 million, $3,882.9 million and $2,336.8 million, respectively. Total employment for these three SICs were 7,300, 8,600, and 8,400 in 1995.

The total number of companies in the three fertilizer SICs are shown in Table 2-10. There are 10 companies in SIC 2873 with sales over $1 billion and 28 companies with sales <$10 million. Two companies in SIC 2874 have sales over $1 billion and 12 companies have sales <$10 million. Only one company in SIC 2875 has sales over $1 billion, but 78 companies have sales <$10 million. Therefore, there are few large firms in these SICs. These companies are also small in terms of number of employees. Figures are provided in the EPA report. The report indicates that there are 77 of 114 companies in SIC 2873 employing fewer than 1000 persons. There are 36 companies in SIC 2874 and 148 companies in SIC 2875 considered small businesses based on the standards of the Small Business Administration (those employing fewer than 500 persons).

Manufacturers, formulators, distributors/dealers and brokers of the micronutrients boron, copper, iron, manganese, molybdenum and zinc generally deal with one or more of these chemicals. The EPA report (Table 3-2) lists 74 companies that fit the category of micronutrient manufacturers, formulator etc.

**Table 2-10. Number of Companies in Fertilizer Production and Mixing**

| Industry | Number of Companies Reported by the Census of Manufactures 1992 | Number of Companies Reported by Information Access Company 1997 |
|---|---|---|
| **SIC 2873 - Nitrogenous Fertilizers** | 103 | 114 |
| **SIC 2874 - Phosphatic Fertilizers** | 54 | 50 |
| **SIC 2875 - Fertilizers, Mixing only** | 313 | 165 |

Cement kiln dust may be used as a liming material because of the high calcium oxide content. The U.S. EPA report to Congress for Cement Kiln Dust, Volume II: Methods and Findings, December, 1993 reports that 122,000 tons of cement kiln dust are used as a soil amendment, and 57,849 tons are used as liming materials.

Most nitrogenous fertilizer is produced in the south central U.S., and most phosphorus fertilizer is produced from phosphate rock deposits in the southeastern U.S. As described previously, most potash comes from Canada. Plants that mix fertilizer are dispersed throughout the country. Most of these plants are small, serving local (within approximately 30 miles of the plant) and regional markets. These plants bulk blend products custom made for the local markets based on crops and soil conditions. Micronutrients, pesticides and even seeds are sometimes added to custom blends. Many of the firms have soil testing laboratories to assist the farmers in determining the optimum fertilizer blend.

In the last two decades, fertilizer production has increased fifty percent. Greater than 10 percent of the volume is exported. Most of the companies, particularly fertilizer mixing companies, are small.

## 2.6 RECYCLED MATERIALS IN FERTILIZER MANUFACTURE

A number of industrial wastes and by-product materials are used in the manufacture of inorganic fertilizers. Such recycling practices are most common in the manufacture of micronutrient fertilizers, particularly zinc fertilizers. The following recyclable materials can be used as feedstocks to make zinc micronutrient fertilizers:

- Electric arc furnace dust (dust collected from emission control devices in steel manufacturing), otherwise known as K061 (its RCRA waste code)
- Brass foundry dusts (also from emission control devices)
- Tire ash (typically, ash from burning of tires for energy recovery)
- Galvanizing fines

K061 is regulated as a listed hazardous waste under RCRA, and can contain significant amounts of non-nutritive metals such as lead and cadmium. Brass foundry dusts often exhibit a hazardous characteristic when tested according to the Toxicity Characteristic Leaching Procedure (TCLP), usually because of lead and cadmium. Tire ash is also typically a characteristic hazardous waste due to cadmium concentrations. Galvanizing wastes typically do not exhibit a hazardous waste characteristic. It should be noted that non-waste feedstocks that are also used to make zinc fertilizers, such as refined ores from lead mining, can often have concentrations of non-nutritive metals comparable to those in waste feedstock materials. As presented in Chapter 3 of this report, levels of metal contaminants in zinc fertilizer products vary substantially, and depend largely on how the raw materials are processed, rather than on which type of feedstock is used.

Another type of hazardous waste–demetallized photographic fluids–is used to make multinutrient fertilizer products (http://www.itronics.com)

Further discussion of how RCRA regulates recycling of hazardous wastes and hazardous secondary materials to manufacture fertilizers is presented in Chapter 4 of this report.

Examples of industrial secondary materials that are not currently regulated by RCRA as hazardous wastes and that can be recycled to manufacture fertilizers include:

- Cement kiln dust (CKD), which is used primarily as a lime substitute to adjust soil pH
- Mining waste; at least one iron fertilizer product is made from mine tailings (www.ironite.com)
- Gypsum (a source of calcium, sulfur and boron) from coal-burning electric power generation facilities
- Ash from wood-burning power generation facilities
- Pulp and paper sludges, which are generally used as soil amendments

## 3.0 COMPOSITION OF FERTILIZERS AND SOILS

Phosphate fertilizers are known to contain varying levels of heavy metals such as cadmium, lead, nickel and chromium (Mortvedt, 1987; Charter et al., 1993). These metals originate in the phosphate rock (Mortvedt and Giordano, 1977; Kpomblekou-A and Tabatabai, 1994); much of the cadmium, and other metals, remains with the phosphate during processing (Wakefield, 1980). Phosphate fertilizers, though, are by no means the only fertilizer product with measurable levels of heavy metals. Studies have documented the presence of heavy metals in zinc micronutrient fertilizers (Mortvedt, 1985), in biosolids (Matthews, 1996) applied to agricultural lands, and organic fertilizers such as manure and compost (Raven and Loeppert, 1997; Arora et al., 1975). Because these heavy metals may enter the human food chain either directly (via uptake into the grain, fruit or vegetable) or indirectly (via ingestion by foraging animals), studies have been conducted recently to compare the soil background levels of these metals with levels in fertilizer materials (Mermut et al., 1996) and to assess plant uptake and distribution of these metals (Mortvedt, et al., 1981; Mortvedt and Giordano, 1977; Chaney, 1983; Gavi et al, 1997).

This section addresses the following questions:

- What are the concentrations of heavy metals in U.S. soil and soil in other parts of the world?
- What is the macronutrient composition of different fertilizers?
- What are the heavy metal concentrations in fertilizers and liming materials?
- What other potentially hazardous constituents may be present in fertilizers and liming materials?

## 3.1 HEAVY METALS IN SOILS

Because heavy metals are naturally present in soil, it is instructive to begin the assessment of fertilizer metals addition to soil with an evaluation of the background levels of these metals in soil. Over the last twenty years, a number of studies have been carried out to assess the levels of metals in soils. Because those studies were carried out for scientific reasons other than assessment of effects of heavy metals addition from fertilizers, the site selection criteria for samples and statistical treatment of the data are not generally comparable across studies. However, these studies, *in toto*, may provide some insight into potentially "typical" values for metals in soils.

Table 3-1 provides an overview of sixteen different studies of metals in soils in which samples were collected from reasonably large (several hundred square miles) geographic areas so that minor site-to-site variations may be negligible. As listed in Table 3-1, the studies in which the number of samples substantially exceeds the number of sites indicates that one or more subsurface soil samples (indicated as "sub") were collected in addition to the surface soil sample (indicated as "surf"). The abbreviated results of several studies (No. 3 and 16) were listed in another study (Holmgren et al., 1993) for comparison purposes, and for those, complete site/sampling descriptions are not available. The notation "nd" indicates that information such as the number of sites has not been determined. Sampling locations included agricultural lands

## Table 3-1. Compilation of Studies for Soil Metal Concentrations

| Site Descriptions for Soil Metal Concentration Studies | | | | | |
|---|---|---|---|---|---|
| **Region** | **First Author (Year)** | **Samples** | **Sites** | **Soil type** | **Depth** |
| 1. USA | Holmgren (1993) | 3045 | 3045 | ag/no ss[a] | surface[b] |
| 2. USA | Shacklette (1984) | 1318 | 1318 | natural[c] | sub-20cm[d] |
| 3. USA | Sposito (1984)[e] | nd[f] | nd | nd | nd |
| 4. Minnesota | Pierce (1982) | 159 | 53 | natural | surf/sub[g] |
| 5. Florida | Ma (1997) | 94 | 40 | natural | surf/sub |
| 6. Ohio | Logan (1983) | 239 | 239 | ag/no ss | surface |
| 7. Ontario | Frank (1976) | 296 | 296 | ag | surface |
| 8. Saskatchewan | Mermut (1996) | 26 | 13 | ag | surf/sub |
| 9. Canada | McKeague (1980) | 173 | 53 | natural | surf/sub |
| 10. England | McGrath (1986) | 2276 | 2776 | no sources[h] | surface |
| 11. Wales | Davies (1985) | 1308 | 654 | all | surf/sub |
| 12. Eastern Europe[h] | Kabata-Pendias (1992)[i] | nd[i] | nd[i] | natural | surface |
| 13. Netherlands | Edelman (1986) | 28 | 28 | natural | surface |
| 14 India | Kuhad (1989) | 36 | 9 | ag | surf/sub |
| 15 China | Chen (1991) | 12,400 | 4095 | no sources[h] | surf/sub |
| 16 World | Ure (1982)[e] | nd | nd | nd | nd |

a) Agricultural land with no sewage sludge application.
b) In this study, primary collection was for surface soils; subsurface soil concentrations were also reported when surface soil Cd was $\geq$ 1.0 ppm.
c) Background soil –no agriculture, industry, or residential contributions.
d) Subsurface soil samples collected at a depth of 20 cm.
e) Study results reviewed in Holmgren, et al. (1993)
f) Not determined from available reference.
g) Surface and subsurface soil samples collected.
h) All lands except those directly impacted by an anthropogenic source.
i) Compilation of data from 47 different studies.

(ag) and agricultural lands to which sewage sludge had not been applied (ag/no ss). True background soil samples (natural) were collected in pristine, undisturbed environments. The English and Chinese study stated that soils were collected in all regions except those directly impacted by an adjacent industrial source (McGrath et al., 1986; Chen et al., 1991).

The generation of geometric means for soil metals concentrations is the preferable statistical treatment of comprehensive studies because of the logarithmic distribution of metal concentrations commonly observed in soils. For those studies where both geometric and arithmetic means were available, both statistics are included in Table 3-2 of average concentrations for cadmium (Cd), lead (Pb), arsenic (As), chromium (Cr), mercury (Hg), nickel (Ni), vanadium (V), copper (Cu) and zinc (Zn). As indicated by "nd" (not determined), various studies did not include measurement of all metals.

In general, for Studies 1 and 2 in the USA (Holmgren et al., 1993; Shacklette and Boerngen,1984), m concentrations for the agricultural lands without sewage sludge addition (Study 1) are comparable to those from the natural lands (Study 2). These values for the USA agricultural lands contrast somewhat with both the Ontario and Saskatchewan agricultural land studies (Studies 7 and 8) (Frank et al., 1976; Mermut et al., 1996)) where soil cadmium, and possibly lead and zinc, were elevated relative to U background levels, possibly due to anthropogenic additions (e.g., fertilizer, urban atmospheric deposition). While anthropogenic input to soil metals levels is suggested by the authors for comparisons of the surface and subsurface soil samples in the Saskachewan study, the climatology of the region (limited rainfall relative to southern USA regions) and the mineralogy of the area may also help to explain differences in soil metal content between the U.S. and Canadian plains. In support of anthropogenic input, cadmium, lead and zinc in low clay content soils (clay soils having higher metals levels naturally) show that these metals are at statistically higher levels in surface soil relative to subsurface soil. Fertilizer addition to these Canadian soils has occurred for 30-40 years.

The ranges of metal concentrations for the surface soils are listed in Table 3-3 for reference only. As anticipated, both extremely high and low values were found in most studies, and in that regard, the range of concentrations in US "background" soils often exceeds that found in the Canadian studies. In the U.S., metals are generally found at higher levels in the West relative to the East and in the North relative to the South. Of note in the study conducted in Poland and western USSR, ranges of soil metals concentrations were given for both background soils and then also for soils from industrial regions, urban gardens, vineyards and fertilized agricultural regions. On the basis of these results, the governments have outlined broad land regions based on soil metals concentrations and then made recommendations on the types of agricultural practices appropriate for these lands.

## 3.2 NITROGEN, PHOSPHATE AND POTASH COMPOSITION OF NPK FERTILIZERS

Due to the diversity of NPK fertilizers, several authors have segregated and analyzed these fertilizers by class. Specific types or classes of NPK that have been analyzed include MAP (monoammonium phosphate), DAP (diammonium phosphate), TSP (triple super phosphate), MP

## Table 3-2. Average Concentrations of Selected Metals in Soils around the World

| Mean Surface Soil Concentrations of Metals in Surface Soils, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **Avg.** | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| 1. USA | geometric | 0.18 | 11 | nd[a] | nd | nd | 17 | nd | 18 | 43 |
| | arithmetic | 0.27 | 12 | nd | nd | nd | 24 | nd | 30 | 57 |
| | median | 0.20 | 11 | nd | nd | nd | 18 | nd | 19 | 53 |
| 2. USA | geometric | nd | 16 | 5.2 | 37 | 0.058 | 13 | 58 | 17 | 48 |
| | arithmetic | nd | 19 | 7.2 | 54 | 0.09 | 19 | 80 | 25 | 60 |
| 3. USA | "typical"[a] | 0.35 | 50 | nd | nd | nd | 30 | nd | 50 | 15 |
| 4. Minnesota | arithmetic | 0.39 | nd | nd | 39 | nd | 18 | nd | 23 | 60 |
| 5. Florida[b] | geometric | 0.21 | 4.1 | 1.1 | 3.9 | 0.0042 | 6.5 | nd | 3.7 | 12 |
| | arithmetic | 0.22 | 5.4 | 2.4 | 5.1 | 0.0067 | 6.7 | nd | 4.7 | 12 |
| 6. Ohio | arithmetic | 0.2 | 19 | nd | 12 | nd | 18 | nd | 19 | 75 |
| 7. Ontario | "mean"[a] | 0.56 | 46 | 12 | 22 | 0.11 | 16 | nd | 25 | 54 |
| 8. Saskatchewan | arithmetic | 0.58 | 16 | 6.6 | 59 | nd | 30 | 90 | 37 | 87 |
| 9. Canada[b] | arithmetic | ≤0.3 | 20 | nd | 43 | 0.059 | 20 | nd | 22 | 74 |
| 10. England | geometric | 0.9 | 48 | nd | nd | nd | 21 | nd | 18 | 85 |
| 11. Wales | geometric | 0.5 | 73 | nd | nd | nd | 16 | nd | 16 | 79 |
| 12. Eastern Europe | nl[c] | 0.4 | 26 | nd | nd | nd | nd | nd | 16 | 45 |
| Poland | nl | 0.4 | 18 | nd | 23 | nd | 10 | nd | 8 | 49 |
| 13. Netherlands | range[d] | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| 14. India | "mean" | 0.8 | 15 | nd | nd | nd | 30 | nd | 57 | 26 |
| 15. China | geometric | 0.07 | 24 | 9.2 | 54 | 0.040 | 23 | 77 | 20 | 67 |
| | arithmetic | 0.10 | 27 | 11 | 61 | 0.065 | 27 | 82 | 23 | 74 |
| 16. World | geometric | 0.62 | 34 | nd | nd | nd | 26 | nd | 60 | 29 |

a) Author designation for type of data presented.
b) Data given as average of surface and subsurface concentrations.
c) Not listed.
d) Data given only as ranges, see Table 3-3.

**Table 3-2. (Continued)**

## Table 3-3. Concentration Ranges for Selected Metals in Soils around the World

| Range of Surface Soil Concentrations of Metals Measured, ppm (ug/g or mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Region** | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| 1. USA | < 0.01-2.0 | < 1-135 | nd[a] | nd | nd | 0.7-269 | nd | < 0.6-495 | < 3-264 |
| 2. USA | nd | < 10-700 | < 0.1-97 | 1-2000 | < 0.01-4.6 | < 5-700 | < 7-500 | < 1-700 | < 5-2900 |
| 3. USA | nl[b] | nl | nl | nl | nl | nl | nl | nl | nl |
| 4. Minnesota[c] | 0.06-0.74 | nd | nd | 14-111 | nd | 7-66 | nd | 16-50 | 28-97 |
| 5. Florida | 0.07-0.39 | 0.42-24 | 0.01-6.1 | 0.43-23 | 0.0005-0.043 | 4.5-9.6 | nd | 0.01-16 | 6.7-18 |
| 6. Ohio | 0.03-2.9 | 9-39 | nd | 4-23 | nd | 9-38 | nd | 11-37 | 47-138 |
| 7. Ontario | 0.10-8.1 | 1.5-888 | 1.1-92 | 10-46 | 0.01-1.14 | 1.3-119 | nd | 2.1-144 | 4.6-162 |
| 8. Saskatchewan | 0.2-0.8 | 9-20 | 2.9-12 | 22-97 | nd | 13-59 | 32-180 | 19-68 | 41-137 |
| 9. Canada[c] | $\leq$0.3 | 5-50 | nd | 10-100 | 0.005-0.1 | 5-50 | nd | 5-50 | 10-200 |
| 10. England | 0.1-114 | 3-16,400 | nl | 0.6-615 | nl | 0.7-240 | nl | 0.5-520 | 5-2125 |
| 11. Wales[d] | 0.1-1.5 | 13-211 | nl | nl | nl | 4-38 | nl | 5-36 | 22-159 |
| 12. Eastern Europe | 0.08-2.7 | 5-85 | nd | 12-1085 | nd | 1-104 | nd | 1-110 | 4-360 |
| industrial[e] | 2-270 | 72-3044 | nd | nd | nd | nd | nd | 24-2015 | 400-5567 |
| urban garden[f] | 0.4-5 | 17-165 | nd | nd | nd | nd | nd | 12-240 | nd |
| vineyard[g] | nd | nd | nd | nd | nd | nd | nd | 50-83 | nd |
| ag/fert[h] | 0.4-107 | nd | nd | nd | nd | nd | nd | 80-1600 | nd |
| 12. Poland | 0.1-6.4 | 5-286 | nd | 4-68 | nd | 1-68 | nd | 1-31 | 3-762 |

## Table 3-3. (Continued)

| Range of Surface Soil Concentrations of Metals Measured, ppm (ug/g or mg/kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Region** | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| 13. Netherlands | nd | nd | 1.4-21 | 11-117 | nd | nd | 4-126 | nd | 6-153 |
| 14. India | 0.5-1.3 | 10-23 | nd | nd | nd | 20-45 | nd | 25-170 | 15-96 |
| Austria[i] | nd | nd | nd | 1.4-38 | nd | nd | nd | nd | 7-220 |
| Belgium[i] | nd | nd | 0.4-25 | 20-200 | nd | nd | 25-300 | nd | 25-150 |
| Sweden[i] | nd | nd | nd | 0.9-57 | nd | nd | nd | nd | 4-310 |
| 15. China | nl | nl | nl | nl | nl | nl | nl | nl | nl |
| 16. World | nl | nl | nl | nl | nl | nl | nl | nl | nl |

a) Metal not determined in the study
b) Not listed – concentration ranges not given.
c) Range given for surface and subsurface soils together
d) 10th to 95th percentile concentrations reported
e) Concentrations in industrial soils of Eastern Europe
f) Concentrations in urban gardens of Eastern Europe
g) Concentrations in vineyards of Eastern Europe
h) Concentrations in fertilized agricultural lands of Eastern Europe
i) Limited comparison data provided in Kuhad et al., 1989

(potash or potassium), single nutrient fertilizers and multiple nutrient fertilizers. A complete listing of the various types of NPK fertilizers and their macronutient content (i.e., N, $P_2O_5$, and $K_2O$) is given in Table 3-4 for reference.

## 3.3 HEAVY METALS IN FERTILIZERS AND LIMING MATERIALS

Macro- and micronutrient fertilizers and liming materials may contribute heavy metals to surface agricultural lands. Some of the raw materials that provide this input include rock phosphates (for NPK and NPKS fertilizers), high zinc-content recycled industrial waste (for zinc micronutrient fertilizers) and municipal sewage sludge (for organic fertilizers). In general, on a mass concentration basis (mg/kg), the NPK fertilizers are by comparison with the zinc micronutrient fertilizers, lower in metals content.

Concentrations of nine selected metals (cadmium, lead, arsenic, chromium, mercury, nickel, vanadium, copper and zinc) in world-wide rock phosphates are listed in Table 3-5. Sources of rock phosphates in the USA include North Carolina (NC), Florida (FL) and Idaho (ID). Specific analyses of rock phosphates from the U.S. are listed at the end of Table 3-5. No analytical results were specifically attributed to analyses of Idaho rock phosphates.

Table 3-6 shows the results for analyses of diverse NPK fertilizers. It is especially instructive to separate the analyses of MAP, DAP and TSP as the concentrations of metals (with possible exception of Ni) appear to increase with this sequence of products. (Again, "nd" in these tables indicates that the analyte was not determined. If analyzed and not detected, the analyte is listed as being less than the method detection limit if available.) Cadmium levels less than 10-50 ppm appear consistently throughout these analyses; however, some fertilizer samples, such as those commercially-available in California, have concentrations greater than 150 ppm. Tests of rock phosphates for heavy metal content have indicated that the quality of the ores has been declining over the last two decades (Charter et al., 1993). The heavy metals content of ore may increase with depth of the mine, so that some older mines may produce materials with increasing cadmium levels.

For comparison, the concentrations of metals in various types of organic fertilizers are listed in Table 3-7. The organic fertilizers include composts, bone meal, manures and municipal sewage sludge (sew sl). The levels of Cd, Pb, Ni, V and Cu in these fertilizers are roughly equivalent to levels found in NPK fertilizers; however, Zn levels are often higher. Variability beyond that indicated here is anticipated in the sewage sludges because of the varying nature of the incoming waste streams.

The concentrations of metals in various secondary nutrient and micronutrient fertilizers, primarily Zn fertilizers, are listed in Table 3-8. As indicated earlier, on a mass concentration basis, these fertilizers have higher Cd, Pb, Ni and Cu levels than those found in NPK fertilizers.

**Table 3-4. Average Nitrogen, Phosphorus (as $P_2O_5$) and Potassium (as $K_2O$) Composition of NPK Fertilizers for 1996 (Percent)[a]**

| Description | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| **MULTIPLE NUTRIENT FERTILIZERS** | | | |
| N-P-K | 14.5 | 11.5 | 13.9 |
| N-P | 16.0 | 27.4 | 0.0 |
| N-K | 17.1 | 0.0 | 19.3 |
| P-K | 0.0 | 16.0 | 29.9 |
| **NITROGEN FERTILIZERS** | | | |
| Ammonium Nitrate | 33.6 | 0.0 | 0.0 |
| Ammonium Nitrate Solution | 20.2 | 0.0 | 0.0 |
| Ammonium Nitrate-limestone Mixtures | 22.0 | 0.0 | 0.0 |
| Ammonium Nitrate-sulfate | 29.9 | 0.0 | 0.0 |
| Ammonium Polysulfide | 20.0 | 0.0 | 0.0 |
| Ammonium Sulfate | 20.9 | 0.0 | 0.0 |
| Ammonium Sulfate Solution | 6.3 | 0.0 | 0.0 |
| Ammonium Sulfate-nitrate | 26.0 | 0.0 | 0.0 |
| Ammonium Sulfate-urea | 33.3 | 0.0 | 0.0 |
| Ammonium Thiosulfate | 12.0 | 0.0 | 0.0 |
| Anhydrous Ammonia | 82.0 | 0.0 | 0.0 |
| Aqua Ammonia | 18.9 | 0.0 | 0.0 |
| Calcium Ammonium Nitrate | 17.0 | 0.0 | 0.0 |
| Calcium Cyanamide | 21.0 | 0.0 | 0.0 |
| Calcium Nitrate | 15.5 | 0.0 | 0.0 |
| Calcium Nitrate-urea | 33.4 | 0.0 | 0.0 |
| Ferrous Ammonium Sulfate | 7.1 | 0.0 | 0.0 |
| Magnesium Nitrate | 7.0 | 0.0 | 0.0 |
| Nitric Acid | 15.0 | 0.0 | 0.0 |
| Nitrogen Solution 28% | 28.1 | 0.0 | 0.0 |
| Nitrogen Solution 30% | 30.0 | 0.0 | 0.0 |

**Table 3-4. (Continued)**

| Description | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| **NITROGEN FERTILIZERS** | | | |
| Nitrogen Solution 32% | 32.0 | 0.0 | 0.0 |
| Nitrogen Solution < 28% | 16.5 | 0.0 | 0.0 |
| Nitrogen Solution > 32% | 36.2 | 0.0 | 0.0 |
| Sodium Nitrate | 16.2 | 0.0 | 0.0 |
| Sulfur Coated Urea | 36.1 | 0.0 | 0.0 |
| Urea | 45.9 | 0.0 | 0.0 |
| Urea Solution | 20.1 | 0.0 | 0.0 |
| Urea-formaldehyde | 36.2 | 0.0 | 0.0 |
| Zinc Ammonium Sulfate Solution | 11.1 | 0.0 | 0.0 |
| Zinc Manganese Ammonium Sulfate | 9.0 | 0.0 | 0.0 |
| **PHOSPHATE FERTILIZERS** | | | |
| Ammonium Metaphosphate | 12.0 | 51.0 | 0.0 |
| Ammonium Phosphate | 11.2 | 46.9 | 0.0 |
| Ammonium Phosphate Nitrate | 27.0 | 14.3 | 0.0 |
| Ammonium Phosphate Sulfate | 16.0 | 20.0 | 0.0 |
| Ammonium Polyphosphate | 15.0 | 60.0 | 0.0 |
| Basic Lime Phosphate | 0.0 | 6.0 | 0.0 |
| Basic Slag | 0.0 | 9.2 | 0.0 |
| Bone Meal, Raw | 4.0 | 16.4 | 0.0 |
| Bone Meal, Steamed | 1.8 | 16.4 | 0.0 |
| Bone, Precipitated | 0.0 | 36.6 | 0.0 |
| Calcium Metaphosphate | 0.0 | 60.0 | 0.0 |
| Colloidal Phosphate (Soft Phosphate) | 0.0 | 2.0 | 0.0 |
| Diammonium Phosphate | 18.0 | 46.0 | 0.0 |
| Limestone, Phosphatic | 0.0 | 13.1 | 0.0 |

**Table 3-4. (Continued)**

| Description | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| **PHOSPHATE FERTILIZERS** | | | |
| Liquid Ammonium Polyphosphate | 10.1 | 33.8 | 0.0 |
| Magnesium Phosphate | 0.0 | 17.8 | 0.0 |
| Monoammonium Phosphate | 10.9 | 51.8 | 0.0 |
| Nitric Phosphate | 14.0 | 10.0 | 0.0 |
| Phosphate Rock | 0.0 | 3.0 | 0.0 |
| Phosphoric Acid | 0.0 | 53.3 | 0.0 |
| Precipitated Phosphate | 0.0 | 34.4 | 0.0 |
| Superphosphate, Enriched | 0.0 | 27.0 | 0.0 |
| Superphosphate, Normal | 0.0 | 20.7 | 0.0 |
| Superphosphate, Triple | 0.0 | 45.7 | 0.0 |
| Superphosphoric Acid | 0.0 | 70.1 | 0.0 |
| **POTASH FERTILIZERS** | | | |
| Lime-potash Mixtures | 0.0 | 0.0 | 9.8 |
| Manure Salts | 0.0 | 0.0 | 21.5 |
| Muriate of Potash 60% (Pot. Chloride) | 0.0 | 0.0 | 60.1 |
| Muriate of Potash 62% | 0.0 | 0.0 | 62.1 |
| Potash Suspensions | 0.0 | 0.0 | 20.0 |
| Potassium Carbonate | 0.0 | 0.0 | 61.3 |
| Potassium Nitrate | 13.6 | 0.0 | 43.3 |
| Potassium Sulfate | 0.0 | 0.0 | 51.3 |
| Potassium-magnesium Sulfate | 0.0 | 0.0 | 22.6 |
| Potassium-metaphosphate | 0.0 | 55.0 | 37.0 |
| Potassium-sodium Nitrate | 14.5 | 0.0 | 14.2 |

**Table 3-4. (Continued)**

| Description | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| **ORGANIC FERTILIZERS** | | | |
| **Blood, Dried** | 11.7 | 0.3 | 0.0 |
| **Castor Pomace** | 5.0 | 1.0 | 1.0 |
| **Cocoa Shell Meal** | 2.0 | 1.0 | 2.0 |
| **Compost** | 2.3 | 1.8 | 1.6 |
| **Cottonseed Meal** | 6.0 | 2.0 | 1.0 |
| **Fish Scrap** | 6.0 | 6.0 | 6.0 |
| **Guano** | 12.0 | 11.0 | 2.0 |
| **Manure** | 1.9 | 1.0 | 1.0 |
| **Peat** | 2.0 | 0.0 | 0.0 |
| **Sewage Sludge, Activated** | 6.0 | 2.0 | 1.2 |
| **Sewage Sludge, Digested** | 10.0 | 2.0 | 0.0 |
| **Sewage Sludge, Heat Dried** | 6.2 | 2.0 | 1.3 |
| **Sewage Sludge, Other** | 6.0 | 2.0 | 0.9 |
| **Soybean Meal** | 6.0 | 1.0 | 2.0 |
| **Tankage, Animal** | 8.0 | 5.0 | 6.0 |
| **Tankage, Process** | 8.6 | 0.2 | 0.0 |

a) Source: AAFPCO Database, 1997

## Table 3-5. Concentrations of Selected Metals in Rock Phosphates

| Concentrations of Metals in Rock Phosphates, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| **1. Kpomblekou-A and Tabatabai (1994)[a]: Africa, Peru, USA (3)[b]** | | | | | | | | | | |
| n = 12[c] | mean | 19 | 18 | nd[d] | 78 | nd | 15 | nd | 15 | 204 |
| | median | 10 | 14 | nd | 46 | nd | 10 | nd | 8 | 124 |
| | range | 5-47 | 7-43 | nd | 18-331 | nd | 1-61 | nd | 6-41 | 54-576 |
| **2. Kongshaug et al. (1992): Africa, Middle East, Russia, USA (1)** | | | | | | | | | | |
| n = 6 | mean | 18 | 11 | 8.5 | 97 | 0.04 | 27 | 116 | nd | nd |
| | median | 11 | 7 | 11 | 109 | 0.05 | 33 | 100 | nd | nd |
| | range | 0.1-60 | 3-35 | 1-15 | 1-225 | 0.01-0.06 | 2-37 | 3-300 | nd | nd |
| **3. Hamamo et al. (1995): USA(1) and others of unnamed origin** | | | | | | | | | | |
| n = 4 | mean | nd | nd | 14 | nd | nd | nd | 41 | nd | nd |
| | median | nd | nd | 17 | nd | nd | nd | 30 | nd | nd |
| | range | nd | nd | 6.5-19 | nd | nd | nd | 17-92 | nd | nd |
| **4. Raven and Loeppert (1997): Africa and USA(1)** | | | | | | | | | | |
| n = 2 | Africa[e] | 1.3 | 29 | 21 | 33 | < 0.4 | 50 | 69 | nd | 79 |
| | USA[e] | 49 | 4.6 | 17 | 140 | < 0.4 | 17 | 23 | 9.6 | 382 |
| **5. Washington Dept of Ecology (1997): unnamed origin** | | | | | | | | | | |
| n = 1 | conc | 36 | < 20 | < 30 | 136 | < 0.005 | 18 | 29 | 11 | 385 |
| **6. Arora, et al., (1975): unnamed origin** | | | | | | | | | | |
| n = 1 | conc | nd | 962 | nd | 184 | nd | nd | nd | 32 | 187 |
| **7. California Department of Food and Agriculture (1997): unnamed origin** | | | | | | | | | | |
| n = 4 | mean | 33 | 7.6 | 7.4 | nd | nd | 125 | nd | 39 | nl |

**Table 3-5. (Continued)**

| Concentrations of Metals in Rock Phosphates, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| | median | 0.5 | 7.5 | 7.5 | nd | nd | (n = 1) | nd | 35 | nd |
| | range | 0.0-130 | 2.5-13 | 1.4-13 | nd | nd | –[f] | nd | 5.5-80 | nd |
| **8. USA Rock Phosphates - Analyses for individual samples** | | | | | | | | | | |
| Study 1[g] | NC | 42 | 9 | 16[h] | 137 | nd | 12 | nd | 8 | 332 |
| Study 1 | North FL | 10 | 9 | 7[h] | 47 | nd | 6 | nd | 5 | 91 |
| Study 1 | FL | 11 | 11 | 7[h] | 45 | nd | 6 | nd | 6 | 108 |
| Study 2 | USA | 11 | 12 | 12 | 109 | 0.05 | 37 | 82 | nd | nd |
| Study 3 | FL | nd | nd | 6.5 | nd | nd | nd | 92 | nd | nd |



a) Reference for the study data
b) Site of origin of the rock phosphates analyzed/reported (number of identified USA samples)
c) Total number of samples analyzed/reported
d) nd = not determined
e) Too few samples to determine mean and range; sample results listed separately by site of origin of the rock phosphate
f) Nickel analyzed in only one sample; range not available
g) Data from study number indicated earlier in Table 3-5
h) Analyses for As reported separately in Charter et al., 1995

## Table 3-6. Concentrations of Selected Metals in NPK Fertilizers

| Concentrations of Metals in NPK Fertilizers, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| **1. Charter, et al. (1993): commercially-available in Iowa** | | | | | | | | | | |
| MAP[a] | mean | 7.1 | 9.1 | nd[b] | 57 | nd | 17 | nd | < 1.5 | 75 |
| n = 23 | median | 7.0 | < 9 | nd | 56 | nd | 17 | nd | < 1.5 | 73 |
| | range | 6.4-8.3 | < 9-12 | nd | 51-73 | nd | 15-20 | nd | < 1.5-1.6 | 60-91 |
| DAP[c] | mean | 10 | 9.8 | nd | 71 | nd | 19 | nd | 1.6 | 170 |
| n = 25 | median | 6.7 | < 9 | nd | 48 | nd | 14 | nd | < 1.5 | 86 |
| | range | 5.4-94 | < 9-12 | nd | 45-616 | nd | 13-127 | nd | < 1.5-3.2 | 71-2193 |
| TSP[d] | mean | 15 | 11 | nd | 133 | nd | 17 | nd | 3.5 | 159 |
| n = 24 | median | 8.1 | 12 | nd | 74 | nd | 16 | nd | 2.9 | 97 |
| | range | 6.8-47 | < 9-16 | nd | 63-548 | nd | 14-40 | nd | 1.6-13 | 75-696 |
| MP[e] | mean | 1.6 | 9.1 | nd | nd | nd | 2.9 | nd | 1.6 | 1.5 |
| n = 25 | median | 1.6 | < 9 | nd | nd | nd | 2.8 | nd | < 1.5 | 1.3 |
| | range | 1.3-1.9 | < 9-12 | nd | nd | nd | < 2.8-4.4 | nd | < 1.5-2.6 | 1.1-2.6 |
| **2. Washington, Dept of Ecology (1997): diverse formulations** | | | | | | | | | | |
| n = 21 | mean | 14 | 2.7 | < 3.8 | 141 | 0.03 | 20 | 81 | 7.7 | 177 |
| | median | 0.15 | 1.0 | < 1.5 | 2.2 | < 0.003 | 0.5 | 0.5 | 0.5 | 17 |
| | range | < 0.1-145 | < 0.4-21 | < 0.6- < 16 | < 0.1-896 | < 0.005-0.403 | < 0.2-195 | < 0.2-721 | < 0.1-81 | < 0.4-1480 |
| **3. Arora, et al. (1975): diverse formulations** | | | | | | | | | | |
| single[f] | mean | nd | 200 | nd | 74 | nd | nd | nd | 11 | 96 |
| n = 7 | median | nd | 118 | nd | 8.5 | nd | nd | nd | 2.8 | 11 |
| | range | nd | 42-488 | nd | 3-393 | nd | nd | nd | 0.6-49 | 4-418 |
| multi[g] | mean | nd | 283 | nd | 80 | nd | nd | nd | 12 | 88 |
| n = 13 | median | nd | 285 | nd | 81 | nd | nd | nd | 13 | 89 |
| | range | nd | 150-443 | nd | 50-116 | nd | nd | nd | 5.4-18 | 38-164 |

## Table 3-6. Continued

| Concentrations of Metals in NPK Fertilizers, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| **4. Raven and Loeppert (1997): diverse formulations** | | | | | | | | | | |
| n = 14 | mean | 4.1 | 2.7 | 6.0 | 51 | < 0.4 | 9.7 | 80 | 5.4 | 80 |
| | median | 0.15 | 1.1 | 0.4 | 17 | < 0.4 | 0.6 | 4.9 | 1.4 | 9.5 |
| | range | < 0.2-36 | < 0.2-48 | < 0.4-16 | < 1-196 | < 0.4 | < 0.2-48 | < 0.2-237 | < 0.6-42 | 4.6-386 |
| **5. International Mineral Corporation (1997): diverse formulations** | | | | | | | | | | |
| $P_2O_5$[h] | conc | 6.8 | 4.1 | < 0.1 | 81 | < 0.1 | 13 | 180 | 1.3 | 74 |
| NPK[i] | mean | 5.3 | 1.6 | < 0.1 | 70 | < 0.1 | 11 | 210 | 4.6 | 60 |
| n = 3 | median | 5.4 | 1.0 | < 0.1 | 71 | < 0.1 | 11 | 200 | 0.5 | 58 |
| | range | 5-6 | 0.9-3 | < 0.1 | 64-75 | < 0.1 | 10-12 | 180-250 | 0.4-1.3 | 57-65 |
| $K_2O$[j] | mean | < 0.1 | 0.30 | < 0.1 | 0.08 | < 0.1 | 0.51 | 1.0 | 0.3 | 0.9 |
| n = 10 | median | < 0.1 | 0.13 | < 0.1 | < 0.1 | < 0.1 | 0.10 | 1.0 | 0.3 | 0.8 |
| | range | < 0.1 | < 0.1-1.0 | < 0.1 | < 0.1-0.2 | < 0.1 | < 0.1-2.6 | < 0.1-1.8 | < 0.1-1.1 | 0.2-2.1 |
| **6. Mermut et al. (1996) Saskatchewan: diverse formulations** | | | | | | | | | | |
| n = 11 | mean | 3.0 | 1.5 | 2.7 | 33 | nd | 23 | 44 | 2.8 | 37 |
| | median | 3.4 | 1.5 | 3.0 | 35 | nd | 13 | 46 | 3.0 | 41 |
| | range | < 0.1-6.3 | 0.04-3.5 | < 1-5.8 | 0.4-83 | nd | 0.5-81 | < 0.1-114 | 0.1-7.3 | 0.3-83 |
| **7. Hamamo et al. (1995): diverse formulations** | | | | | | | | | | |
| n = 5 | mean | nd | nd | 10 | nd | nd | nd | 131 | nd | nd |
| | median | nd | nd | 7.5 | nd | nd | nd | 162 | nd | nd |
| | range | nd | nd | 6.5-13 | nd | nd | nd | 49-203 | nd | nd |
| **8. Mortvedt and Osborn (1982): phosphate fertilizers** | | | | | | | | | | |
| n = 5 | mean | 124 | 15 | nd | nd | nd | 114 | nd | 40 | 1153 |
| | median | 131 | 15 | nd | nd | nd | 125 | nd | 35 | 1315 |
| | range | 48-188 | 13-18 | nd | nd | nd | 53-135 | nd | 5-98 | 540-1550 |
| **9. Mortvedt, Mays, Osborn (1981): diammonium phosphate fertilizers** | | | | | | | | | | |

## Table 3-6. Continued

| Concentrations of Metals in NPK Fertilizers, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| n = 3 | mean | 76 | 6 | nd | nd | nd | 95 | nd | 9 | 850 |
| | median | 74 | 6 | nd | nd | nd | 120 | nd | 8 | 1260 |
| | range | 2-153 | 4-8 | nd | nd | nd | 10-156 | nd | 1-18 | 1-1290 |
| **10. Mortvedt and Giordano; diammonium and liquid phosphate fertilizers** | | | | | | | | | | |
| DAP/ID RP[k] | | 50 | 4.4 | nd | 485 | nd | 64 | 1600 | 2.7 | 715 |
| DAP/NC RP[l] | | 30 | 4.7 | nd | 195 | nd | 38 | 90 | 1.0 | 285 |
| Liq/ID RP[m] | | 44 | 9.0 | nd | 344 | nd | 8.0 | 1150 | 1.1 | 673 |
| Liq/NC RP[n] | | 17 | 5.2 | nd | 175 | nd | 35 | 52 | 1.4 | 500 |
| **11. California Department of Food and Agriculture (1997): diverse formulations** | | | | | | | | | | |
| N[o] | n = 1 | 0.0 | 0.0 | 0.0 | nd | nd | nd | nd | 4.0 | nd |
| $P_20_5$ | mean | 89 | 8.9 | 11 | nd | nd | 41[p] | nd | 107 | nd |
| n = 32 | median | 132 | 1.0 | 13 | nd | nd | 11 | nd | 52 | nd |
| | range | 0-163 | 0-200 | 0-21 | nd | nd | 9.8-132 | nd | 1-1170 | nd |
| NPK | mean | 37 | 532 | 13 | 134 | 0.85 | 34[q] | nd | nd | nd |
| n = 41 | median | 19 | 4.0 | 8.0 | n = 1 | n = 1 | 26 | nd | 53 | nd |
| | range | 0-200 | 0-5425 | 0.15-155 | 134 | 0.85 | 19-58 | nd | 0-1400 | nd |

a) Analyses of 23 monoammonium phosphate samples
b) Not determined
c) Analyses of 25 diammonium phosphate samples
d) Analyses of 24 triple super phosphate samples
e) Analyses of 25 muriate of potash samples
f) Analyses of single nutrient fertilizers formulations (4 N fertilizers, 2 $P_2O_5$ fertilizers, 1 $K_2O$ fertilizer)
g) Analyses of multi-nutrient (NPK and NPKS) formulations
h) Analyses of phosphate (P205) fertilizers
i) Analyses of multi-nutrient (NPK) fertilizers
j) Analyses of potash ($K_2O$) fertilizers
k) DAP produced from an Idaho rock phosphate
l) DAP produced from a North Carolina phosphate
m) Liquid fertilizer produced from an Idaho rock phosphate

**Table 3-6. Continued**

n) Liquid fertilizer produced from a North Carolina rock phosphate
o) Analyses of nitrogen (N) fertilizers
p) n = 4
q) n = 3

## Table 3-7. Concentrations of Selected Metals in Organic/Biosolids Fertilizers

| Concentrations of Metals in Organic Fertilizers, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| **1. Raven and Loeppert (1997)** | | | | | | | | | | |
| organic[a] | mean | 0.5 | 4.1 | 4.4 | 7.4 | < 0.4 | 6.9 | 12 | 13 | 178 |
| n = 4 | median | 0.5 | 4.0 | 5.2 | (n = 2)[b] | < 0.4 | 8.7 | 15 | (n = 2)[b] | (n = 2)[b] |
| | range | 0.3-0.7 | 0.7-7.5 | 2.5-6.8 | < 0.9-14 | < 0.4 | 3.2-9.6 | 0.4-18 | 9.4-18 | 164-192 |
| sew sl[c] | Austinite | 3.3 | 87 | 9.4 | 106 | 1.5 | 37 | 35 | 300 | 563 |
| | Milorganite | 7.2 | 130 | nd | 2940 | 1.1 | 31 | 19 | nd[d] | 450 |
| **2. Arora, et al. (1975)** | | | | | | | | | | |
| organic[e] | mean | nd | 125 | nd | 12 | nd | nd | nd | 6.7 | 75 |
| n = 4 | median | nd | 123 | nd | 12 | nd | nd | nd | 6.9 | 50 |
| | range | nd | 90-168 | nd | 10-14 | nd | nd | nd | 2.8-13 | 15-199 |
| **3. Metrogro Corp (1997)** | | | | | | | | | | |
| sew sl[c] | compost | 6.0 | 64 | 3.8 | 52 | 2.8 | 32 | nd | 386 | 598 |
| | cake | 6.0 | 77 | 1.9 | 77 | 2.3 | 32 | nd | 508 | 697 |
| **4. California Department of Food and Agriculture (1997)** | | | | | | | | | | |
| n = 14[f] | mean | 2.8 | 31 | 2.1 | 42 | 4.0 | 38[g] | nd | 113 | nd |
| | median | 1.0 | 19 | 1.7 | (n = 2)[b] | (n = 2)[b] | 40 | nd | 100 | nd |
| | range | 0.0-15 | 2.5-110 | 0.0-10 | 0.75-83 | 0.0-8.0 | 32-43 | nd | 4.5-330 | nd |

a) Includes corn leaves, manure and compost
b) Sample size (n = 2) too small to calculate median_
c) Sewage sludge (n = 2); sample concentrations listed separately


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d) Not determined
e) Includes fresh and rotted manure
f) Includes humus, compost, sewage sludge, tankage, hoof and horn meal

## Table 3-8. Concentrations of Selected Metals in Zinc, Secondary Nutrient and Micronutrient Fertilizers

| Concentrations of Metals in Zinc, Secondary Nutrient and Micronutrient Fertilizers, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| **1. Mortvedt (1985)** | | | | | | | | | | |
| Zn[a] | mean | 777 | 12,650 | nd[b] | nd | nd | 1070 | nd | nd | 380,000 |
| n = 9 | median | 590 | 1,900 | nd | nd | nd | 92 | nd | nd | 351,000 |
| | range | 4-2165 | 50-52E3[c] | nd | nd | nd | 10-8,950 | nd | nd | (92-890) E3[d] |
| **2. Amrani, et al. (1997)** | | | | | | | | | | |
| Zn | mean | 114 | 4276 | nd | nd | nd | nd | nd | nd | 500,000 |
| n = 6 | median | 61 | 293 | nd | nd | nd | nd | nd | nd | 660,000 |
| | range | 43-435 | 90-23E3 | nd | nd | nd | nd | nd | nd | (7-1,000) E3 |
| K061[e] | conc | 359 | 19,170 | nd | nd | nd | nd | nd | nd | 10,000 |
| **3. CoZinCo Co. (1997): various products from diverse manufacturers, analyzed by CoZinCo** | | | | | | | | | | |
| Zn | mean | nd | 9,700 | nd | nd | nd | nd | nd | nd | 256,000 |
| n = 41 | median | nd | 10,050 | nd | nd | nd | nd | nd | nd | 245,000 |
| | range | nd | 10-29E3 | nd | nd | nd | nd | nd | nd | (95-430) E3 |
| **4. Washington Department of Ecology (1997)** | | | | | | | | | | |
| Granular Zinc | | 275 | 11,300 | < 34 | 580 | 3.36 | 83 | 41 | 1680 | 178,000 |
| Granular Zinc | | 52 | 1400 | < 35 | 68 | nd | 62 | < 1 | 672 | 203,000 |
| Micronutrient Mix | | < 1.7 | < 11 | < 17 | 3.1 | 0.028 | 21 | < 1 | 19,400 | 60,300 |
| Micronutrient Mix | | 55 | 3590 | 83 | 457 | 0.226 | 4 | 33 | 39,900 | 94,300 |
| High Mag Gro[f] | | < 0.6 | 15 | < 6 | 2 | 0.023 | 10 | 0.9 | 13 | 66 |
| Manganese Sulfate | | < 3 | < 100 | < 30 | 10 | 0.005 | 50 | < 3 | 21 | 61 |
| Boronat[f] | | < 1.5 | < 11 | 1040 | < 2.6 | 0.17 | < 5 | 17 | 8 | 6 |

## Table 3-8. (Continued)

| Concentrations of Metals in Zinc, Secondary Nutrient and Micronutrient Fertilizers, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
| **5. California Department of Food and Agriculture (1997)** | | | | | | | | | | |
| Zn | mean | 149 | 4054 | 30 | 105 | nd | nd | nd | 491 | nd |
| n = 24 | median | 23 | 18 | 0.5 | n = 1 [g] | nd | nd | nd | 10 | nd |
| | range | 0-495 | 0-26,500 | 0-280 | –[h] | nd | nd | nd | 0-2,550 | nd |
| S[i] | mean | 0.43 | 2.5 | 5.8 | nd | nd | nd | nd | 29 | nd |
| n = 7 | median | 0.0 | 0.0 | 1.0 | nd | nd | nd | nd | 14 | nd |
| | range | 0-3.0 | 0-8.7 | 0.1-19 | nd | nd | nd | nd | 0-109 | nd |
| Fe[j] | mean | 71 | 3787 | 1544 | nd | nd | nd | nd | 1238 | nd |
| n = 9 | median | 21 | 2625 | 118 | nd | nd | nd | nd | 292 | nd |
| | range | 0-334 | 0-18,750 | 0.3-4950 | nd | nd | nd | nd | 5.7-3190 | nd |
| Zn-Fe-Mn blends | average | 248 | 15,400 | 48 | nd | nd | nd | nd | 2485 | nd |
| n = 2 | range | 95-400 | 13,400-17,400 | 24-71 | nd | nd | nd | nd | 1970-3000 | nd |

a) Zinc micronutrient fertilizer; 18% Zn fertilizer = 180,000 ppm Zn; 36% Zn fertilizer = 360,000 ppm Zn
b) Not determined
c) E3 denotes multiplication by 1000, and applies to second number only; 50-52E3 = 50 - 52,000
d) E3 denotes multiplication by 1000, and applies to both numbers; (92-890)E3 = 92,000 - 890,000
e) Electric arc furnace dust
f) Product name
g) One sample analyzed for Cr; no median value
h) One sample analyzed for Cr; no range
i) Sulfur micronutrient fertilizer
j) Iron micronutrient fertilizer

The concentrations of metals in diverse commercially-available fertilizers from two studies (reported by Latimer and the Texas Agricultural Experiment Station,1997a and 1997b) are listed in Table 3-9. The levels of Pb in several products suggest that these products may be derived from recycled industrial waste, although no designation was given to these fertilizer formulations.

The concentrations of selected metals in liming agents are shown in Table 3-10. With possible exception of the kiln dust lime, the mass concentrations reported here appear similar to levels reported for other organic and inorganic fertilizers.

The concentrations of metals in the various gypsum and phosphogypsum samples are listed in Table 3-11. Approximately 5 tons of phosphogypsum are produced as a by-product in the production of 1 ton of phosphoric acid fertilizer. On a worldwide scale, of the residual phosphogypsum produced, 14% is reprocessed, 28% is discharged to water and 58% is stored in stacks (Carmichael, (1988) in Rutherford, et al., 1994). Some of this material is used as a soil amendment, especially for clay soils. Its greater agricultural use, though, is found in its ability to supply secondary nutrients Ca and S.

## 3.4 RADIOACTIVE COMPOUNDS IN FERTILIZERS

Phosphate and phosphogypsum fertilizers applied to agricultural lands contain trace radioactive nuclides which originate with the rock phosphates. Radionuclides, including uranium (U), radium (Ra) and thorium (Th), and their decay products can remain in these fertilizer products. Uranium in rock phosphate ranges from 3-400 mg/kg in deposits around the world (Mortvedt, 1992). During processing, much of the U, up to 67% of the initial concentration, and Th will remain with the phosphate fertilizer, while Ra will be contained primarily in the phosphogypsum by-product (Rutherford et al., 1995). The U content of triple superphosphate will be greater than that of phosphoric acid because the phosphoric acid, initially obtained from the rock phosphate is concentrated and reacted with additional rock phosphate, resulting in an U concentration approximately 3 times greater than in the phosphoric acid (Erdem et al., 1996).

The concentrations of radionuclides 238U, 226Ra and 232Th in Bq/kg and mg/kg (as available) from various studies are summarized in Table 3-12. As shown there, 238U concentration in rock phosphates around the world varies considerably, 90-4800 Bq/kg; a similar range is found for 226Ra, 40-5022 Bq/kg. The 232Th concentrations are lower, 16-622 Bq/kg. The rock phosphate from Tunisia, with 238U content of 4400 Bq/kg, 226Ra content of 5022 Bq/kg and 232Th content of 622 Bq/kg, when processed into superphosphate had concentrations of 3740, 3394 and 420 Bq/kg for U, Ra and Th respectively, and when processed into triple

**Table 3-9. Concentrations of Selected Metals in Commercially-Available Agricultural Fertilizers That Have No Product Classification Given**

| Concentrations of Metals in Unnamed Fertilizers, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| **1. Texas Agricultural Experiment Station (1997a)** | | | | | | | | | | |
| n = 67 | mean | 7.4 | 93 | nd | nd | nd | 21 | nd | nd | nd |
| | median | < 1 | < 5 | nd | nd | nd | 3.3 | nd | nd | nd |
| | range | < 1-79 | < 5-2940 | nd | nd | nd | < 2.5-127 | nd | nd | nd |
| **2. Texas Agricultural Experiment Station (1997b)** | | | | | | | | | | |
| n = 16 | mean | nd | 756 | nd | nd | nd | nd | nd | nd | nd |
| | median | nd | 0.63 | nd | nd | nd | nd | nd | nd | nd |
| | range | nd | < 0.1-11,700 | nd | nd | nd | nd | nd | nd | nd |

## Table 3-10. Concentrations of Selected Metals in Liming Materials

| Concentrations of Metals in Liming Agents, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| **1. Raven and Loeppert (1997)** | | | | | | | | | | |
| Calcite | | 0.7 | 1.1 | < 2 | nd | < 0.4 | 1.4 | 3.0 | 2.3 | nd |
| Dolomite | | < 0.2 | 0.7 | 1.2 | 32 | < 0.4 | 33 | 15 | nd[a] | 8.0 |
| **2. Washington Department of Ecology (1997)** | | | | | | | | | | |
| Dical lime[b] | | < 3 | < 20 | < 30 | < 5 | 0.0063 | < 10 | < 2 | < 10 | 7.7 |
| Kiln dust lime[b] | | 3.6 | 150 | 37 | 73 | 0.041 | 18 | 49 | 158 | 1770 |
| Wood ash | | < 1.5 | 125 | 48 | 34 | 0.414 | 23 | 41 | 116 | 424 |
| Limestone | | < 3 | < 2 | < 30 | < 5 | 0.0075 | < 10 | < 2 | < 10 | 16 |
| Cal pril lime[b] | | < 3 | < 20 | < 30 | < 5 | 0.006 | < 10 | < 2 | < 10 | 21 |
| Dolomite | | < 1.5 | 49 | < 15 | < 2.5 | 0.022 | < 5 | 1 | 3 | 224 |
| **3. California Department of Food and Agriculture (1997)** | | | | | | | | | | |
| coal/wood ash | mean | 1.0 | 81 | 7.6 | nd | nd | 16 | nd | 119 | nd |
| | median | 0.0 | 16 | 3.0 | nd | nd | (n = 1)[c] | nd | 75 | nd |
| n = 13 | range | 0-4.0 | 1-380 | 1.2-41 | nd | nd | –[d] | nd | 15-515 | nd |
| Limestone #1 | | 6.5 | 46 | 1.1 | nd | nd | nd | nd | 38 | nd |
| Limestone #2 | | 8.1 | 53 | 5.1 | nd | nd | nd | nd | 46 | nd |

a) Not determined
b) Product name
c) Single sample analyzed for Ni; no median value
d) Single sample analyzed for Ni; no range

# Table 3-11. Concentrations of Selected Metals in Gypsum and Phosphogypsum

| Concentrations of Metals in Gypsum and Phosphogypsum, ppm (ug/g or mg/kg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| **1. May and Sweeney (1982); phosphogypsum slag from phosphoric acid production; Florida** | | | | | | | | | | |
| n = 110 | mean | 7 | 1 | 42 | nd[a] | nd | 2 | 19 | 8 | 9 |
| | | n = 1[b] | n = 6 | n = 37 | nd | nd | n = 57 | n = 110 | n = 106 | n = 50 |
| **2. Washington Department of Ecology (1997); gypsum** | | | | | | | | | | |
| gypsum | | < 1.7 | 11 | < 17 | < 2.8 | 0.011 | < 6 | 2.8 | 7.2 | 54 |
| **3. California Department of Food and Agriculture (1997)** | | | | | | | | | | |
| gypsum | mean | 0.83 | 2.5 | 3.1 | nd | nd | nd | 45 | 29 | nd |
| n = 3 | median | 0.0 | 0.0 | 3.0 | nd | nd | nd | 43 | 25 | nd |
| | range | 0-2.5 | 1.5-3.0 | 3-3.4 | nd | nd | nd | 41-50 | 21-42 | nd |

a) Not determined
b) Metal detected in 1 of 110 samples and less than detection limit in 109 of 110 samples

## Table 3-12. Concentrations of Radionuclides in Fertilizers and Rock Phosphates

| Product[a] | Source[b] | Conc, Bq/kg | | | Conc, mg/kg | | |
|---|---|---|---|---|---|---|---|
| | | 238U | 226Ra | 232Th | U | Ra | Th |
| **Earth Crust** | | | | | | | |
| Scholten[c] | world | 25 | nld | 25 | nl | nl | nl |
| Rutherford | USA | nl | 30-40 | 30-40 | nl | nl | nl |
| **Rock Phosphates** | | | | | | | |
| Mortvedt | world | nl | nl | nl | 59 | 18 | 8 |
| | USA | nl | nl | nl | 50-200 | nl | nl |
| | FL/USA | 800 | 800 | 325 | nl | nl | nl |
| Hamamo | nl | nl | nl | nl | 8-139 | nl | nl |
| Erdem | MidEast | nl | nl | nl | 34 | nl | nl |
| Scholten | SC/USA | 4800 | 4800 | 78 | nl | nl | nl |
| | FL/USA | 1500 | 1600 | 16 | nl | nl | nl |
| | Morocoo | 1700 | 1700 | 30 | nl | nl | nl |
| | Kola | 90 | 40 | 90 | nl | nl | nl |
| | China | 150 | 150 | 25 | nl | nl | nl |
| Makwabe | Tanzania | 4400 | 5022 | 622 | 481 | nl | 183 |
| **NPK Fertilizers** | | | | | | | |
| Mortvedt | Finland | 3800 | 1100 | nl | nl | nl | nl |
| Ioannides | Africa | nl | 16-4584 | nl | nl | nl | nl |
| **Phosphoric Acid (28% $P_2 0_5$)** | | | | | | | |
| Erdem | MidEast | nl | nl | nl | 24.5 | nl | nl |
| **Superphosphate** | | | | | | | |
| Hamamo | nl | nl | nl | nl | 184-195 | nl | nl |
| Makwabe | Tanzania | 3740 | 3394 | 420 | 325 | nl | 119 |
| **Triple Superphosphate** | | | | | | | |
| Hamamo | | nl | nl | nl | 184-195 | nl | nl |
| Erdem | MidEast | nl | nl | nl | 77.6 | nl | nl |
| Makwabe | Tanzania | 6940 | 3116 | 660 | 362 | nl | 135 |
| **Phosphogypsum** | | | | | | | |
| Rutherford | FL/USA | nl | 610 | 7 | nl | nl | nl |
| Rutherford | Togo | nl | 850-1120 | 30-39 | 3 | nl | nl |
| Erdem | MidEast | nl | 1250 max | nl | nl | nl | nl |
| Makwabe | Tanzania | nl | 3219 | nl | nl | nl | nl |

a) Product analyzed
b) Source of product
c) First author of study cited

superphosphate had concentrations of 6940, 3116 and 362 Bq/kg for U, Ra and Th , respectively. The residual phosphosgypsum had 226 Ra content of 3219 Bq/kg (Makwabe and Holm, 1993).

Phosphogypsum concentrations of 226Ra are variable, as reported in these studies. Concentration of 226Ra ranged from 610 Bq/kg in a Florida-rock phosphate derived phosphogypsum to 3219 Bq/kg in the phosphogypsum derived from the Tansanian rock phosphate.

## 3.5 PERSISTENT ORGANIC CHEMICALS IN FERTILIZERS AND LIMING MATERIALS

The presence of chlorinated dibenzodioxins and chlorinated dibenzofurans (CDD/CDF) and polychlorinated biphenyls (PCB) in fertilizer materials (other than biosolids) has been investigated for cement kiln dust (CKD) used as a liming material. These data have been incorporated into the U.S. EPA Dioxin Reassessment document (U.S. EPA, Office of Research and Development, 1994).

Tetra- through octa CDD and CDF were detected in the “gross CKD” (that being the initial particulate material collected as an emission product by the air pollution control device from kiln operation) of 10 of 11 kilns sampled, where 6 of the kilns burned hazardous waste concurrently with a fossil fuel. These same CDD and CDF were also detected in the “net CKD” (that being the particulate material collected by the air pollution control device following recycling of gross CKD back through the kiln system; net CKD is used for land disposal) of 8 of the 11 kilns samples. Analyses for 7 PCB congeners was also conducted, but these were not detected in the CKD samples.

The CDD and CDF content of gross CKD was 0.008-247 ng TEQ (toxic equivalency units)/kg; the CDD and CDF content of net CKD was 0.045-195 ng TEQ/kg. The mean CDD/CDF content of net CKD for hazardous waste-burning kilns was higher than that for the kilns which burned only fossil fuel, 35 ng TEQ/kg versus 0.03 ng TEQ/kg, respectively. One kiln sample had a CDD/CDF concentration that was two orders of magnitude greater than that of the other kilns; if this one result were eliminated as atypical, then the mean CDD/CDF concentration in net CKD for hazardous waste-burning kilns would be 2.9 ng TEQ/kg, as opposed to 35 ng TEQ/kg. (Note: for consistency with concentration units used earlier for metals in fertilizer products, 2.9 ng/kg= 2.9 x $10^{-6}$ mg/kg and 35 ng/kg= 35 x $10^{-6}$ mg/kg.).

The TEQ for dioxins in other fertilizer and liming materials has been measured recently by the State of Washington, Department of Ecology. These data are shown in Table 3-13. As listed there, these products are derived from industrial wastes such as CKD, K061 waste, and tire ash. The total dioxin toxic equivalency (TEQ) concentration, as defined in footnote b of Table 3-13, ranges from approximately 0.5-350 ng/kg in actual fertilizer materials, and as high as 815 ng/kg in the raw material KO61 used to produce the corresponding zinc fertilizer.

## 3.6 HEAVY METALS IN HOME GARDENING PRODUCTS

The results of recent analyses for heavy metals in home gardening products are listed in Table 3-14. The concentrations of metals in the individual products are listed. The mean and median concentrations, and range of concentrations for product categories, are listed when more than three products were analyzed. Levels of these metals, on a mass concentration basis, are similar to those found in agricultural products.

**Table 3-13. Concentrations of Dioxins in Fertilizer and Liming Materials Derived from Industrial By-Products**

| Material Sampled | Total Dioxin TEQ Concentration (ng/kg) [a,b] |
|---|---|
| Liming Material - Cement Kiln Dust Sample #1 | 0.67 |
| Liming Material - Cement Kiln Dust Sample #2 | 0.95 |
| Liming Material - Wood Ash (Hog Fuel Boiler) | 35.4 |
| Liquid Zinc Fertilizer | 0.59 |
| Liquid Zinc Fertilizer (Duplicate) | 1.31 |
| Steel Foundry Dust (K061) (Raw Material) | 815 |
| Granular Zinc Fertilizer from K061 | 342 |
| Granular Zinc Fertilizer from K061 (Duplicate) | 322 |
| Tire Ash (Raw Material) | 1.62 |
| Granular Zinc Fertilizer from Tire Ash | 5.60 |

a) In calculating the TEQ, concentrations of forms (congeners) that were not detected were assumed to equal 0.

b) TEQ Concentration: There are 17 forms of dioxins considered to be toxic, but not all are equally toxic. The most toxic dioxin is called 2,3,7,8-TCDD, and other similar dioxins have been assigned toxicity values relative to it. These relative toxicity values are called toxicity equivalency factors (TEFs). 2,3,7,8-TCDD is assigned a TEF of 1, and the others are assigned values less than 1. Total concentrations of dioxins in the environment are reached by factoring in the TEF of each form of dioxin before adding them together. The resulting concentration is referred to as TEQ (toxic equivalent).

Source: http://www.wa.gov/ecology/pie/fert.html

## Table 3-14. Concentrations of Selected Metals in Home Fertilizer Products

| Fertilizer | Product | Concentration of Metals in Home Fertilizer Products (µg/g or mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
| NPK | Ace Hardware Tomato & Vegetable Food | 1.81 | 5.3 | 2.9 | nd | 0.484 | 11 | nd | nd | 368 |
| | Jobe's Fertilizer Spikes | 2.57 | 2.0 | 6.4 | nd | 0.013 | 17 | nd | nd | 39 |
| | Miracid | 0.01 | 0.6 | nd | nd | 0.06 | nd | nd | nd | 1,010 |
| | Miracle-Gro | 0.02 | 0.1 | nd | nd | nd | nd | nd | nd | 688 |
| | Nu Life Spring Feed | 0.11 | 5.0 | 1.2 | nd | 0.282 | 15 | nd | nd | 388 |
| | Peters Professional | 0.01 | 0.1 | 1.3 | nd | 0.1 | <1 | nd | nd | 528 |
| | S&H Organic Fertilizer | 0.98 | 5.4 | 4.6 | nd | 0.031 | 12 | nd | nd | 62 |
| | Schultz Bloom-Plus | 0.01 | <0.02 | 3.4 | nd | <0.02 | <1 | nd | nd | 544 |
| | Scotts Vegetable Food | 2.49 | 3.3 | 5.9 | nd | 0.006 | 10 | nd | nd | 6 |
| | Walt's Rainy Pacific Northwest Blend | 1.11 | 0.4 | 12.1 | nd | 0.066 | 2 | nd | nd | 57 |
| | Webfoot SuperPhosphate | 56.50 | 2.4 | 6.0 | nd | 0.031 | 113 | nd | nd | 694 |
| | Whitney Farms Super Phosphate | 4.62 | 7.9 | 13.7 | nd | 0.051 | 29 | nd | nd | 70 |
| Mean | | 5.85 | 2.7 | 5.8 | nd | 0.103 | 21 | nd | nd | 371 |
| Median | | 1.05 | 2.2 | 5.3 | nd | 0.051 | 12 | nd | nd | 378 |
| Range | | 0.01-56.50 | <0.02-7.9 | 1.2-13.7 | nd | 0.006-0.484 | <1-113 | nd | nd | 6-1,010 |
| Iron | Black Leaf Granular | 1.10 | 14.3 | 0.9 | nd | 0.0026 | 6 | nd | nd | 24,940 |
| | Hoffman Iron Sulfate | 4.80 | 426.1 | 18.7 | nd | 0.307 | 333 | nd | nd | 83,135 |
| | Ironite | 32.37 | 3,290.0 | 4,512.7 | nd | 16.9 | 18 | nd | nd | 10,182 |
| | Nu Life Iron Sulfate | 0.06 | 0.6 | nd | nd | nd | 368 | nd | nd | 177 |
| Mean | | 9.58 | 932.8 | 1510.8 | nd | 5.74 | 181 | nd | nd | 29,609 |
| Median | | 2.95 | 220.2 | 18.7 | nd | 0.307 | 176 | nd | nd | 17,561 |
| Range | | 0.06-32.37 | 0.6-3,290.0 | 0.9-4,512.7 | nd | 0.0026-16.9 | 6-368 | nd | nd | 177-83,135 |
| Multi--nutrient Mix | Nu Life Trace Elements | 86.82 | 2,491.0 | 29.2 | nd | 2,491.0 | 515 | nd | nd | 68,150 |
| Other | Lilly Miller Ultralime | 0.29 | 3.0 | 3.1 | nd | 0.009 | 5 | nd | nd | 18 |
| | Nu Life Rid Moss | 0.28 | 4.4 | 2.4 | nd | 0.119 | 33 | nd | nd | 175 |

Source: Seattle Times (1998): http://www.seattletimes.com/news/health-science/html98/fchar_051798.html

## 4.0 FERTILIZER REGULATIONS, STANDARDS, GUIDELINES AND BENCHMARKS

This section describes the regulation of fertilizers and soil amendments and the constituents of these products. Since there is no federal fertilizer law, the state laws regulating fertilizer composition and efficacy are described first. Federal rules which may be of some relevance for regulating the use of industrial by-products in fertilizers are discussed in the second sub-section. The third sub-section describes international fertilizer regulations. The fourth sub-section describes federal and international standards for the land application of sewage sludge and include limits for metals in sludge and soil following sludge application.

This section addresses the questions:

- Who regulates fertilizer composition and application?
- What are the state regulations regarding fertilizer composition?
- Although there are no specific Federal laws regarding fertilizer composition or efficacy, what Federal regulations may be applied to some aspect of fertilizer use and soil contamination?
- What international laws exist governing fertilizer application and soil contamination?
- What are the regulations for application of biosolids (sewage sludge) to land?

### 4.1. STATE REGULATIONS

State regulations for fertilizers are generally developed and administered by state agriculture departments. Such regulations primarily address efficacy claims and composition statements of the active ingredients displayed on fertilizer labels. Most states have fertilizer regulations similar to that of the AAPFCO model Uniform State Fertilizer Bill reproduced in Appendix D. Section 4 of that bill requires registration and/or licensing of each brand and grade of fertilizer by the person whose name appears on the label before the product may be distributed. The application for registration includes the brand and grade and a guaranteed analysis. Section 3 of the bill defines guaranteed analysis as:

"the minimum percentage of plant nutrients claimed in the following order and form:

(1) Total Nitrogen (N) ____%
Available Phosphate ($P_2O_5$) ____%
Soluble Potash ($K_2O$) ____%

(2) For unacidulated mineral phosphatic material and basic slag, bone, tankage or other organic phosphatic materials, the total Phosphate and/or degree of fineness may also be guaranteed.

(3) Guarantees for plant nutrients other than nitrogen, phosphorus and potassium may be permitted or required by regulation by the _____. The guarantees for such other nutrients shall be expressed in the form of the element. The source (oxides, salts, chelates, etc.) of such other nutrients may be required to be stated on the application for registration and may be included on the label. Other beneficial substances or

compounds, determinable by laboratory methods, also may be guaranteed by permission of the _____ and with the advice of the Director of the Agricultural Experiment Station. When any plant nutrients or other substances or compounds are guaranteed, they shall be subject to inspection and analysis in accord with the methods and regulations prescribed by the _____."

Thus, any claims that are made concerning chemicals necessary or conducive to plant growth must be substantiated. If a chemical included in the analysis is not listed on the label, no analysis is required, except (Section 12, Adulteration):

"No person shall distribute an adulterated fertilizer product. A fertilizer shall be deemed to be adulterated:

(a) If it contains any deleterious or harmful substance in sufficient amount to render it injurious to beneficial plant life, animals, humans, aquatic life, soil or water when applied in accordance with directions for use on the label, or if adequate warning statements or directions for use which may be necessary to protect plant life, animals, humans, aquatic life, soil or water are not shown on the label."

Consistent with the AAPFCO model fertilizer bill, most states currently have a general prohibition on distribution of “adulterated” fertilizer products. AAPFCO and the states have only recently begun to develop specific guidelines on what might constitute adulterated products. In 1998 AAPFCO amended its Uniform State Fertilizer Bill to provide further interpretation of what constitutes adulturation of fertilizers. Under AAPFCO’s Policy Statement #25 entitled “Metals in Fertilizer Materials”, fertilizer materials are to be considered adulterated if they contain metals in amounts greater than the levels established by the Canadian Standards, and that biosolids are adulterated when they exceed the levels of metals permitted by the U.S. EPA §503 regulations. Under Policy Statement #26, products that meet the guidelines for metals may include the following statement on the label: “When applied as directed, this product meets the guidelines for metals adopted by the Association of the American Plant food Control Officials.” AAPFCO is also currently developing additional labeling recommendations that would indicate the ingredients contained in fertilizer products.

State-specific fertilizer initiatives (as of February 1999) include the following

- In 1998 the State of Washington became the first state to enact legislation to comprehensively regulate contaminants in fertilizers. Washington’s Safe Fertilizer Act mandates a set of new regulatory requirements for contaminant testing, registration and labeling, and contaminant standards. The Act specified that until national risk-based standards are developed, Washington would adopt the Canadian fertilizer standards on an interim basis. The Act also allows adjustments to the Canadian standards based on application rates that are consistent with agricultural practices in the State of Washington. Further studies of heavy metals and dioxins in fertilizers and soils in Washington, and new research on plant biouptake of metals (being conducted by Washington State University), were also mandated by the Act.

- The State of Texas also enacted in 1988 new regulations governing fertilizer contaminants analogous to those of Washington, though based on the EPA §503 standards for sewage sludge rather than the Canadian standards.

- The State of California (CDFA and CalEPA), has prepared a risk assessment characterizing acceptable lead, cadmium and arsenic levels in fertilizer materials, based on California soils and agricultural practices ("Development of Risk-Based Concentratoins for Arsenic, Cadmium, and Lead in Inorganic Commercial Fertilizers", March 1998, Foster Wheeler Environmental Corporation). California does not yet have comprehensive fertilizer regulations in place, although legislative proposals are under development.

- In Pennsylvania, for fertilizers made from industrial waste products, the Department of Agriculture requires testing data from manufacturers and approval of the registration by the Department of Environmental Protection.

## 4.2. FEDERAL REGULATIONS

There are no specific Federal laws regulating the composition or efficacy of fertilizers. There are regulations concerning the production, use and disposal of hazardous materials, drinking and surface water contamination and air pollution that are indirectly relevant to the use of hazardous materials in fertilizers and the application of fertilizers to land. In addition, the Hazardous Waste Regulation, 40 CFR Part 503, Standards for the Use or Disposal of Sewage Sludge, provides limits for the concentration of metals in sludge that is applied to land and to the chemical loadings on the land following application. This standard is described in detail in Section 4.4. Other U.S. regulations which are applicable, in part, to the use of industrial by-products in hazardous wastes are discussed below.

### 4.2.1 OSHA

The Occupational Safety and Health Administration (OSHA) Hazard Communication Standard (29 CFR 1910.1200) applies to chemical manufacturers and importers of "hazardous chemicals" which includes agricultural operations. This standard provides for a comprehensive program of hazard communication including warning workers about chemical hazards via labels, material safety data sheets (MSDSs), other warning mechanisms and employee training. The standard does not apply to family members working on farms, only employees.

One provision of this regulation is that chemicals in concentrations of 1% or more (0.1% for carcinogens) must be listed on the MSDSs for products used in the workplace. Manufacturers and importers must provide MSDSs for their products. Specifically:

(1) 1910.1200 (b)(1)

This section requires chemical manufacturers or importers to assess the hazards of chemicals which they produce or import, and all employers to provide information to their employees about the hazardous chemicals to which they are exposed by means of a hazard communication program, labels and other forms of warning, material safety data sheets, and information and training.

(2) 1910.1200 (d) (1)

If a mixture has not been tested as a whole to determine whether the mixture is a health hazard, the mixture shall be assumed to present the same health hazards as do the components which comprise one percent (by weight or volume) or greater of the mixture, except that the mixture shall be assumed to present a carcinogenic hazard if it contains a component in concentrations of 0.1 percent or greater which is considered to be a carcinogen under paragraph (d)(4) of this section;

The requirement for MSDSs does not apply, however, for chemicals subject to labeling requirements of specific acts such as the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the Toxic Substance Control Act (TSCA), the Federal Food, Drug, and Cosmetic Act (FFDCA), and consumer products regulated under the Consumer Product Safety Act (CPSA) and the Federal Hazardous Substances Act (FHSA). Also, this section of the OSHA regulations do not apply to any hazardous waste as defined by the Solid Waste Disposal Act (SWDA), as amended by the Resource Conservation and Recovery Act (RCRA) and any hazardous substance defined by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) when the product is the focus of remedial or removal action being conducted in accordance with EPA Regulations.

OSHA regulates hundreds of air contaminants, including heavy metals and persistent organic chemicals in 29 CFR 1910.1000, but agricultural operations are exempt. Agricultural operations are not exempt, however, from the cadmium regulations (29 CFR 1910.1027) limiting airborne exposure to cadmium during a work shift to 5 $\mu g/m^3$. In addition, the standard regulating the storage and handling of anhydrous ammonia (29 CFR 1910.111 (a) and (b)) applies to agricultural operations.

### 4.2.2 EPA Regulations for Hazardous Waste Derived Fertilizers

One of the primary objectives of the RCRA program is to encourage legitimate recycling of hazardous wastes, while maintaining appropriate regulatory controls to ensure that such practices are protective of human health and the environment. In the case of fertilizers, current RCRA requirements address two major environmental concerns: (a) how hazardous waste secondary materials are managed prior to recycling, and (b) controls on contaminants in the fertilizer products made from such materials. RCRA generally does not regulate the actual units or processes that are used in recycling. The following is a summary of the current regulatory framework for hazardous waste derived fertilizers:

- RCRA regulations currently require that (with one exception) fertilizers made from recycled hazardous wastes have to meet the applicable “land disposal restrictions” treatment standards (these “LDR” treatment standards have been developed by EPA for essentially all hazardous wastes that are land disposed). These standards are generally technology-based, and are expressed as concentrations in leachate when tested according to the Toxicity Characteristic Leaching Procedure (TCLP). This leaching procedure was originally developed by EPA to simulate how contaminants leach from wastes in municipal solid waste landfills.

- The current regulations provide one exemption from having to meet the LDR treatment standards--fertilizers made from electric arc furnace dust (RCRA waste code K061) are not required to meet any specific contaminant standards.

- Management of hazardous secondary materials prior to recycling for fertilizers is subject to the "use constituting disposal" (UCD) provision of RCRA (40 CFR 266.20). This provision in essence requires that hazardous waste secondary materials must be managed as hazardous wastes prior to being recycled. Thus, for example, shipments of such materials are subject to manifest requirements, and storage of the materials (e.g., by the fertilizer manufacturer) will generally require a RCRA permit.

- Certain types of wastes are specifically exempted in the RCRA statute (the so-called Bevill exemption) from being regulated as hazardous waste, unless EPA establishes through rulemaking that such wastes should be regulated as hazardous wastes. Thus, fertilizers made from such exempt wastes (which include mining wastes, and gypsum from coal-fired power plants) are not subject to RCRA standards, even if the wastes (or the fertilizer) were to exhibit a hazardous waste characteristic.

### 4.2.3 Military Munitions Rule: Hazardous Waste Identification and Management; Explosives Emergencies; Manifest Exemption for Transport of Hazardous Waste on Right-of-Ways on Contiguous Properties; Final Rule

The Military Munitions Rule (FR, February 12, 1997) discusses the recycling of propellant or explosive as fertilizer. If processed in a manner rendering it suitable for land application, this is a permissible under RCRA. "Under 40 CFR 266.20(b) commercial fertilizers that are produced for the general public's use that contain recyclable materials are not presently subject to regulation provided they meet the treatment standard under 40 CFR Part 268, subpart D, for each recyclable material that they contain." (page 6629). Chemical agents or munitions exhibiting a hazardous waste characteristic, or already listed as a hazardous waste (40 CFR Part 261), are subject to all applicable regulatory requirements of RCRA Subtitle C.

Currently, recycling of munitions into fertilizers has been demonstrated in the laboratory on a bench-scale, and in limited pilot-scale validation and demonstration tests. A mobile unit will be available for military tests by mid-1999, and a larger stationary production facility is planned (http://www.arctech.com).

### 4.2.4 Metal Containing Pesticides

Metals can be added to soil from the application of pesticides. There are a number of pesticide products containing cadmium, arsenic, copper, mercury and other metals. Many of these products are, however, no longer registered by EPA. Table 4-1 shows the metal-containing pesticide products that are banned, have restricted use, have been canceled in the Special Review Process or have tolerances on food crops.

EPA Office of Pesticide Programs (OPP) publishes a list of pesticides banned and severely restricted in the U.S. (http://www.epa.gov/oppfead1/piclist.html). Table 4-1 shows pesticides containing metals that have been banned from use or have severely restricted use in the United States as of August 1, 1997. Pesticides may be banned either by EPA canceling the registrations or by the registrant (i.e. the manufacturer) voluntarily canceling the registration. The last remaining use of cadmium chloride was voluntarily canceled in 1990 during the special review of cadmium products. All uses were canceled in 1991 (56 FR 14522, April 10, 1991). All registrations of inorganic arsenicals have been canceled except for a few select uses (arsenic trioxide insecticide and mole/gopher control). Copper acetoarsenite and copper arsenate uses were canceled in 1977 (42 FR 18422, April 7, 1977). Uses of mercury as an antifouling agent in paint were canceled in 1990 for indoor paint (55 FR 26754, June 29, 1990) and in 1991 for outdoor paint (56 FR 105, May 31, 1991).

**Table 4-1. Regulatory Status of Metal-Containing Pesticides [a]**

| Pesticide Product | Status | Comments |
|---|---|---|
| aluminum phosphide | registration supported, restricted use | See 40 CFR 152.170 (53 FR 15986, May 4, 1988) |
| arsenic acid | severely restricted | Wood preservative products only |
| arsenic trioxide | severely restricted | Insecticide and mole/gopher control |
| cadmium compounds | banned | Voluntary cancellation as a result of the Special Review Process |
| calcium arsenate | banned | Voluntary cancellation |
| chromic acid | restricted use | wood preservative products |
| copper acetoarsenite | banned | Voluntary cancellation as a result of the special review process |
| copper arsenate | banned | Voluntary cancellation as a result of the Special Review Process |
| cupric oxide | registration canceled | |
| cuprous oxide | restricted use | Wood preservative and anti-fouling paint |
| lead arsenate | banned | Voluntary cancellation as a result of the Special Review Process |
| magnesium phosphide | restricted use | magnaphos tablets and bags |
| mercuric chloride | banned | Voluntary cancellation as a result of the Special Review Process |
| mercurous chloride | banned | Voluntary cancellation as a result of the Special Review Process |
| phenarsazine chloride | banned | Voluntary cancellation as a result of the Special Review Process |

**Table 4-1. (Continued)**

| Pesticide Product | Status | Comments |
|---|---|---|
| phenylmercury acetate | banned | Voluntary cancellation as a result of the Special Review |
| phenylmercuric oleate | banned | Voluntary cancellation |
| sodium arsenate | severely restricted use | Brush on wood preservative products |
| sodium arsenite | banned | |
| tributyltin | severely restricted use, review in progress | anti-fouling paints |
| triphenyl tin hydroxide | restricted use, review in progress | fungicide |
| zinc phosphide | registration supported, restricted use | rodent bait |

[a]Sources: Banned/restricted pesticides (http://www.epa.gov/oppfead1/piclist.html); Special Reviews (http://www.epa.gov/oppsrrd1/Rainbow/93Rainbow/Chapt-2.txt.html);

Table 4-2 contains a list of metal-containing pesticides for which there is at least one tolerance set on food crops (i.e. these pesticides have some agricultural use). There are also a number of pesticides which are exempt from tolerances on raw agricultural commodities assuming the products are applied in accordance with good agricultural practices. These chemicals are too numerous to mention but consist of many pesticides that contain plant micronutrients. For example, many copper, magnesium and zinc salts and boric acid are listed in 40 CRF Subpart D Section 180.1001 - 1164 as exempt from tolerances.

**Table 4-2 Pesticides With Tolerances on Raw Agricultural Commodities[a]**

| Pesticide Product | Status | Comments |
|---|---|---|
| aluminum phosphide | 40 CFR 185.200 | Residues not to exceed 0.01 parts per million (ppm) on vegetables, 0.1 ppm on other crops |
| aluminum tris (O-ethylphosphonate) | 40 CFR 180.176 | For example, 3 ppm on tomatoes and 0.5 ppm on citrus |
| basic copper carbonate | 40 CFR 185.136 | Tolerance of 3 ppm in pears |
| basic zinc sulfate | 40 CFR 180.244 | Tolerance of 30 ppm on peaches |
| coordination product of zinc ion and maneb | 40 CFR 180.176 | tolerances set on commodities such as apples and cranberries |
| magnesium phosphide | 40 CFR 180.375 | For example, tolerance of 0.1 ppm on wheat and 0.01 ppm on tomatoes |
| methanearsonic acid | 40 CFR 180.289 | Tolerances of 0.7 ppm in or on cottonseed and 0.35 ppm in or on citrus fruit |

| Pesticide Product | Status | Comments |
|---|---|---|
| triphenyl tin hydroxide | 40 CFR 180.236 | For example, 0.05 ppm on pecans, peanuts and potatoes |
| zinc phosphide | 40 CFR 180.284 | Tolerance of 0.01 ppm on grapes and sugar cane |

[a]Sources: Tolerances: 40 CFR Subpart D, Sections 180.101 to 180.482; Tolerance exemptions: 40 CFR Subpart D, Sections 180.1001 to 180.1164.

Although most of the highly toxic pesticide products (i.e. those containing mercury, cadmium and arsenic) have been banned, there are still pesticide products which have the potential for adding metals to soils and plants. Many of these pesticides contain metals which are also considered plant micronutrients.

### 4.2.5 Radon in Phosphogypsum

The National Emission Standards for Hazardous Air Pollutants (NESHAP) for radon regulates radon emissions from phosphogypsum stacks (40 CFR Part 61, Subpart R). The regulation allows phosphogypsum to be removed from phosphogypsum stacks for agricultural purposes if the radium-266 concentration is determined annually and does not exceed 10 picocuries per gram (pCi/g). EPA analyzed the potential risks associated with long-term use of phosphogypsum in agriculture to set this limit. The Fertilizer Institute filed a petition on August 3, 1992 to reconsider this revised rule. The changes that EPA is considering do not, however, affect the concentration limit of 10 pCi/g.

## 4.3. INTERNATIONAL FERTILIZER REGULATIONS

International fertilizer regulations differ in their content and in enforcement. The regulations for Canada and Japan contain requirements limiting concentrations of heavy metals and, in the case of Japan, organic chemicals in fertilizers. Regulations for the European Union (EU) are also discussed because these directives must be followed by all EU countries.

### 4.3.1 Canadian Fertilizers Act and Regulations

The Canadian Fertilizers Act R.S., c. F-9, s.l (1993) and Fertilizers Regulations contain metal limits used by the Canadian Food Inspection Agency to regulate all fertilizers and soil supplements sold in Canada. Although these limits were not based on quantitative risk assessments, the Trade Memorandum T-4-93, August, 1996 from the Food Production and Inspection Branch states that these limits:

> “..were developed to help ensure that fertilizers and supplements continue to pose only a minimum risk of adverse effects due to metal contamination... The AAFC metal standards are based on generic principles and are generally applicable to fertilizers or supplements applied to land or in crop protection.”

Although the metal limits were originally written for the land application of biosolids, these limits now apply to all fertilizer products. Metal limits were developed by the Ontario Ministry of

Agriculture and Food in 1978. These limits were revised and adopted by Agriculture Canada for application to biosolids and similar products in 1980. Table 4-3 shows the limits for metals in fertilizer and soils following application of fertilizers as stated in Trade Memorandum T-4-93 (August, 1996). Agriculture and Agri-Food Canada is considering limits for two additional metals, chromium (210 kg/ha) and copper (150 kg/ha). These limits have not yet been implemented.

The Canadian government enforces metals regulations for fertilizers by requiring all micronutrient fertilizers, fertilizer/pesticide mixes, and most supplements to be registered through the Canadian Food Inspection Agency (CFIA). For a product to become registered, the manufacturer must submit metal analyses of its product, and the levels must be below the Canadian limits. Non-registered fertilizer products are subject to marketplace monitoring, in which products are randomly selected by the CFIA for metal analyses. If the CFIA finds a product on the market that exceeds the Canadian limits on metals, it has the powers of detention and seizure of the product. More information about Canada's Fertilizers Regulations can be found on the internet at http://www.dfia-acia.agr.ca/english/actsregs/fert/fertrege.html.

The Canadian limits shown in Table 4-3 require some additional explanation. The Maximum Acceptable Cumulative Metal Additions to Soil (kg/ha) pertain to additions over a long term. For the purposes of this calculation, "long term" is taken to mean 45 years. In comparisons made in Section 5 of this report, these values were divided by 45 to more closely approximate annual limits. The Maximum Acceptable Metal Concentrations (mg/kg dry weight) in the fertilizer product were originally developed for biosolids and are based on the assumption that (Agriculture and Agri-Food Canada, Food Production and Inspection Branch, Trade Memorandum T-4-93, August, 1996):

> "A cumulative total application to soil of 200 dry tonnes per hectare of a product that contains 50% moisture and a total N guarantee of 2.5% (i.e. 5% nitrogen on a dry weight basis). Such a product, applied annually at a rate of 220 kg N/ha (or 4,400 kg dry product/ha) would reach the standards for maximum acceptable cumulative metal additions to soil within 45 years"

**Table 4-3. Canadian Maximum Acceptable Cumulative Metal Additions to Soil and Maximum Acceptable Metal Concentrations in Products**

| Metal | Annualized Max. Acceptable Cumulative Metal Addition to Soil (kg/ha)[a] | Maximum Acceptable Metal Concentrations (mg/kg dry weight)[b] |
|---|---|---|
| **Arsenic** | 15 | 75 |
| **Cadmium** | 4 | 20 |
| **Cobalt** | 30 | 150 |
| **Mercury** | 1 | 5 |
| **Molybdenum** | 4 | 20 |

| | | |
|---|---|---|
| **Nickel** | 36 | 180 |
| **Lead** | 100 | 500 |
| **Selenium** | 2.8 | 14 |
| **Zinc** | 370 | 1850 |

a) The values in this column pertain to total cumulative additions to soil over the long term (i.e., 45 years)
b) See text for explanation of the derivation of these limits.

In addition:

> "Acceptable metal concentrations increase as the rate of application decreases relative to 4400 kg dry product/ha (e.g. if the rate of application is 2200 kg dry product/ha, this is half 4400 kg therefore the metal concentrations can be double the [maximum acceptable metal concentrations (mg/kg dry weight)]. Or, when products are applied on the basis of their nitrogen content, acceptable metal concentrations increase proportionally with total %N **on a dry weight** basis"

Additional explanation for estimating the maximum acceptable metal concentrations (mg/kg dry weight) may be found in the Trade Memorandum T-4-93.

Trade Memorandum T-4-112 (April 1994), Information Required for the Assessment of By-Products and Other "Waste" Materials Sold as Fertilizers or Supplements, provides for pre-market assessment of specific end-use product types (e.g., micronutrient fertilizers, supplements, soil amendments, wetting agents, and microbial innoculants) and other products if there is a cause for concern. This assessment addresses issues of safety, labelling and efficacy. It requires identification and description of the product and its constituents, identification of the industrial process from which the product is derived, the benefits of the product, rates and methods of application, and documented analyses for heavy metals, dioxins and furans.

The selection of specific product types for assessment is reviewed in an information source for the inspection's staff, entitled "Regulation of Recycled Material and By-Products Under the Fertilizers Act". This information source was drawn up as a guide, and was not intended to be inclusive of all potential recycled by-products, nor representative of current or actual practices. As listed in that source, examples of industrial by-products, and the chemicals these products may contain, are:

1. Baghouse/flue dust (heavy metals including, iron, zinc, manganese and molybdenum),
2. Cement kiln dust (potassium, calcium, sulphur, iron, magnesium, aluminum, and PAHs),
3. Coal fly ash (aluminum, silicon, iron, calcium, potassium, sodium, arsenic molybdenum, selenium and PAHs),
4. Galvanizing fluid (zinc, iron and other heavy metals),
5. Gypsum (calcium sulfate and traces of dioxins, furans and boric acid),

6. Bauxite mine tailings (aluminum, dicalcium silicate),
7. Newsprint (heavy metals, PAHs),
8. Phosphogypsum (gypsum, fluoride),
9. Pulp and paper sludge (a variety of organic and inorganic substances),
10. Smelter slag (heavy metals, magnesium, calcium),
11. Waste lime (calcium, magnesium, cyanides and sulfites).

### 4.3.2 Japan

Japan regulates incinerator ash from both industrial and municipal waste treatment incinerators. Sludge ash is used for soil improvements. The standards for organic and inorganic chemicals in incinerator ash are shown in Appendix E, International and National Limits for Pollutants in Biosolids, because these limits apply to the leaching of chemicals from incinerator ash produced from burning sewage sludge. These values are from the Prime Minister's Office Ordinance for Establishing Evaluation Standards Regarding Industrial Wastes, including Metals (1995).

### 4.3.3 European Union

The European Union Directive, Council Directive On the Approximation of the Laws of the Member States Relating To Fertilizers (76/116/EEC) sets forth the regulations regarding "straight and compound" fertilizers. The directive is similar to the AAPFCO model document in that it describes only the fertilizer content and package markings. Member states may adapt this regulation. Fertilizer marketed as "EEC fertilizer" is subject to official control measures to assure compliance with the declared nutrient content. Subsequent directives have added fertilizer types to the Annex I (N, P and K) and Annex II (Secondary nutrient Fertilizers) of this directive and tolerances for specific components to Annex III. For example, Urea-ammonium sulphate, 0.5% was added to all three Annexes in a Commission Directive of May 10, 1996 (96/28/EC).

The EU Council Directive of 12 June, 1986 (86/278/EEC) describes the use of sewage sludge in agriculture. The limits for metals are described in the following section and in Appendix E, Table E-1 International Contaminant Concentration Limits for Biosolid Application to Land

The Council Directive of 12 December, 1991 (91/689/EEC) replaces the previous Council Directive of 20 March, 1978 (78/319/EEC) on disposal of dangerous waste. This directive defines waste, requires that discharges be identified and recorded, transportation and storage be inspected and controlled and that establishments responsible for disposal and recovery of wastes on behalf of third parties be identified to the Commission. Annex I of this directive identifies categories of hazardous waste. Annex II lists the chemical constituents of wastes and Annex III identifies the properties of wastes which render them hazardous. In simplified form, this regulation is similar to those of U.S. EPA.

The reuse of materials is encouraged in a non-obligatory council directive of 18 March, 1991. Member states are encouraged to become self-sufficient in waste disposal, and the Council discusses the desirability of adopting specific rules on recovered waste. Article 4 states:

> "Member States shall take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment."

Annex IIB lists operations which may lead to recovery and describes the R10 recovery method:

> "Spreading on land resulting in benefit to agriculture or ecological improvement, including composting and other biological transformation processes..."

This directive does not, however, provide any guidance on limits of contaminants in the environment.

### 4.3.4 Cadmium in Fertilizers

Rock phosphates contain cadmium as a trace element (See Table 3-5). Because of the concern about the toxicity of this element and the need for application of phosphate fertilizers, a number of countries have standards and guidelines limiting the cadmium content of fertilizers and soil. Table 4-4 presents a number of these limits for countries around the world. Most of the limits are stated as a weight of cadmium per weight of phosphorus or phosphate in the fertilizer. In some cases, the cadmium limits are for the total fertilizer weight. Belgium has the lowest limit for all fertilizers, 2.5 mg/kg dry weight, and the Netherlands has the lowest limit for compost and "very clean" compost, 1.25 mg/kg and 0.7 mg/kg, respectively. Cadmium limits in biosolids applied to land are discussed in the next section.

## 4.4. BIOSOLIDS APPLICATION TO LAND

### 4.4.1 EPA 40 CFR Part 503 Standards for the Use or Disposal of Sewage Sludge

The U.S. EPA regulates use and disposal of biosolids via 40 CFR Part 503, "Standards for the Use or Disposal of Sewage Sludge." In this regulation, EPA sets limits for certain metals in biosolids when applied to agricultural land. These limits are summarized in Table 4-5. Concentrations limits for nine inorganic (metal) pollutants in the sewage sludge and for the soil following application of the sewage sludge are included in the regulation. In addition, in May 1993, EPA prepared a list of 31 potential pollutant candidates to be included in the regulation. These pollutants were selected based upon the frequency of detection in the 1988 National Sewage Sludge Survey. Based on screening risk assessments, EPA is scheduled to propose (by March 1999) comprehensive numerical standards and appropriate management practices for biosolids. These will apply to all use and disposal practices, including land application, surface disposal, and incineration, and will encompass limits for dioxins/furans and coplanar PCBs. A final rule is anticipated by 2001.

Many individual states include several limits for other metals. Appendix E presents limits for metals in biosolids for Pennsylvania and the New England states. Many of these limits are the same or lower than those in the Section 503 rule. All the states listed have limits for chromium (which was deleted from Part 503 rule based on a court decision). Connecticut has additional limits for chromium (VI) and barium.

### 4.4.2 International Biosolids Regulations

Inorganic and organic concentration limits in sludge and soils following land application are presented in Appendix E. These values have been abstracted from *A Global Atlas of Wastewater Sludge and Biosolids Use and Disposal* (1996) for 15 countries and the European Union. Canadian regulations for biosolids application to land are the same as for any fertilizer (see Table 4-2). All these countries regulate metals (cadmium, chromium, copper, lead, mercury, nickel and zinc) in biosolids and most regulate arsenic. It is difficult to determine which country has the most conservative limits because they vary by metal; however, the Netherlands and the Scandinavian countries generally have the lowest limits.

## Table 4-4. International Regulations on Cadmium in Fertilizer[a] and Soil[b]

| Country | Year | Value | Units | Type | Comments |
|---|---|---|---|---|---|
| Australia | 1995 | 350 | mg/kg phosphorus | voluntary maximum | Fertilizer Industry Federation of Australia |
| | 2000 | 300 | mg/kg phosphorus | voluntary maximum | Fertilizer Industry Federation of Australia |
| | NA[c] | 250 | mg/kg phosphorus | voluntary maximum | Fertilizer used for horticulture |
| | NA | 10 | mg/kg | voluntary maximum | Fertilizers and soil amendments with < 2% phosphorus |
| | NA | 80 | mg/kg | voluntary maximum | Trace element supplements |
| Austria | NA | 275 | mg/kg phosphorus | limit | Fertilizer |
| Belgium | NA | 2.5 | mg/kg dry weight | maximum | Fertilizer |
| | NA | 200 | mg/kg phosphorus | voluntary limit | Fertilizer |
| | NA | 1-3 | mg/kg dry weight | maximum | Soil |
| | NA | 150 | g/hectare/year | maximum | Soil supply |
| Canada | 1993 | 20 | mg/kg | maximum | Fertilizer, sewage sludge and compost |
| | 1993 | 4 | kg/hectare | maximum acceptable cumulative addition | Soil |
| Denmark | 1998 | 110 | mg/kg phosphorus | threshold limit | Statutory order for phosphate fertilizers No. 233 |
| Finland | NA | 50 | mg/kg phosphorus | maximum | Agricultural and garden fertilizers |
| Germany | NA | 90 | g/tonne[d] $P_2O_5$ | voluntary maximum | At least 89% of products should not exceed 70 g Cd/ton $P_2O_5$ and 63% should not exceed 40 g Cd/ton $P_2O_5$ |
| | NA | 200 | mg/kg phosphorus | voluntary maximum | Fertilizer |
| Japan | 1991 | ≤ 0.01 | mg/liter solution of analysis | limit | soil, Basic Environmental Law |
| | NA | 343 | mg/kg phosphorus | limit | Fertilizer |

**Table 4-4. (Continued)**

| Country | Year | Value | Units | Type | Comments |
|---|---|---|---|---|---|
| | 1991 | ≤ 1 | ppm | limit | Agricultural soil |
| Netherlands | 1987 | 35 | mg/kg phosphorus | limit | Proposed for fertilizer |
| | 1995 | 1.25 | mg/kg | maximum | For compost |
| | 1995 | 0.7 | mg/kg | maximum | For "very clean" compost |
| Norway | 1995 | 100 | mg/kg phosphorus | limit | For fertilizer |
| Sweden | 1992 | 100 | g Cd/tonne phosphorus | limit | For fertilizer |
| Switzerland | NA | 50 | g Cd/tonne phosphorus | maximum | For fertilizer |
| United Kingdom | NA | none | | | |
| European Union | 1986 | 0.15 | mg/kg dry weight of soil/year | mandatory cumulative maximum limit | Soil loading |

[a] For information on cadmium levels in sewage sludge see Appendix E, Table E-1

[b] Sources: OECD Proceedings, Sources of Cadmium in the Environment, Paris, France, 1996, J.J Mortvedt, Fertilizer Research 43: 55-61, 1996 and J.J. Mortvedt and J.D. Beaton, Phosphorus in the Global Environment. Scope, 1995.

[c] NA = Year of initiation of standard or limit is not available

[d] A tonne equals 1000 kg, therefore, g/tonne = mg/kg

**Table 4-5. EPA CFR 40 Part 503 Inorganic Pollutants in Sewage Sludge[a]**

| Pollutant | Ceiling Concentration mg/kg product for Land Application | Cumulative Loading Rate (kg/ha) for Agricultural Land Application | Monthly Average Concentration (mg/kg product) for Agricultural Land Application | Annual Pollutant Loading Rate for Land Application (kg/ha/365 days) |
|---|---|---|---|---|
| Arsenic | 75 | 41 | 41 | 2.0 |
| Cadmium | 85 | 39 | 39 | 1.9 |
| Copper | 4300 | 1500 | 1500 | 75 |
| Lead | 840 | 300 | 300 | 15 |
| Mercury | 57 | 17 | 17 | 0.85 |
| Molybdenum | 75 | | | |
| Nickel | 420 | 420 | 420 | 21 |
| Selenium | 100 | 100 | 100 | 5.0 |
| Zinc | 7500 | 2800 | 2800 | 140 |

a) The ceiling concentrations and monthly average concentrations are limits for pollutants in the sewage sludge product, not the soil

Some countries also regulate other inorganic chemicals (e.g. molybdenum, boron, selenium) as well as some organic chemicals. For example, Australia sets limits for pesticides in sludge and soil, China regulates mineral oil and Austria regulates persistent organics. Japan applies the same standards for industrial waste to biosolids waste because biosolid sludge is incinerated and these incinerators are considered industrial plants and must meet the environmental regulations for industry. Japan has limits for many organic and inorganic compounds as the extractable solution in the waste.

## 4.5 SUMMARY OF REGULATIONS

Canada specifically regulates nine metals in all fertilizers. Certain European countries and Australia regulate cadmium in phosphate fertilizers. Japan regulates metals and some organic chemicals in incinerator ash that is applied to agricultural land. The U.S. regulates fertilizers that are made from hazardous waste by setting limits for certain metals in those wastes before the waste or product containing the waste can be applied to the land.

States regulate fertilizers, generally through the state agriculture departments. Most states have fertilizer regulations similar to the AAPFCO Uniform State Fertilizer Bill shown in Appendix D. These bills generally regulate plant nutrient and efficacy claims made on the product labels. States (and AAPFCO) have recently begun to also adopt specific standards for contaminants in fertilizers.

There are international, national and state regulations for the application of sewage sludge (biosolids) to land. These laws and regulations have specific limits for toxic metals in sludge and frequently include limits for metals in the soil following application of biosolids.

## 5.0 CHARACTERIZATION OF ADDITION OF METALS TO SOILS AS A RESULT OF FERTILIZER APPLICATION - COMPARISON TO REGULATORY LIMITS

This section combines information from Section 2 on fertilizer consumption, Section 3 on metals in fertilizers and soils and Section 4 on regulations for metals in fertilizers and soils. First, we describe the assumptions necessary for the calculation of metal additions to soil following fertilizer application. Next, application rates for N, P and K fertilizers and micronutrients are combined with information on metal concentrations in these products to determine potential soil additions of metals resulting from fertilizer use. Then we compare these values for metals in fertilizers and soils to the available regulatory limits. The fourth part of this section describes questions that have arisen and data gaps identified in the characterization of soil contamination following application of fertilizers which contain non-nutritive heavy metals.

Note that at this time, only the changes in soil concentrations from metal additions are considered. This report does not attempt to evaluate the impacts of these soil additions on human health or the environment.

This section addresses the following questions:

- What do we know about trace-metal contamination of fertilizers and the resulting application to soils?
- Based on simplifying assumptions, what concentrations of metals in soil might be expected following fertilizer application?
- How do these levels compare to national and international standards and guidelines?
- Based on typical fertilizer application rates, how long will it take to double soil background contaminant levels?
- What additional information is necessary to thoroughly characterize the extent of soil contamination following fertilizer application?

## 5.1 ASSUMPTIONS FOR THE CALCULATION OF METAL SOIL LOADINGS RESULTING FROM FERTILIZER APPLICATION

A number of assumptions must be made to calculate the annual addition of metals to soil (mg/kg or kg/hectare = kg/ha) following fertilizer application. Data from Section 3 listing metal contaminants in various fertilizers have been combined with typical application rates for fertilizer products. The basic equation for the calculation of metal addition to soil (mg/kg) is:

$$\frac{mg\ X}{kg\ soil} = \frac{mg\ X}{kg\ product} \times \frac{1\ kg\ product}{(\%\ Y/100)\ kg\ a.i.} \times AR\ (\frac{kg\ a.i.}{ha}) \times \frac{ha}{2{,}000{,}000\ kg\ soil} \qquad \textbf{(1)}$$

where: X = metal contaminant
Y = fertilizer nutrient (e.g., zinc, nitrogen, $P_2O_5$, $K_2O$)
AR = application rate (kg/ha)
a.i. = active fertilizer ingredient (e.g. nitrogen, N)

The value 2,000,0000 kg soil/ha is calculated based upon an assumed soil density of 1.33 g/cm$^3$ using the following equation:

$$1{,}995{,}000\ \frac{kg\ soil}{ha} = \frac{100\ m \times 100\ m \times 0.15\ m}{ha} \times \frac{1.33\ (g/cm^3)}{0.01\ (m/cm)^3} \times \frac{kg}{1000g}$$
$$= \sim 2{,}000{,}000\ \frac{kg\ soil}{ha} \qquad \textbf{(2)}$$

This assumes that the soil density is 1.33 g/cm$^3$ (US EPA Office of Wastewater Management, 1995; Foth, 1990; Manrique and Jones, 1991; US EPA, 1997a) and that the soil plow depth is 15 cm (0.15 m) (Rothbaum et al., 1986). (Note that the soil density, or bulk soil density, is the mass of oven dry soil per volume sampled, and thus includes both the soil particles and the interstitial air.) A hectare is 10,000 m$^2$. The yearly addition of contaminant X to the soil (kg X/ha) is calculated:

$$\frac{kg\ X}{ha} = \frac{mg\ X}{kg\ fertilizer\ product} \times \frac{1\ kg\ product}{(\%\ Y/100)\ kg\ a.i.} \times AR\ (\frac{kg\ a.i.}{ha}) \times \frac{kg}{1{,}000{,}000\ mg} \qquad \textbf{(3)}$$

Some limits for metals in soils are reported on a mg/kg basis. To convert from kg/ha to mg/kg, multiply the value of the contaminant in kg/ha by 0.5:

$$\frac{mg\ X}{kg\ soil} = \frac{kg\ X}{ha} \times \frac{ha}{2{,}000{,}000\ kg\ soil} \times \frac{1{,}000{,}000\ mg\ X}{1\ kg\ X} = 0.5\ \frac{kg\ X}{ha} \qquad \textbf{(4)}$$

The applications to soil are calculated per crop year; that is, application rates used in the tables may result from multiple applications of a single product in a single growing season. But we have not considered applications of several fertilizer types during a crop year since that information is not available at this time.

## 5.2 SOIL CONCENTRATIONS OF METALS FOLLOWING APPLICATION OF N, P AND K FERTILIZERS AND MICRONUTRIENT FERTILIZERS

Although there are considerable data on concentrations of metals in fertilizer products, the data are neither comprehensive nor representative of all fertilizer types. For example, analyses of metals in 141 different NPK , 61 phosphate and 63 zinc fertilizer samples were available for these comparisons. In contrast, analyses of only 2 or 3 boron, iron, magnesium, and manganese fertilizers were available. In addition, the 141 NPK samples (and all other fertilizer samples, as well) were typically not characterized with respect to all 9 metals compared in this report. The most frequently analyzed/reported metals included Cd, Pb, As, and Zn. Data on Hg concentrations in fertilizer products are somewhat limited by analytical method detection limits (i.e., samples were analyzed, and concentrations were reported as less than a detection limit that is substantially higher than concentrations at which Hg was detected in other samples). The application rates are chosen to cover a range of potential values.

The application rates for N, P, and K fertilizers, micronutrient fertilizers, lime and gypsum used for calculations here are summarized in Table 5-1 (N, P, and K) and Table 5-2 (micronutrient, lime and gypsum). The N, P, and K fertilizer application rates are taken from the USDA/NASS database and reflect rates applied to six field crops (1996 crop year), the eight vegetables with more than 100,000 planted acres in one type (cucumbers not included because neither fresh nor processed type alone exceeded 100,000 planted acres) (1994 crop year) and the six fruits with more than 100,000 planted acres (1995 crop year). The six field crops include corn, cotton, potatoes, soybeans, tobacco and wheat; the eight vegetable crops include snap beans, broccoli, carrots, corn, lettuce, onions, peas and tomatoes; the six fruit crops include watermelons (listed in the USDA/NASS database under vegetables), oranges, grapefruit, apples, grapes and peaches. (Note: These 20 crops were selected for subsequent calculations in this report because they account for a large majority of the crop acreage planted in the U.S. each year.) The USDA/NASS database lists fertilizer application rates separately for the three types of wheat (winter, durum and spring). For this report a single, aggregate application rate for wheat was developed, and used, which consisted of the acreage-weighted rate for the three types of wheat. In a similar manner, single acreage-weighted rates were also developed for snap beans (fresh and processed), corn (fresh and processed), and tomatoes (fresh and processed). The N, P ($P_2O_5$), and K ($K_2O$) fertilizer application rates for these crops (6 field, 8 vegetables, 6 fruit) are summarized in Appendix Table F-1. Six different global application rates were considered initially for N, P, and K application rates, and these rates are listed at the top of Table 5-1. The three selected application rates for all subsequent calculations are listed at the bottom of Table 5-1. The 6 application rates considered initially included: the maximum rate cited for these crops (max of range); the 19th highest average application rate for the 20 crops selected (95th percentile), the 16th highest average application rate for the 20 crops selected (80th percentile), the average of the top 10 average application rates (avg top 10); the average of all average application rates (avg avg); and the average of all average application rates weighted by the number of acres planted in that crop (avg acre weighted). (Note: The 19th and 16th highest average application rates are unbiased non-parametric statistical estimates of the 95th and 80th percentile average application rates, respectively; see Dudewicz, 1976.)

**Table 5-1. NPK Fertilizer Application Rates (lbs/acre) Used in Calculation of Metal Addition to Soil for Field Crops, Vegetables and Fruits[a]**

| Parameter | N | P | K |
|---|---|---|---|
| max of range | 414 | 252 | 534 |
| 95th pctile | 206 | 173 | 177 |
| 80th pctile | 186 | 120 | 139 |
| avg (top 10) | 178 | 122 | 138 |
| avg (avg) | 124 | 84 | 103 |

| | | | |
|---|---|---|---|
| avg (acre weighted) | 84 | 49 | 69 |
| The following rates were used in subsequent calculations | | | |
| avg | 124 | 84 | 103 |
| high | 206 | 173 | 177 |
| maximum | 414 | 252 | 534 |

a) Source: USDA, ERS, NASS database; see text for more details.

As shown at the bottom of Table 5-1, the average of all average application rates was selected to represent an "average" application rate; the 19th highest average application rate for the 20 crops (95th percentile) was selected to represent a "high" application rate; and the maximum rate cited for these crops (max of range) was selected to represent a "maximum" application rate. The maximum application rates were used on watermelon, lettuce and tomato crops, for N, P, and K respectively. The 95th percentile application rate (high) was the rate applied to broccoli, potatoes, and oranges for N, P, and K respectively.

The Food and Agriculture Organization of the United Nations (FAO) has published world-wide application rates for several additional crops such as peanuts, barley, oats, rye, sunflower, sugar beets, sugar cane, and pasture lane (FAO, 1996). These application rates are based on estimates by experts in the field as opposed to recorded measurements documented in the USDA/NASS database. However, they could be used to supplement the survey data from USDA/NASS that is used in this report. Based on the U.S. data from the FAO, the average application rates are 34 lb/A for nitrogen fertilizers, 18.7 lb/A for $P_2O_5$ fertilizers, and 44.4 lb/A for $K_2O$ fertilizers for peanuts, barley, oats, rye, sunflower, sugar beets, sugar cane, and pasture land. Pasture had the lowest application rates for all three fertilizers at 4.5, 1.8, and 1.78 lb/A for nitrogen, $P_2O_5$, and $K_2O$ fertilizers respectively. The high application rates are 93 lb/A for sugar beets, 44 lb/A for peanuts, and 220 lb/A for sugar cane for nitrogen, $P_2O_5$ and $K_2O$ fertilizers respectively. Although the data from the FAO were not used in these calculations of application rates in Table 5-1, the application rates from the FAO fall within the ranges of the application rates that were used.

The average, high and maximum secondary nutrient, micronutrient, lime and gypsum application rates are listed in Table 5-2. These rates were derived from interviews with experts in the area, including leading scientists with the agricultural extension services at 7 states, and from

**Table 5-2. Secondary Nutrient, Micronutrient and Lime Application Rates (lbs/acre) Used in Calculation of Metal Addition to Soil for Field Crops, Vegetables and Fruits[a]**

| Fertilizer Type | Average[b] | High[c] | Maximum[d] |
|---|---|---|---|
| Zinc | 5 | 10 | 20 |
| Sulfur (nutrient) | 20 | 40 | 60 |
| Sulfur (pH) | 800 | 2,000 | 2,500 |
| Boron | 2 | 3 | 4 |

| | | | |
|---|---|---|---|
| Manganese | 4 | 10 | 18 |
| Magnesium | 25 | 100 | 180 |
| Iron | 10 | 20 | 30 |
| Lime ($CaCO_3$) | 4,000 | 8,000 | 15,000 |
| Gypsum | 2,000 | 4,000 | 8,000 |

a) Source: Ag Extension Service interviews and Internet site-provided information from Ag Extension Services; see text for more details.
b) Average rate from Ag Extension Service data (see Appendix F, Table 1)
c) High is rate determined from Extension Service data (see Appendix F, Table 1)
d) Maximum is highest rate quoted in Extension Service data (see Appendix F, Table 1)

information published by agricultural extension services on the Internet for 8 states. Agricultural extension agency scientists and leading professionals were contacted in CA, OR, WA, AL, OH, NY and NB. Data were obtained from Internet sites for extension services in the following states: NB, MN, GA, AL, FL, IL, MO and TX. The data obtained from these interviews and searches are listed in Appendix Table F-2. Due to the more limited nature of these data compared with the extensive USDA/NASS database, the average and high application rates were selected as best estimates from these searches; the maximum application rate was the highest rate quoted or listed by any agricultural extension service.

The yearly average additions of metals to soil (kg/ha) were calculated for each fertilizer product using Equation [1]. These calculations are tabulated in Appendix G of this report for:

$P_2O_5$ fertilizers: Tables G-1(a-e),
NPK fertilizers applied for $P_2O_5$ content: Tables G-2(a-e),
NPK fertilizers applied for N content: Tables G-3a-e),
Potash ($K_2O$) fertilizers: Tables G-4(a-e),
Zinc (Zn) fertilizers: Tables G-5(a-d),
Manganese (Mn) fertilizers: Tables G-6(a-e),
Boron (B) fertilizers: Tables G-7(a-e),
Iron (Fe) fertilizers: Tables G-8(a-e),
Sulfur (S) fertilizers applied for nutrient content: Tables G-9(a-e),
Sulfur fertilizers (S) applied for pH adjustment: Tables G-10(a-0e),
Liming Materials: Tables G-11(a-e),
Gypsum: Tables G-12(a-e), and
Micronutrient mixes: Tables G-13(a-e).

**Important Note:**

For these calculations, each product-specific metal X level (mg X/kg of product) and the product-specific concentration of active ingredient (e.g. 20% zinc fertilizer = 0.2 kg a.i./kg product) were combined with the three global application rates for average, high and maximum application of active ingredient (Equation [3]), to obtain an average, high and maximum yearly addition of each metal for that specific product. At the conclusion of each table is listed the average yearly metal addition from all products, as (or if) applied at the average, high and maximum application rate. In addition, in Appendix G the product which produces the highest yearly addition of the specific metal being characterized is shaded for visual identification.

As indicated in Equation [3], the yearly addition of metal to soil is determined by both the level of the metal in the product and the level of the desired nutrient. A fertilizer product can contribute high levels of heavy metals to soil when the heavy metal concentration in the product is high and/or when the desired plant nutrient is at a low level in the product. For example, one lime product had $CaCO_3$ content of only 7.6%. Although the Cd concentration in this product was comparable to levels in other lime products, the calculated addition of Cd to soil was high, due to the low nutrient content. For this report, soil metal addition rates for each product were calculated, and then the average soil metal addition rate from all products of a fertilizer category was calculated. The **average** product of each fertilizer category is defined here as that product which would give the average soil addition rate of a given metal.

The fertilizer products that were analyzed in this way are those reported in Section 3, Tables 3-6 though 3-11, with some exceptions. Exceptions include those products for which the active ingredient percentage was not identified (e.g., Table 3-9 samples), the single magnesium fertilizer sample identified (Table 3-8), and the organic and/or biosolids fertilizers (Table 3-7).

Inasmuch as this report was designed to evaluate only the inorganic fertilizers, the organic fertilizers and/or soil amendments (sewage sludge, humus, compost, tankage, etc.) were not carried through this set of calculations. Those NPK fertilizers that were clearly identified as being "biosolids-based" were also eliminated from these calculations. In addition, soil amendments, potting soils, and “soil conditioners” were not carried through this set of calculations, this due in part because application rates were not fully characterized.

Tables 5-3a through 5-8a provide the summary of the average metals soil additions (kg/ha soil) that may result from average, high and maximum application rates of inorganic fertilizers, gypsum and lime. Tables 5-3b through 5-8b provide the summary of the average, high and maximum soil metal contaminant levels resulting from the individual products in each fertilizer category which give rise to the highest calculated soil loadings with the global average, high and maximum product-specific application rates.

Application of zinc fertilizers (Table 5-3a) at the maximum application rate results in soil additions of less than 0.1 kg/hectare of all metals except for lead (0.884 kg/hectare). Phosphate products (Table 5-3a) at the maximum application rate also result in metal addition to the soil of less than <0.1 kg/hectare for all metals except chromium (0.1 kg/hectare), vanadium (0.173 kg/ha) and zinc (0.150 kg/hectare). NPK fertilizers applied for N content (Table 5-4a) and applied at the maximum rate contribute 0.10 kg/ha/year of lead to the soil (Table 5-4a). Boron and $K_20$ fertilizers (Tables 5-5a and 5-6a) contribute extremely low levels of contaminants, generally <0.001 kg/ha/year at the maximum application rate, with exception of 0.023 kg/ha/year of arsenic from boron fertilizers. Iron fertilizers contribute almost 0.5 kg/ha/year of arsenic and 1.6 kg/ha/year of lead to the soil when applied at the maximum rate (Table 5-5a). The manganese fertilizers (Table 5-6a) contribute very low levels of contaminants, with the highest level contributed by the zinc in the manganese fertilizers at 0.004 kg/ha/year at the maximum application rate. Adding sulfur to the soil as a nutrient adds 0.18 kg/ha of zinc to the soil; adding sulfur for pH adjustment adds 0.11 kg/ha of copper to the soil each year (Table 5-7a) at the maximum application rate. Average additions of zinc and vanadium (0.48 and 0.30 kg/ha, respectively) are the highest metals additions from gypsum applications (Table 5-8a). Zinc, lead and copper (at 6.6, 0.69 and 0.63 kg/a, respectively) are the metals added in highest quantities with liming agents (Table 5-8a).

The data from Tables 5-3(a/b) to 5-8(a/b) are represented graphically in Figures 5-1 to 5-9. As shown in Figure 5-1, the data for Cd additions to soil from the different fertilizer types are compared, and those individual products which are known to be derived from industrial waste products are so indicated.

The number of metals analyzed in each fertilizer product varied from as few as one or two, to the entire suite of nine metals. In Tables 5-3a through 5-8a, the number of samples in which a Cd concentration was measured is given in the header information of that table. In general, Cd was the one metal analyzed most frequently. However, because some of the metals were analyzed far less frequently than Cd, the number of samples, by fertilizer type, which provided concentration data for each metal have been tabulated (see Table 5-9).
As shown there, the data for several of the metals in several fertilizer types is limited, and this may significantly affect the accuracy of conclusions drawn about the soil additions of these metals.

This table provides a listing of the number of products in each fertilizer category for which metals data were available, and the number of those products which exceeded the annualized Canadian Fertilizers Regulations limits when applied at the nutrient application rates chosen here. Note that in each fertilizer category, metals concentrations were not available for all products. For example, for the $P_2O_5$ fertilizers, Cd levels were listed for 61 products, Pb levels were given for 58 products, As levels were given for 64 products, and so on. Several of the metals evaluated here, e.g., Cr, V, and Cu, do not have limits imposed by the Canadian regulations, and for these metals an accounting of exceedances was not necessary. The exceedances in Table 5-9 are listed separately in Table 5-10 by the number of products that exceed the Canadian standards at the average, high and maximum nutrient application rates evaluated here. For example, in the $P_2O_5$ products, the one product that exceeded the Canadian standards did so only at the maximum application rate. In the NPK products applied for $P_2O_5$ content (NPK-P), 5 products exceeded the Canadian standards at the high application rate, and 10 products exceeded the standard at the maximum application rate. One lime product exceeded standards for 5 of the metals at the average application rate; one NPK-P product exceeded Pb standards at the average application rate; and one iron product exceeded As standards at the average application rate.

**Table 5-3a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Zinc and Phosphate Fertilizers[a]**

| | Zinc Fertilizers at application rate (n = 22)[b] | | | Phosphate ($P_2O_5$) Fertilizers at application rate (n = 61) | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[c] | kg/ha[d] |
| Yearly Addition in kg/ha | | | | | | | | |
| Cd | 0.007 | 0.014 | 0.029 | 0.011 | 0.022 | 0.033 | 1.9 | 0.089 |
| Pb | 0.221 | 0.442 | 0.884 | 0.003 | 0.007 | 0.009 | 15 | 2.222 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| As | < 0.001 | 0.001 | 0.002 | 0.002 | 0.005 | 0.007 | 2.0 | 0.333 |
| Cr | 0.011 | 0.021 | 0.042 | 0.034 | 0.070 | 0.102 | nl[e] | nl |
| Hg | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.85 | 0.022 |
| Ni | 0.010 | 0.019 | 0.039 | 0.006 | 0.012 | 0.018 | 21 | 0.800 |
| V | 0.001 | 0.001 | 0.003 | 0.052 | 0.107 | 0.155 | nl | nl |
| Cu | 0.023 | 0.046 | 0.091 | 0.020 | 0.042 | 0.061 | 75 | nl |
| Zn | NA[f] | NA | NA | 0.050 | 0.103 | 0.150 | 140 | 8.222 |

a) Source: See Appendices G-5(a-d) for Zn fertilizers and G-1(a-e) for $P_2O_5$ fertilizers
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9.
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions; the numbers in the table were divided by 45 to be comparable to the U.S. annual pollutant loading rates
e) nl = no limits currently set
f) Not applicable: Zinc fertilizers are applied specifically to add zinc to the soil and/or crop.

## Table 5-4a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: NPK for N Content and NPK for P Content Fertilizers[a]

| | Applied for P Content NPK Fertilizers at application rate (n = 91)[b] | | | Applied for N Content NPK Fertilizers at application rate (n = 50) | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[c] | kg/ha[d] |
| Yearly Addition in kg/ha | | | | | | | | |
| **Cd** | 0.008 | 0.017 | 0.025 | 0.006 | 0.009 | 0.018 | 1.9 | 0.089 |
| **Pb** | 0.087 | 0.179 | 0.261 | 0.031 | 0.051 | 0.103 | 15 | 2.222 |
| **As** | 0.004 | 0.008 | 0.012 | 0.008 | 0.013 | 0.027 | 2 | 0.333 |
| **Cr** | 0.019 | 0.039 | 0.057 | 0.081 | 0.134 | 0.270 | nl[e] | nl |
| **Hg** | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.85 | 0.022 |
| **Ni** | 0.006 | 0.013 | 0.019 | 0.018 | 0.030 | 0.061 | 21 | 0.8 |
| **V** | 0.042 | 0.087 | 0.127 | 0.106 | 0.176 | 0.354 | nl | nl |
| **Cu** | 0.013 | 0.028 | 0.040 | 0.064 | 0.107 | 0.215 | 75 | nl |
| **Zn** | 0.054 | 0.112 | 0.163 | 0.308 | 0.513 | 1.030 | 140 | 8.222 |

a) Source: See Appendices G-2 (a-e) for NPK-P and G-3(a-e) for NPK-N.
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits
e) nl = no limits currently set

**Table 5-5a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Boron and Iron Fertilizers[a]**

| | Boron Fertilizers at application rate (n = 2)[b] | | | Iron Fertilizers at application rate (n = 3) | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[c] | kg/ha[d] |
| Yearly Addition in kg/ha | | | | | | | | |
| Cd | < 0.001 | < 0.001 | < 0.001 | 0.009 | 0.018 | 0.027 | 1.9 | 0.089 |
| Pb | < 0.001 | < 0.001 | < 0.001 | 0.549 | 1.098 | 1.647 | 15 | 2.222 |
| As | 0.012 | 0.017 | 0.023 | 0.155 | 0.310 | 0.465[e] | 2.0 | 0.333 |
| Cr | < 0.001 | < 0.001 | < 0.001 | nt[f] | nt | nt | nl[g] | nl |
| Hg | < 0.001 | < 0.001 | < 0.001 | nt | nt | nt | 0.85 | 0.022 |
| Ni | < 0.001 | < 0.001 | < 0.001 | nt | nt | nt | 21 | 0.800 |
| V | < 0.001 | 0.001 | 0.001 | nt | nt | nt | nl | nl |
| Cu | < 0.001 | < 0.001 | < 0.001 | 0.051 | 0.102 | 0.153 | 75 | nl |
| Zn | < 0.001 | 0.001 | 0.001 | nt | nt | nt | 140 | 8.222 |

a) Source: See Appendix G-7(a-e) for Boron and G-8(a-e) for Iron
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits
e) Shading indicates that value exceeds Canadian standard
f) nt = analyte not tested in fertilizers
g) nl = no limits currently set

**Table 5-6a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Potash and Manganese Fertilizers[a]**

| | $K_2O$ Fertilizers at Application Rate (n = 42)[b] | | | Manganese Fertilizers at Application Rate (n = 2) | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[c] | kg/ha[d] |
| Yearly Addition in kg/ha | | | | | | | | |
| Cd | < 0.001 | < 0.001 | 0.001 | < 0.001 | < 0.001 | < 0.001 | 1.9 | 0.089 |
| Pb | 0.001 | 0.001 | 0.003 | < 0.001 | 0.001 | 0.002 | 15 | 2.222 |
| As | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.001 | 2.0 | 0.333 |
| Cr | < 0.001 | 0.001 | 0.001 | < 0.001 | < 0.001 | 0.001 | nl[e] | nl |
| Hg | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.85 | 0.022 |
| Ni | < 0.001 | < 0.001 | 0.002 | 0.001 | 0.002 | 0.003 | 21 | 0.800 |
| V | < 0.001 | 0.001 | 0.002 | < 0.001 | < 0.001 | < 0.001 | nl | nl |
| Cu | < 0.001 | < 0.001 | 0.001 | < 0.001 | < 0.001 | 0.001 | 75 | nl |
| Zn | < 0.001 | 0.001 | 0.002 | 0.001 | 0.002 | 0.004 | 140 | 8.222 |

a) Source: See Appendices G-4(a-e) for Potash and G-6(a-e) and Manganese
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9.
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
e) nl = no limits currently set

**Table 5-7a. Averaged Yearly Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Sulfur (Nutrient) and Sulfur (pH Adjustment) Fertilizers[a]**

| | Sulfur (nutrient) at application rate (n = 9)[b] | | | Sulfur (pH adjustment) at application rate (n = 5) | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[c] | kg/ha[d] |
| Yearly Addition in kg/ha | | | | | | | | |
| Cd | 0.003 | 0.005 | 0.008 | < 0.001 | < 0.001 | < 0.001 | 1.9 | 0.089 |
| Pb | < 0.001 | 0.001 | 0.001 | 0.002 | 0.006 | 0.007 | 15 | 2.222 |
| As | < 0.001 | < 0.001 | 0.001 | 0.007 | 0.017 | 0.022 | 2.0 | 0.333 |
| Cr | 0.009 | 0.017 | 0.026 | nt[e] | nt | nt | nl[f] | nl |
| Hg | < 0.001 | < 0.001 | < 0.001 | nt | nt | nt | 0.85 | 0.022 |
| Ni | 0.008 | 0.016 | 0.023 | nt | nt | nt | 21 | 0.800 |
| V | 0.016 | 0.032 | 0.048 | nt | nt | nt | nl | nl |
| Cu | 0.001 | 0.002 | 0.002 | 0.036 | 0.090 | 0.113 | 75 | nl |
| Zn | 0.060 | 0.120 | 0.181 | nt | nt | nt | 140 | 8.222 |

a) Source: See Appendices G-9(a-e) sulfur (nutrient) and G-10(a-e) for sulfur (pH adjustment)
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9.
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
e) nt = analyte not tested in fertilizers; NPKS and sulfur used for S-nutrient addition; only sulfur products used for pH adjustment
f) nl = no limits currently set

**Table 5-8a. Averaged Yearly Addition Addition of Metals to Soil from All Products Applied at Average, High and Maximum Nutrient Application Rates: Gypsum and Liming Materials[a]**

| | Gypsum at Application Rate (n = 4)[b] | | | Lime at Application Rate (n = 10)[b] | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[c] | kg/ha[d] |
| **Yearly Addition in kg/ha** | | | | **(for year in which addded)[e]** | | | | |
| **Cd** | 0.002 | 0.004 | 0.007 | 0.017 | 0.034 | 0.064 | 1.9 | 0.089 |
| **Pb** | 0.010 | 0.021 | 0.041 | 0.902 | 1.804 | 3.383[f] | 15 | 2.222 |
| **As** | 0.010 | 0.020 | 0.040 | 0.344 | 0.689 | 1.292 | 2.0 | 0.333 |
| **Cr** | 0.003 | 0.006 | 0.013 | 0.371 | 0.742 | 1.391 | nl[g] | nl |
| **Hg** | < 0.001 | < 0.001 | < 0.001 | 0.003 | 0.007 | 0.013 | 0.85 | 0.022 |
| **Ni** | 0.007 | 0.013 | 0.027 | 0.200 | 0.400 | 0.750 | 21 | 0.800 |
| **V** | 0.076 | 0.152 | 0.303 | 0.348 | 0.696 | 1.305 | nl | nl |
| **Cu** | 0.053 | 0.106 | 0.212 | 0.910 | 1.819 | 3.411 | 75 | nl |
| **Zn** | 0.121 | 0.241 | 0.482 | 4.456 | 8.911 | 16.708 | 140 | 8.222 |
| **Yearly Addition in kg/ha** | | | | **(average over 3 years)[h]** | | | | |
| **Cd** | | | | 0.006 | 0.011 | 0.021 | 1.9 | 0.089 |
| **Pb** | | | | 0.300 | 0.601 | 1.127 | 15 | 2.222 |
| **As** | | | | 0.115 | 0.230 | 0.431 | 2.0 | 0.333 |
| **Cr** | | | | 0.124 | 0.247 | 0.464 | nl | nl |
| **Hg** | | | | 0.001 | 0.002 | 0.004 | 0.85 | 0.022 |
| **Ni** | | | | 0.067 | 0.133 | 0.250 | 21 | 0.800 |
| **V** | | | | 0.116 | 0.232 | 0.435 | nl | nl |
| **Cu** | | | | 0.303 | 0.606 | 1.137 | 75 | nl |
| **Zn** | | | | 1.485 | 2.970 | 5.569 | 140 | 8.222 |

a) Source: See Appendices G-11(a-e) for lime and G-12(a-e) for gypsum
b) Number of samples providing Cd values for calculation; number of samples providing other metals are listed in Table 5-9
c) U.S. limits in kg/ha are annual pollutant loading rates
d) Canadian limits in kg/ha are long term cumulative additions, so values were divided by 45 to approximate annual limits
e) Additions of metals for lime addition based on year in which application is made. Lime typically added only once every three years
f) Shading indicates value exceeds Canadian standard
g) nl = no limits currently set
h) Values listed in this portion of the table are the metals additions averaged over 3 years

**Table 5-3b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Zinc and Phosphate Fertilizers[a]**

| | Zinc Fertilizers at application rate | | | Phosphate ($P_2O_5$) Fertilizers at application rate | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[b] | kg/ha[c] |
| Yearly Addition in kg/ha | | | | | | | | |
| Cd | 0.036 | 0.071 | 0.143[d] | 0.038 | 0.078 | 0.113 | 1.9 | 0.089 |
| Pb | 0.856 | 1.713 | 3.426 | 0.094 | 0.194 | 0.282 | 15 | 2.222 |
| As | 0.001 | 0.003 | 0.006 | 0.006 | 0.013 | 0.018 | 2.0 | 0.333 |
| Cr | 0.018 | 0.036 | 0.072 | 0.124 | 0.256 | 0.372 | nl[e] | nl |
| Hg | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.85 | 0.022 |
| Ni | 0.086 | 0.172 | 0.344 | 0.032 | 0.065 | 0.095 | 21 | 0.800 |
| V | 0.001 | 0.003 | 0.005 | 0.151 | 0.311 | 0.452 | nl | nl |
| Cu | 0.064 | 0.128 | 0.255 | 0.550 | 1.135 | 1.650 | 75 | nl |
| Zn | NA[f] | NA | NA | 0.324 | 0.668 | 0.971 | 140 | 8.222 |

a) Source: See Appendices G-5(a-d) for zinc fertilizers and G-1(a-e) for $P_2O_5$ fertilizers
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions); the numbers in the table were divided by 45 to be comparable to the U.S. annual pollutant loading rates
d) Shading indicates value exceeds Canadian standard
e) nl = no limits currently set
f) Not applicable: Zinc fertilizers are applied specifically to add zinc to the soil and/or crop.

**Table 5-4b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: NPK for N Content and NPK for P content Fertilizers[a]**

| | Applied for P Content: NPK Fertilizers at application rate | | | Applied for N Content: NPK Fertilizers at application rate | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[b] | kg/ha[c] |
| Yearly Addition in kg/ha | | | | | | | | |
| **Cd** | 0.074 | 0.154[d] | 0.223 | 0.022 | 0.036 | 0.074 | 1.9 | 0.089 |
| **Pb** | 2.820 | 5.820 | 8.460 | 0.652 | 1.083 | 2.176 | 15 | 2.222 |
| **As** | 0.112 | 0.231 | 0.336 | 0.049 | 0.081 | 0.162 | 2 | 0.333 |
| **Cr** | 0.126 | 0.260 | 0.378 | 0.312 | 0.519 | 1.042 | nl[e] | nl |
| **Hg** | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.001 | 0.85 | 0.022 |
| **Ni** | 0.092 | 0.189 | 0.275 | 0.119 | 0.198 | 0.398 | 21 | 0.8 |
| **V** | 0.186 | 0.384 | 0.558 | 0.639 | 1.063 | 2.134 | nl | nl |
| **Cu** | 0.353 | 0.728 | 1.058 | 1.080 | 1.795 | 3.606 | 75 | nl |
| **Zn** | 0.696 | 1.436 | 2.087 | 6.860 | 11.401 | 22.901 | 140 | 8.222 |

a) Source: See Appendices G-2 (a-e) for NPK-P and G-3(a-e) NPK-N.
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
d) Shading indicates value exceeds Canadian standard.
e) nl = no limits currently set

**Table 5-5b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Boron and Iron Fertilizers[a]**

| | Boron Fertilizers at application rate | | | Iron Fertilizers at application rate | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[b] | kg/ha[c] |
| Yearly Addition in kg/ha | | | | | | | | |
| Cd | < 0.001 | < 0.001 | < 0.001 | 0.025 | 0.050 | 0.075 | 1.9 | 0.089 |
| Pb | < 0.001 | < 0.001 | < 0.001 | 1.400 | 2.800[d] | 4.200 | 15 | 2.222 |
| As | 0.023 | 0.035 | 0.047 | 0.462 | 0.924 | 1.386 | 2.0 | 0.333 |
| Cr | < 0.001 | < 0.001 | < 0.001 | nt[e] | nt | nt | nl[f] | nl |
| Hg | < 0.001 | < 0.001 | < 0.001 | nt | nt | nt | 0.85 | 0.022 |
| Ni | < 0.001 | < 0.001 | < 0.001 | nt | nt | nt | 21 | 0.800 |
| V | < 0.001 | 0.001 | 0.001 | nt | nt | nt | nl | nl |
| Cu | < 0.001 | < 0.001 | < 0.001 | 0.131 | 0.261 | 0.392 | 75 | nl |
| Zn | < 0.001 | 0.001 | 0.001 | nt | nt | nt | 140 | 8.222 |

a) Source: See Appendix G-7(a-e) for boron and G-8(a-e) for iron
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits
d) Shading indicates value exceeds Canadian standard
e) nt = analyte not tested in fertilizers
f) Standards are not specified in these units

**Table 5-6b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Potash and Manganese Fertilizers[a]**

| | $K_2O$ Fertilizers at Application Rate | | | Manganese Fertilizers at Application | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[b] | kg/ha[c] |
| Yearly Addition in kg/ha | | | | | | | | |
| Cd | < 0.001 | 0.001 | 0.002 | < 0.001 | < 0.001 | < 0.001 | 1.9 | 0.089 |
| Pb | 0.002 | 0.004 | .012 | 0.001 | 0.002 | 0.003 | 15 | 2.222 |
| As | < 0.001 | 0.001 | 0.002 | < 0.001 | 0.001 | 0.001 | 2.0 | 0.333 |
| Cr | 0.001 | 0 .002 | 0 .007 | < 0.001 | < 0.001 | 0.001 | nl[d] | nl |
| Hg | < 0.001 | < 0.001 | 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.85 | 0.022 |
| Ni | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.003 | 21 | 0.800 |
| V | 0.005 | 0.008 | 0.024 | < 0.001 | < 0.001 | < 0.001 | nl | nl |
| Cu | 0.002 | 0.004 | 0.013 | < 0.001 | 0.001 | 0.001 | 75 | nl |
| Zn | 0.004 | 0.008 | 0.023 | 0.001 | 0.002 | 0.004 | 140 | 8.222 |

a) Source: See Appendices G-4(a-e) for $K_2O$ and G-6(a-e) for manganese
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
d) nl = no limits currently set

**Table 5-7b. Highest Yearly Maximum Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Sulfur (Nutrient) and Sulfur (pH Adjustment) Fertilizers[a]**

| | Sulfur (nutrient) at application rate | | | Sulfur (pH adjustment) at application rate | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[b] | kg/ha[c] |
| Yearly Addition in kg/ha | | | | | | | | |
| Cd | 0.023 | 0.046 | 0.070 | < 0.001 | < 0.001 | < 0.001 | 1.9 | 0.089 |
| Pb | 0.001 | 0.003 | 0.004 | 0.008 | 0.019 | 0.024 | 15 | 2.222 |
| As | 0.001 | 0.001 | 0.002 | 0.017 | 0.043 | 0.053 | 2.0 | 0.333 |
| Cr | 0.034 | 0.068 | 0.103 | nt[d] | nt | nt | nl[e] | nl |
| Hg | < 0.001 | < 0.001 | < 0.001 | nt | nt | nt | 0.85 | 0.022 |
| Ni | 0.031 | 0.062 | 0.094 | nt | nt | nt | 21 | 0.800 |
| V | 0.063 | 0.127 | 0.190 | nt | nt | nt | nl | nl |
| Cu | 0.003 | 0.005 | 0.008 | 0.098 | 0.244 | 0.305 | 75 | nl |
| Zn | 0.237 | 0.474 | 0.710 | nt | nt | nt | 140 | 8.222 |

a) Source: See Appendices G-9(a-e) for sulfur (nutrient) and G-10(a-e) for sulfur (pH adjustment)
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
d) nt = analyte not tested in fertilizers
e) nl = no limits currently set

**Table 5-8b. Highest Yearly Addition of Metals to Soil from an Individual Product, Applied at Average, High and Maximum Nutrient Application Rates: Gypsum and Liming Materials[a]**

| | Gypsum at Application Rate | | | Lime at Application Rate | | | U.S. 40 CFR Part 503 - Biosolids | Canadian Fertilizer Act |
|---|---|---|---|---|---|---|---|---|
| | average | high | maximum | average | high | maximum | kg/ha[b] | kg/ha[c] |
| Yearly Addition in kg/ha | | | | (for year in which added)[d] | | | | |
| Cd | 0.006 | 0.011 | 0.022 | 0.044 | 0.088 | 0.165 | 1.9 | 0.089 |
| Pb | 0.025 | 0.049 | 0.099 | 7.368 | 14.737 | 27.632 | 15 | 2.222 |
| As | 0.019 | 0.038 | 0.076 | 2.829 | 5.659 | 10.611 | 2.0 | 0.333 |
| Cr | 0.003 | 0.006 | 0.013 | 2.004 | 4.008 | 7.515 | nl[f] | nl |
| Hg | < 0.001 | < 0.001 | < 0.001 | 0.024 | 0.049 | 0.092 | 0.85 | 0.022 |
| Ni | 0.007 | 0.013 | 0.027 | 1.356 | 2.712 | 5.085 | 21 | 0.800 |
| V | 0.112 | 0.224 | 0.448 | 2.417 | 4.834 | 9.064 | nl | nl |
| Cu | 0.094 | 0.188 | 0.376 | 6.838 | 13.676 | 25.643 | 75 | nl |
| Zn | 0.121 | 0.241 | 0.482 | 24.994 | 49.987 | 93.726 | 140 | 8.222 |
| | | | | (average over 3 years)[g] | | | | |
| Cd | | | | 0.015 | 0.029 | 0.055 | 1.9 | 0.089 |
| Pb | | | | 2.456 | 4.912 | 9.211 | 15 | 2.222 |
| As | | | | 0.943 | 1.886 | 3.537 | 2.0 | 0.333 |
| Cr | | | | 0.668 | 1.336 | 2.505 | nL | nl |
| Hg | | | | 0.008 | 0.016 | 0.031 | 0.85 | 0.022 |
| Ni | | | | 0.452 | 0.904 | 1.695 | 21 | 0.800 |
| V | | | | 0.806 | 1.611 | 3.021 | nl | nl |
| Cu | | | | 2.279 | 4.559 | 8.548 | 75 | nl |
| Zn | | | | 8.331 | 16.662 | 31.242 | 140 | 8.222 |

a) Source: See Appendices G-11(a-e) for gypsum and G-12(a-e) for liming materials
b) U.S. limits in kg/ha are annual pollutant loading rates
c) Canadian limits in kg/ha are long term cumulative additions so values were divided by 45 to approximate annual limits.
d) Lime is usually applied only once every 3 years. Values listed in this portion of the table are the metals additions added in the year of application.
e) Shading indicates value exceeds Canadian standard
f) nl = no limits currently set
g) Lime is usually applied only once every 3 years. Values listed in this portion of the table are the metals additions averaged over 3 years.

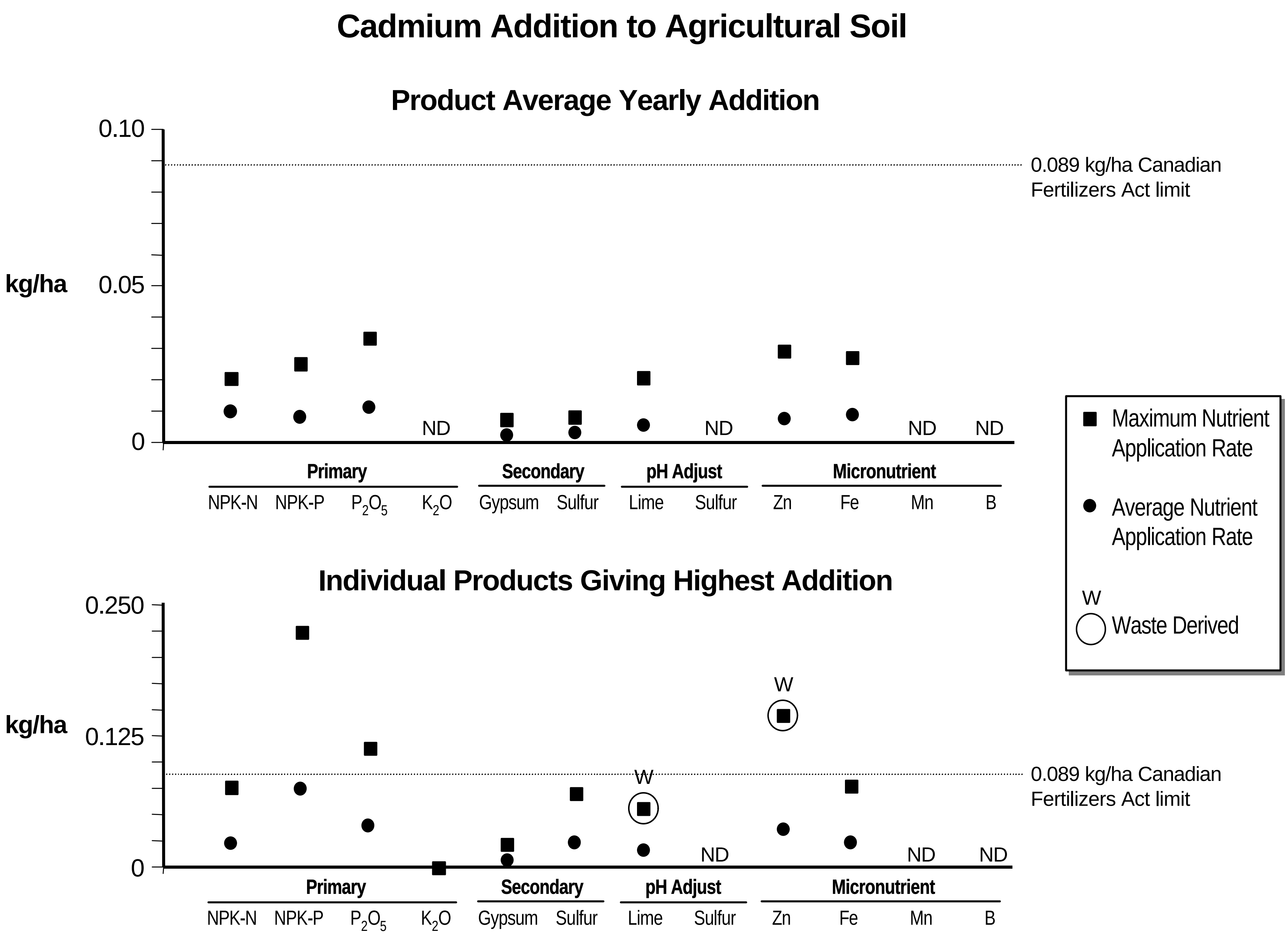


**Figure 5-1. Cadmium Addition to Agricultural Soil from Twelve Fertilizer Types**

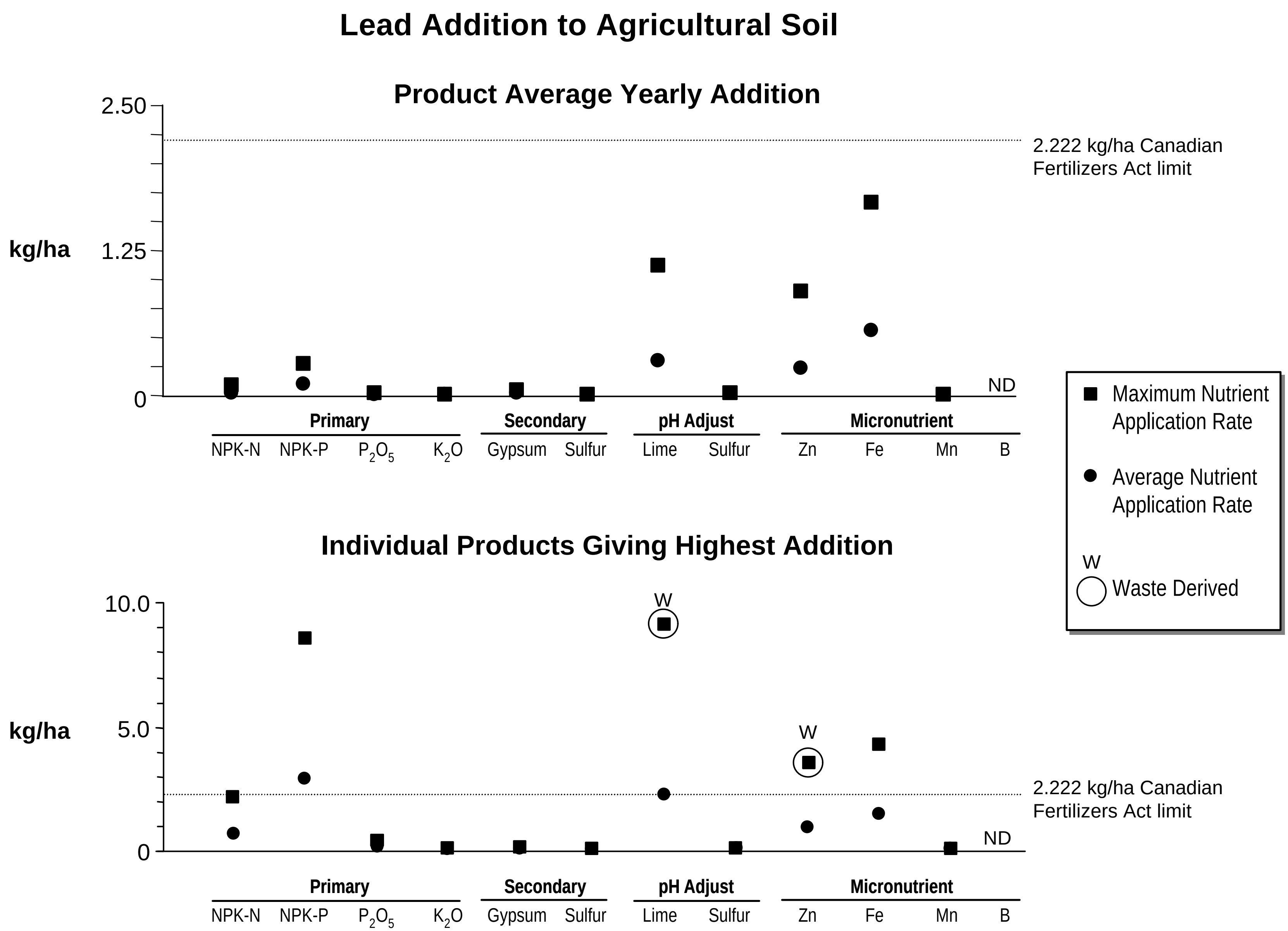


**Figure 5-2. Lead Addition to Agricultural Soil from Twelve Fertilizer Types**

# Arsenic Addition to Agricultural Soil

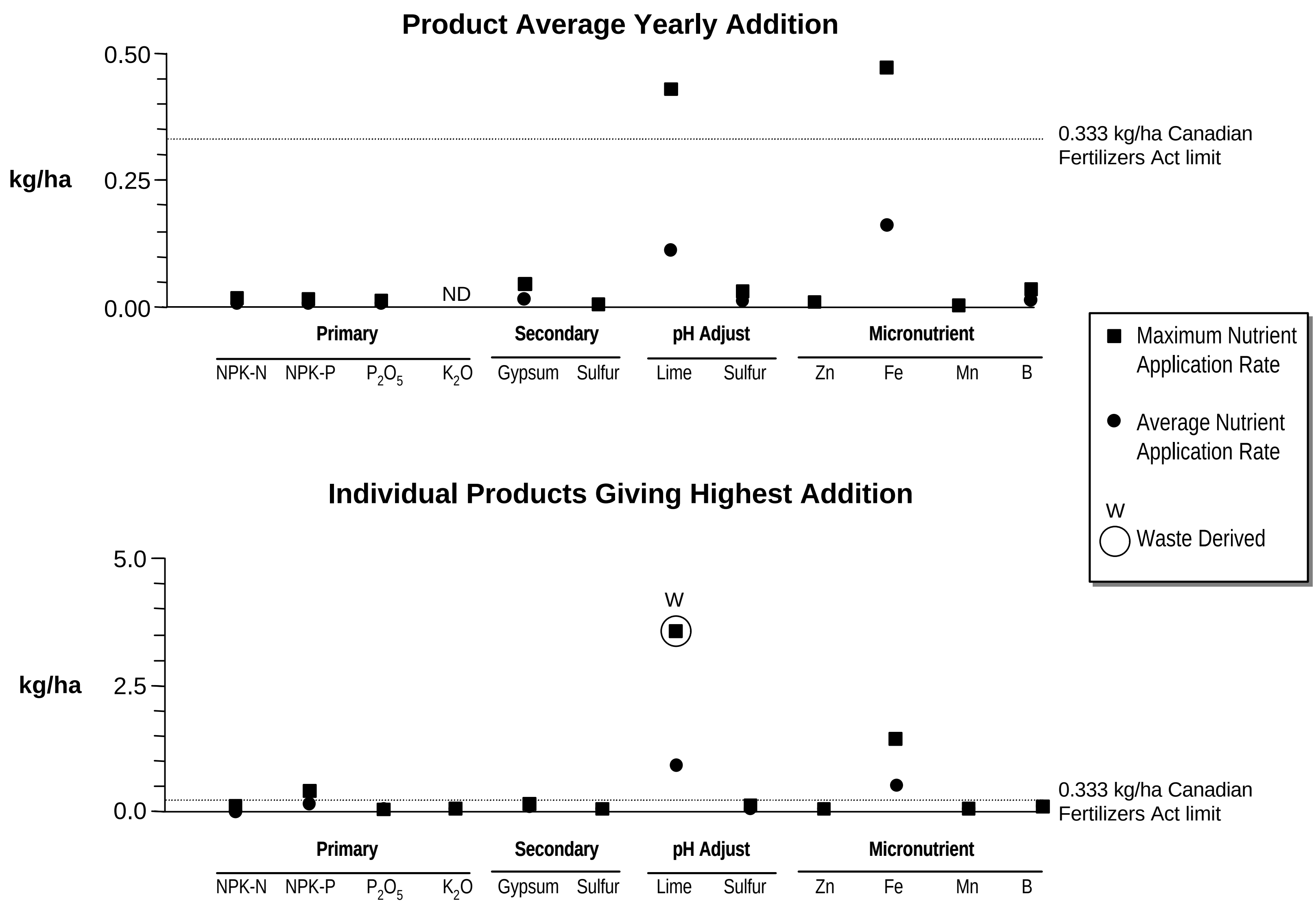


**Figure 5-3. Arsenic Addition to Agricultural Soil from Twelve Fertilizer Types**

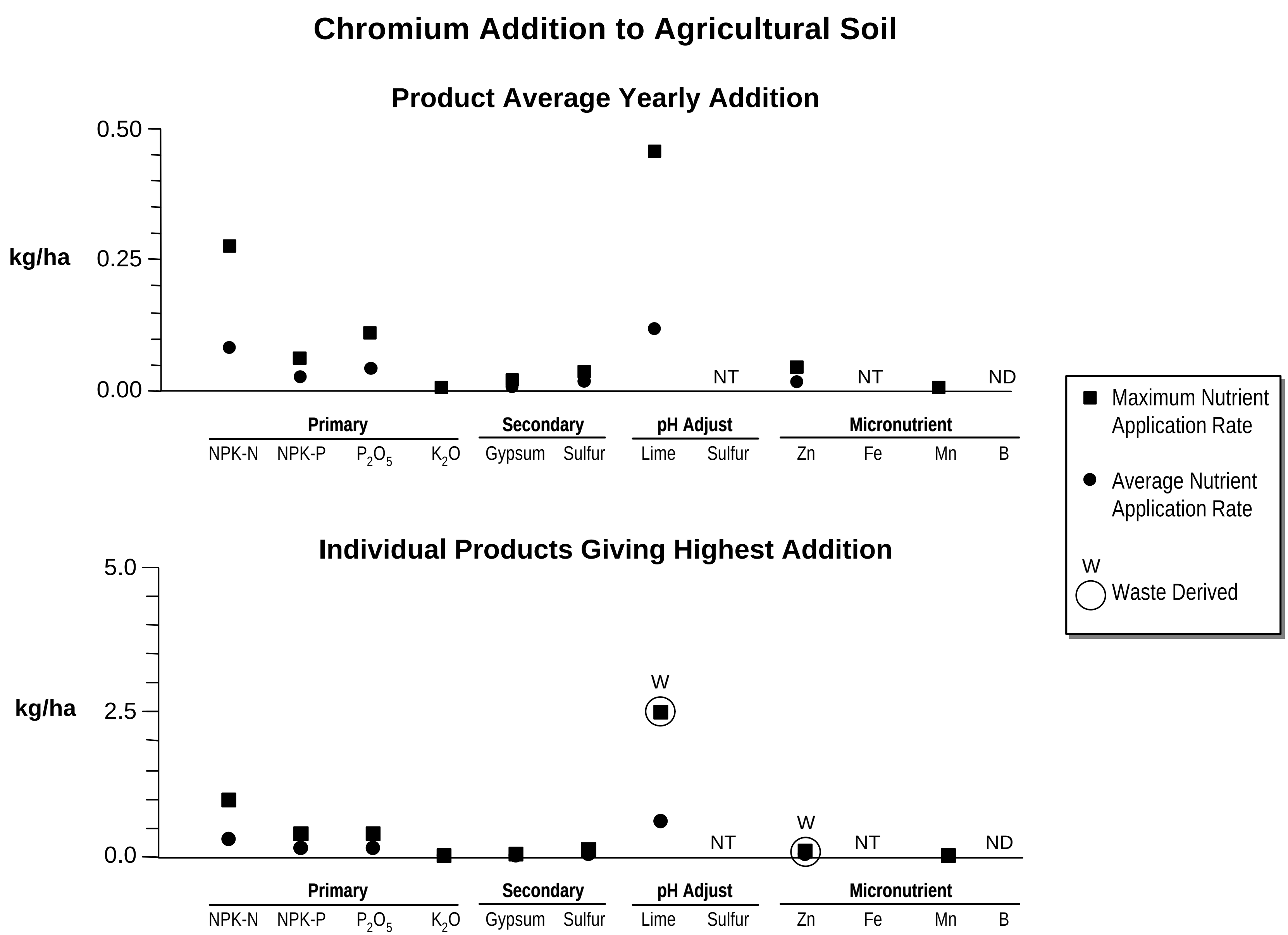


**Figure 5-4. Chromium Addition to Agricultural Soil from Twelve Fertilizer Types**

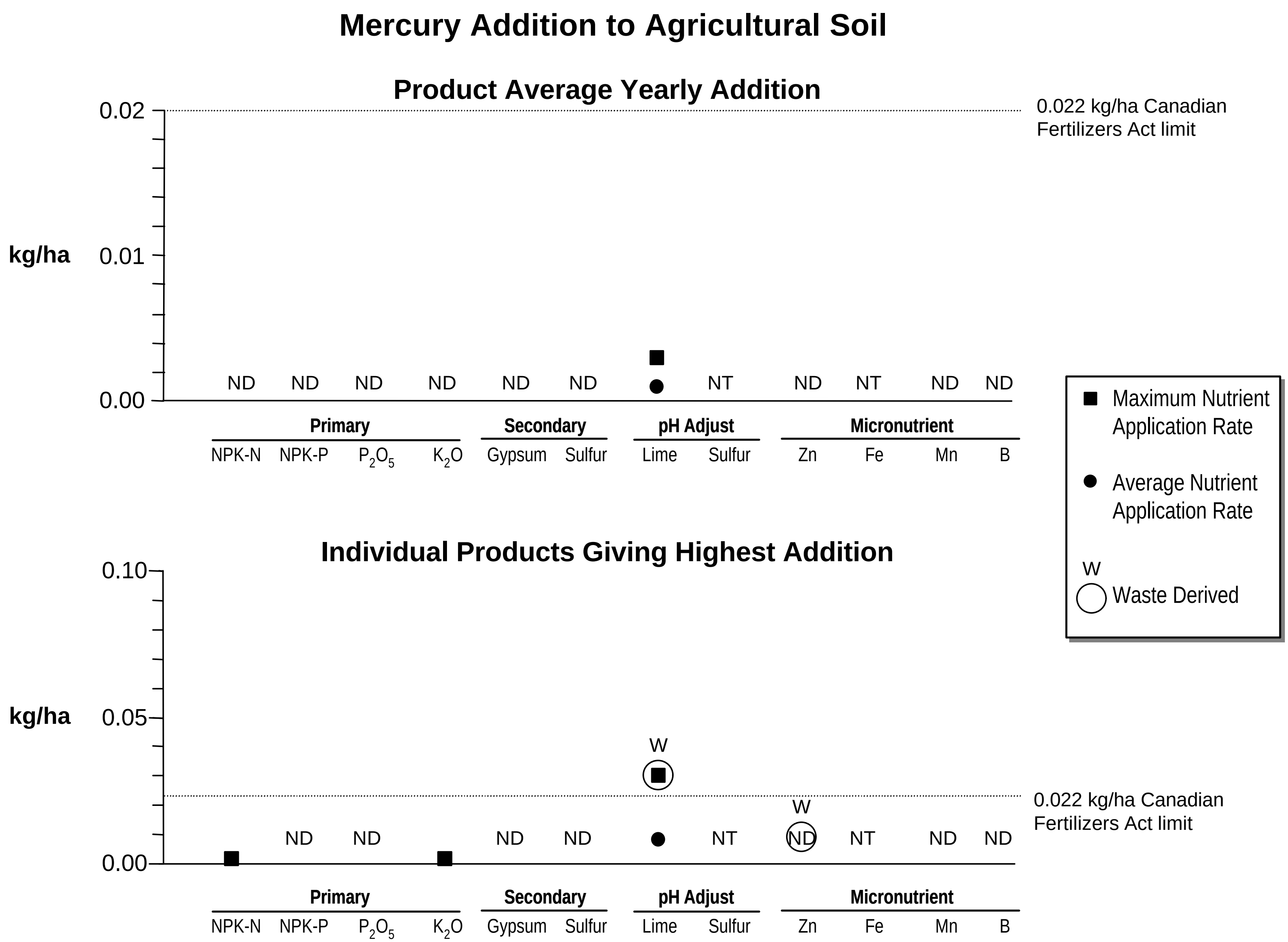


**Figure 5-5. Mercury Addition to Agricultural Soil from Twelve Fertilizer Types**

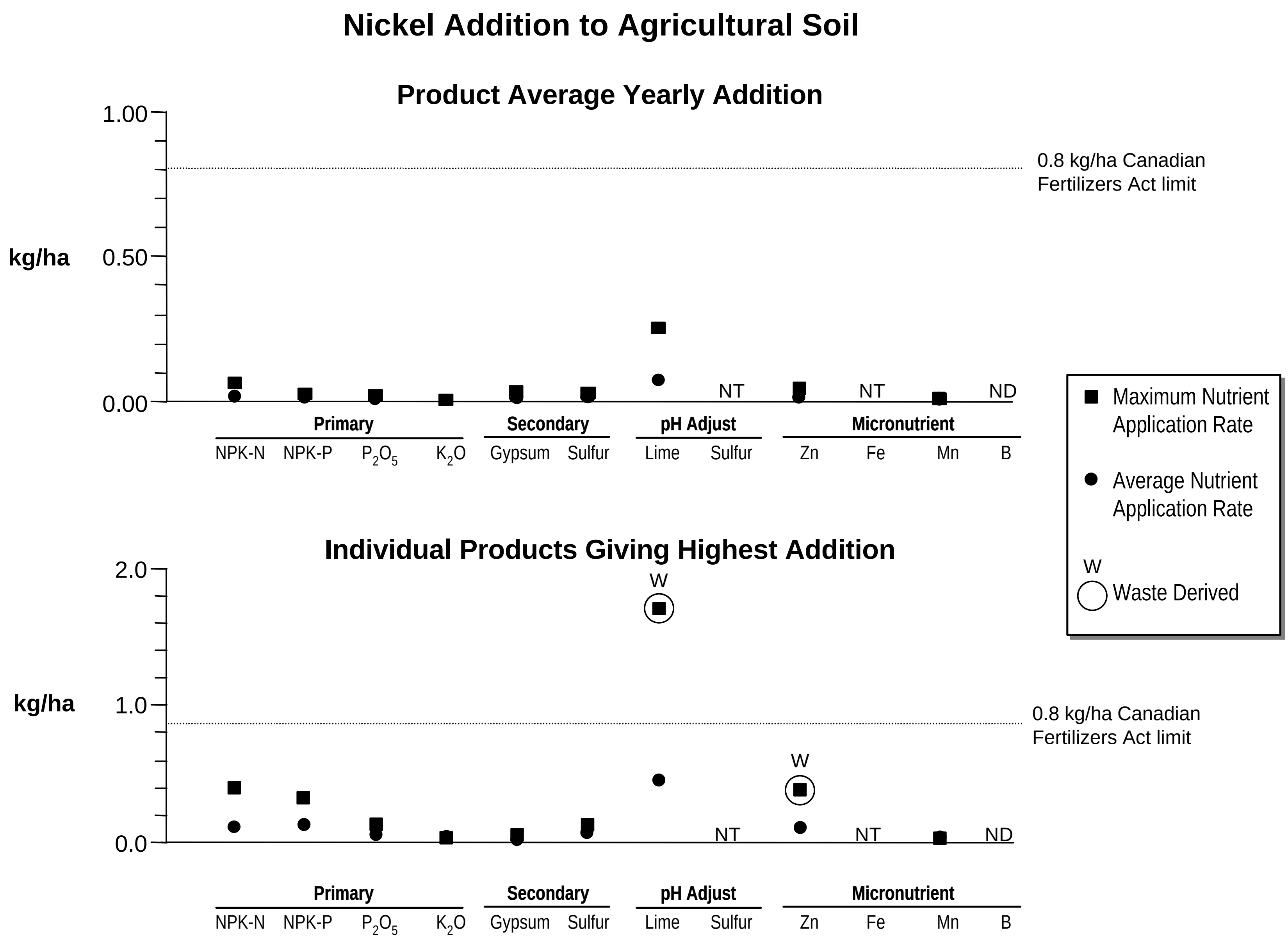


**Figure 5-6. Nickel Addition to Agricultural Soil from Twelve Fertilizer Types**

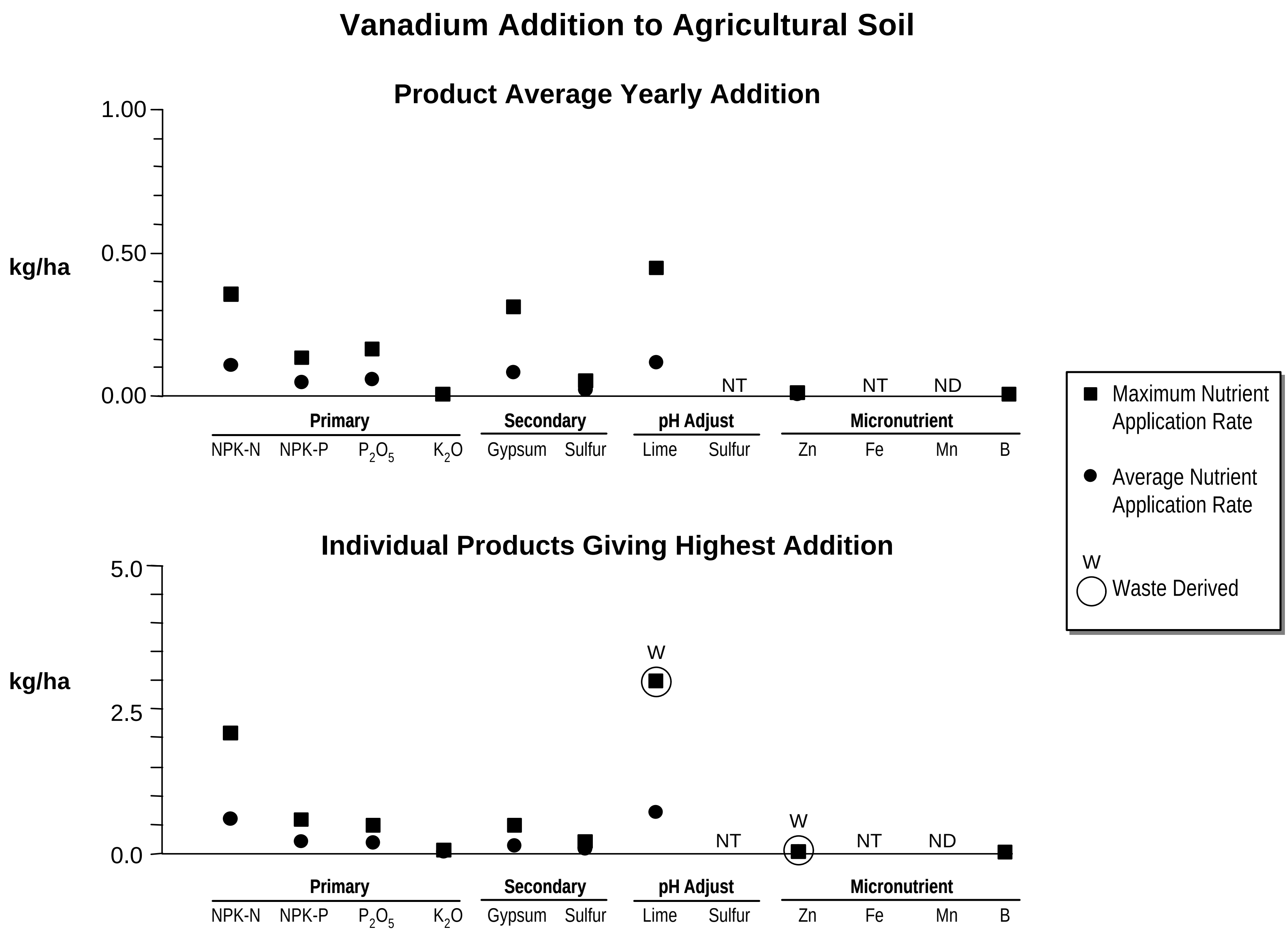


**Figure 5-7. Vanadium Addition to Agricultural Soil from Twelve Fertilizer Types**

# Copper Addition to Agricultural Soil

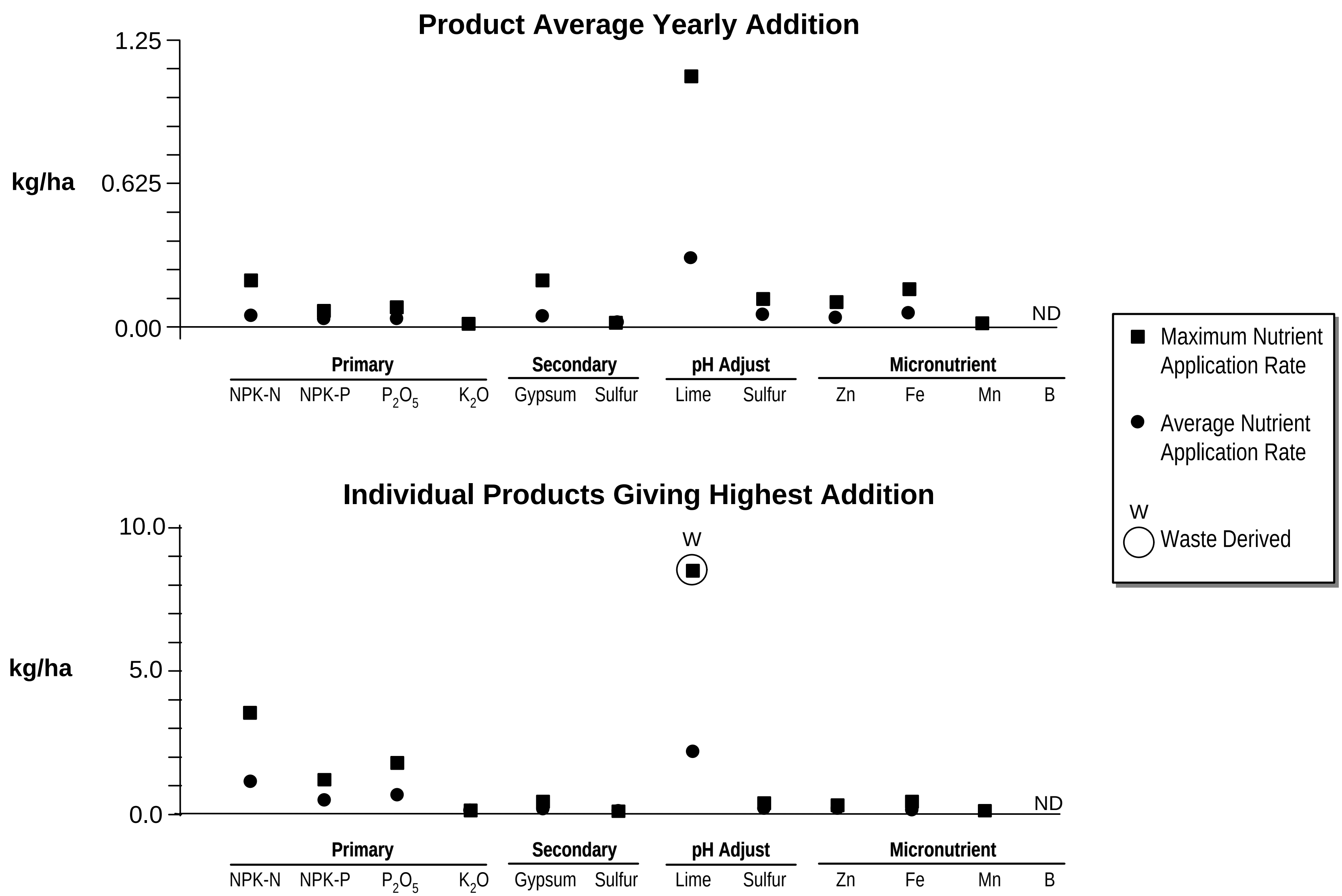


**Figure 5-8. Copper Addition to Agricultural Soil from Twelve Fertilizer Types**

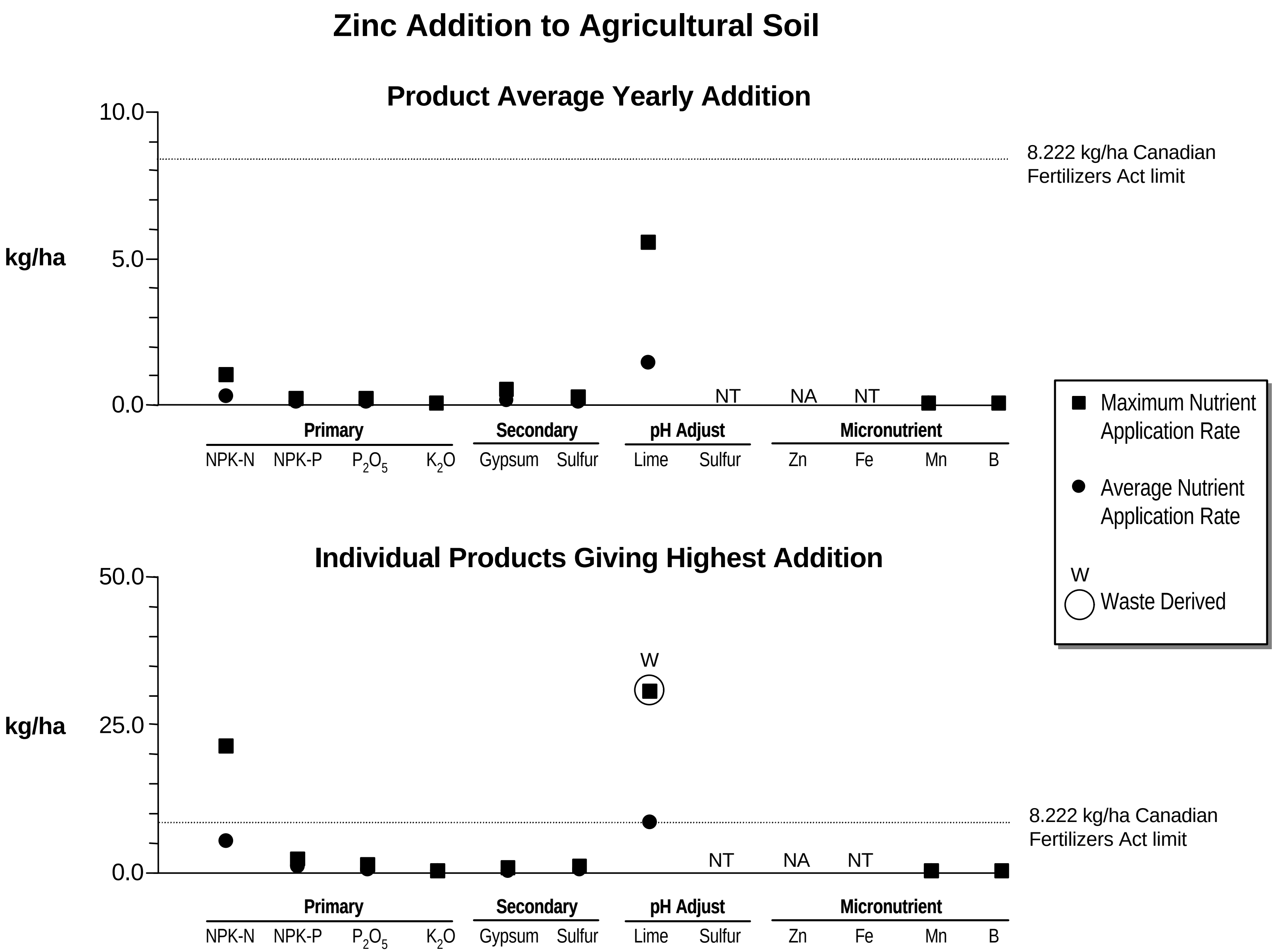


**Figure 5-9. Zinc Addition to Agricultural Soil from Twelve Fertilizer Types**

**Table 5-9. Number of Fertilizer Products Included in Calculation of Average Yearly Additions of Metals to Soil Number of Products[a] (Number of Products That Exceed Canadian Standard)[b]**

| Fertilizer | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| $P_2O_5$ | 61(1) | 58(0) | 64(0) | 27[c] | 4(0) | 33(0) | 8[c] | 58[c] | 28(0) |
| NPK-N | 50(0) | 50(1) | 50(0) | 40 | 43(0) | 43(0) | 43 | 49 | 39(0) |
| NPK-P | 91(10) | 91(4) | 84(1) | 60 | 14(0) | 70(0) | 14 | 89 | 67(0) |
| $K_2O$ | 42(0) | 42(0) | 17(0) | 15 | 16(0) | 41(0) | 16 | 42 | 39(0) |
| Zn | 22(3) | 63(6) | 6(0) | 2 | 1(0) | 11(0) | 2 | 6 | NA |
| Mn | 2(0) | 2(0) | 2(0) | 1 | 1(0) | 1(0) | 1 | 2 | 1(0) |
| Fe | 3(0) | 3(1) | 3(1) | 0 | 0(-)[d] | 0(-) | 0 | 3 | 0(-) |
| Sulfur-Nutrient | 9(0) | 9(0) | 9(0) | 4 | 4(0) | 4(0) | 4 | 9 | 4(0) |
| Sulfur-pH | 5(0) | 5(0) | 5(0) | 0 | 0(-) | 0(-) | 0 | 5 | 0(-) |
| Boron | 2(0) | 2(0) | 2(0) | 1 | 1(0) | 1(0) | 1 | 2 | 1(0) |
| Lime[e] | 10(3) | 10(2) | 10(3) | 7 | 8(1) | 8(1) | 8 | 9 | 7(2) |
| Gypsum | 4(0) | 4(0) | 4(0) | 1 | 1(0) | 1(0) | 4 | 4 | 1(0) |

a) Number of products analyzed for individual yearly addition and average for fertilizer type yearly addition of metals to soil.
b) Number of individual products that exceed annualized Canadian Fertilizers Act limits at either the average, high, or maximum product application rate.
c) Metal for which there is no Canadian Fertilizers Act limit.
d) No products identified in literature with specific concentration given for this metal.
e) Exceedances are based on the year in which applied. See footnotes regarding lime applications in Table G11(a-e).

**Table 5-10. Number of Products That Exceed the Canadian Fertilizers Regulation Standards at the Average, High and Maximum Nutrient Application Rates of the Product**

| Fertilizer | Cd | Pb | As | Hg | Ni | Zn |
|---|---|---|---|---|---|---|
| $P_2O_5$ | 0-0-1[a] (n = 61) | NE[b] | NE | NE | NE | NE |
| NPK-N | NE | NE | NE | NE | NE | 0-1-1 (n = 49) |
| NPK-P | 0-5-10 (n = 91) | 1-3-4 (n = 91) | 0-0-1 (n = 84) | NE | NE | NE |
| $K_2O$ | NE | NE | NE | NE | NE | NE |
| Zinc | 0-0-3 (n = 22) | 0-0-6 (n = 63) | NE | NE | NE | NA[C] |
| Manganese | NE | NE | NE | NE | NE | NE |
| Iron | NE | 0-0-1 (n = 3) | 1-1-1 (n = 3) | NP[d] | NP | NP |
| Sulfur-nutrient | NE | NE | NE | NE | NE | NE |
| Sulfur-pH | NE | NE | NE | NP | NP | NP |
| Boron | NE | NE | NG | NE | NE | NE |
| Lime[e] | 0-0-3 (n = 10) | 1-1-2[e] (n = 10) | 1-3-3 (n = 10) | 1-1-1 (n = 8) | 1-1-1 (n = 8) | 2-2-2 (n = 7) |
| Gypsum | NE | NE | NE | NE | NE | NE |

a) 0-0-1: Number of products that exceed the Canadian Fertilizer standard at the average - high - maximum application rate of the product type.
b) NE: No exceedances of the Canadian Fertilizer standard at any application rate for the product type.
c) NA: Not applicable (Zinc in zinc products).
d) NP: No products in which this element measured.
e) Exceedances are based on the year in which lime is applied. See Footnotes regarding lime applications in Tables G-11(a-e).

## 5.3 ADDITIONAL DATA PROVIDED ON BLENDED PRODUCTS

The inventory of heavy metals additions to soil from NPK fertilizers applied for N content (NPK-N) was largely supplied by the Pennsylvania Department of Agriculture (PDA). The PDA measured concentrations of heavy metals in 125 diverse fertilizers during the first half of 1998. The 125 products tested were selected to represent a cross-section of fertilizer products distributed in Pennsylvania; 32 were solid NPK formulations for the agricultural market, 20 were solid NPK formulations with micronutrients for the agricultural market, 35 were specialty fertilizers for the residential market, 25 were NPK liquid fertilizers, and 20 were primary ingredients. The concentrations of heavy metals in these samples are listed in Appendix H, Tables H-1 through H-5.

These PDA products differed from the products obtained from other surveys, and only selected products were readily amenable to inclusion in the calculations of Appendix G of this report. The 32 solid NPK fertilizer blends were included in the NPK-N (NPK fertilizers applied for N content) portion of Appendix G for determination of an average addition of metals from this class of fertilizers. The NPK blends with micronutrients were not used in the NPK category because the added micronutrients were not specified and their concentrations may have governed the application rates. The specialty fertilizers were not used in Appendix G, as these were listed as products for the residential market; many were listed as being either biosolids-based, organic (e.g., made from fish meal), or blended with micronutrients. The fertilizers listed as “Ag liquid” had the notation that they were applied to land at much lower application rates than solid fertilizers. Because of that caveat, and the fact that no typical application rates were available, these fertilizers were not included in Appendix G of this report. Appendix H of this report, though, does include a listing of metals concentrations in these sample fertilizers, and may be used for reference with the data presented elsewhere in the report.

The data provided by PDA provides important insight into the manner in which fertilizers are now being blended on a custom basis for each farm, soil and crop type. With the proliferation of rapid soil nutrient testing procedures, and computerized calculations of nutrient need vs available nutrient, it is clear that blending of products on a case-by-case basis provides the optimal fertilizer for each application. This customization, though, means that from a survey perspective, it may be very difficult to ascertain the broad range of formulations and application rates that are being used across the country.

In general, the range of metals concentrations in the fertilizers that are found in these PDA samples are similar to the range identified from other studies. The solid NPK ferilizers blended with micronutrients tend to have higher levels of copper, lead, mercury and zinc than that found in the straight NPK blends. Inasmuch as the micronutrient fertilizers tend to have higher metals levels than the NPK fertilizers, it is apparent that the higher levels of heavy metals in the NPK/micronutrient blends are probably due to the added micronutrients. The specialty fertilizers for the residential market, in some cases, also had higher than average levels of copper, lead, mercury and zinc. Presumably, these fertilizers either are biosolids-based or contain micronutrients.

The NPK blends were compared for the metal addition rates that would result from application of the product according to either the N content, the $P_2O_5$ content, or the $K_2O$ content. The data for individual products are listed in Appendix H, Tables H-6 through H-10. The summary statistics for these comparisons are listed in Appendix H Table H-11. The summary statistics include the mean, median and range of soil metals additions for the NPK products, when applied for either N, P or K content at the average, high or maximum application rate. As shown there, application rates used according to N content result in the highest soil loadings of the heavy metals, relative to the $P_2O_5$ and $K_2O$ application rates. The average of all the NPK products, applied at the highest N application rate, is, in all cases, lower than the Canadian Fertilizer Acts limits for annualized additions for cadmium, lead, arsenic, copper, zinc and mercury.

## 5.4 COMPARISON OF METAL CONCENTRATIONS IN SOIL TO NATIONAL AND INTERNATIONAL STANDARDS

The Canadian Fertilizers Act, described in Section 4.3.1, and the 40 CRF Part 503 Biosolids Standards (Section 4.4.1) may be used for comparison to the values presented in section 5.2 for metal addition to land from fertilizer application. Although the biosolids regulation may not be appropriate because we have not considered metal availability, soil type, and soil and organic matter content, these values provide a guideline for the comparisons. The Canadian Fertilizers Regulations specifies limits in terms of the maximum acceptable cumulative metal addition to soil (kg/ha) and the maximum acceptable metal concentrations in fertilizer products (mg/kg dry weight). Since the Canadian regulations for the maximum acceptable cumulative additions to the soil are long-term standards (45 years), these contaminant limits have been divided by 45 for comparison to the calculated values and to the U.S. biosolids annual pollutant loading rates in Tables 5-3a to 5-8a. The biosolids rule presents the annual pollutant loading rate for land (kg/ha/year) and the ceiling concentration for land application (mg/kg product). The soil values can be used for comparison to the concentrations calculated in Section 5.2 (kg/ha). We have assumed that the application rates are for a yearly basis (i.e., may combine multiple applications of a single product), but we have not considered simultaneous application of several fertilizer types.

The U.S. biosolids annual pollutant loading rate for land application (kg/ha/year) range from 0.85 for mercury to 140 for zinc. Comparison of these values to those in Tables 5-3a to 5-8a show that even based on the worst case assumptions, additions of metals to soil for the averaged fertilizers presented in Appendix G are generally two orders of magnitude lower than is specified in the biosolids regulation. When compared to the Canadian limits (divided by 45 to approximate annualized pollutant loading rates), only two fertilizer averages exceed the limits: arsenic from iron fertilizers and arsenic from liming materials exceed the limit when these products are applied at the maximum application rate. Based upon the maximum application rate and the contaminant levels from the individual products in each fertilizer category which give rise to the calculated highest soil loadings for each metal (Tables 5-3b to 5-8b), six fertilizer products exceed the Canadian Fertilizer Act limits for at least one metal: cadmium and lead in zinc fertilizers, cadmium in phosphate fertilizers, cadmium, arsenic, and lead in NPK fertilizers applied for P content, zinc in NPK fertilizers applied for N content, lead and arsenic in iron fertilizers, and lead, arsenic, mercury, nickel and zinc in liming materials.

## 5.5 COMPARISON OF FERTILIZER AGRONOMIC PRACTICES WITH BACKGROUND SOIL METAL CONCENTRATIONS

The calculated yearly additions of metals to soils (mg/kg of soil) due to each fertilizer class (Tables 5-3 to 5-8, a and b) were combined with the average (geometric mean) background soil metals levels to estimate the number of years of continuous applications that would be required for the doubling of background soil metals concentrations (Mortvedt, 1987). There is not necessarily any human health or environmental consequence from a doubling of the soil metal background level. Potential human and environmental effects depend upon many factors that are not considered in this report. The calculation of the number of years to double soil contaminants is, however, a method for comparing increases of contaminant levels in soils resulting from application of different types of fertilizers at different application rates. The number of years to double the background level is obtained by dividing the background soil level by the yearly soil addition rate. This approach assumes that there is no plant uptake of the metals (or that metals taken up are returned to the soil when stems, leaves, roots, etc, are returned to the field), that metals are not lost from the top 15 cm of soil via runoff, wind-borne resuspension, and/or percolation and leaching into lower depths of the soil, and that wet and dry atmospheric deposition of metals do not increase soil background levels. The latter assumption neglects recent work (e.g., Johnston and Jones, 1992), which concludes that atmospheric deposition of cadmium has been a significant source to soil, leading to an increase in some areas of 30-50% in the top 23 cm of soil over the last 100 years.

The results of years to double soil background presented in Tables 5-11a and 5-11b are based on the assumption that the fertilizers contain average contaminant concentrations and are applied either at the average (Table 5-11a) or the maximum nutrient application rate (Table 5-11b). Tables 5-12a and 5-12b use the single highest product metal addition rate with either the average (Table 5-12a) or the maximum (Table 5-12b) nutrient application rate.

Those fertilizer applications where soil background levels are doubled in 45 or fewer years have been shaded for visual identification. The choice of 45 years has no particular environmental or human health consequence, but was chosen because of the manner in which the Canadian Fertilizers Regulation limits are defined. The years to double soil metals levels from lime applications was calculated on the basis of the liming being done only once every 3 years. All other nutrients were calculated on the basis of a yearly addition.

Cadmium is the metal most likely to double in soil levels in less than 45 years, followed by lead, arsenic and copper. Several scenarios evaluated here indicate that mercury and zinc soil levels may double in less than 45 years with the application of lime products. Mercury additions, though, may be lost due to volatilization. Application of liming materials is most likely to cause soil metal concentrations to double in less than 45 years, and several of the products likely to cause this rise in soil metals are recycled industrial wastes.

Background soil metals levels are doubled in less than 10 years when the single product which gives the highest yearly addition to soil is applied at the average nutrient application rate for the following combinations of metal and fertilizer product: Cd from zinc, $P_2O_5$ and NPK-P fertilizers; Pb from NPK-P fertilizers and liming materials; and Zn from liming materials. Background soil metals levels are doubled in less than 10 years when the single product which

| Fertilizer Products | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| Primary Nutrients | | | | | | | | | |
| NPK-N | ■○● | ○● | | | | | | ○● | ● |
| NPK-P | ❑■○● | ○● | ● | | | | | ● | ● |
| $P_2O_5$ | ❑■○● | | | | | | | ● | |
| $K_2O$ | | | | | | | | | |
| Secondary Nutrients | | | | | | | | | |
| Gypsum | | | | | | | | | |
| Sulfur | ■○● | | | | | | | | |
| Soil pH Adjustment | | | | | | | | | |
| Lime | ■○● | ■○● | ■○● | ● | ■○● | ● | ● | ■○● | ■○● |
| Sulfur | ○● | | | | | | | | |
| Micronutrients | | | | | | | | | |
| Zn | ■○● | ■○● | | | | | | | |
| Fe | ■○● | ❑■○● | ■○● | | | | | | |
| Mn | | | | | | | | | |
| B | | | | | | | | | |

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❑ Product average yearly addition rate of metal to soil with nutrient applied at
■ Product average yearly addition rate of metal to soil with nutrient applied at
○ Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at
● Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at

**Figure 5-11. Products That Double Average U.S. Soil Background Level of Indicated Metal in 45 or Fewer Years**

**Table 5-11b. Years to Double Soil Metals Levels using Fertilizer Metal Addition Rates from Product Average Applied at the Nutrient Maximum Yearly Application Rate (footnote a)**

| Fertilizer Type | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| **Years to Double Soil Level (years)** | | | | | | | | | |
| Zinc | 12[b] | 25 | 5,200 | 1,762 | 232 | 872 | 38,667 | 396 | NA[c] |
| $P_2O_5$ | 11 | 2,444 | 1,486 | 725 | 232 | 1,889 | 748 | 590 | 573 |
| NPK (for N) | 20 | 214 | 385 | 274 | 232 | 557 | 328 | 167 | 83 |
| Potash | 360 | 7,333 | 20,800 | 37,000 | 232 | 17,000 | 58,000 | 36,000 | 43,000 |
| Boron | 720 | 44,000 | 452 | 148,000 | 232 | 68,000 | 116,000 | 72,000 | 86,000 |
| Iron | 13 | 13 | 22 | NC[d] | NC | NC | NC | 235 | NC |
| NPK (for P) | 14 | 84 | 867 | 1,298 | 232 | 1,789 | 913 | 900 | 528 |
| Manganese | 720 | 11,000 | 10,400 | 74,000 | 232 | 11,333 | 232,000 | 36,000 | 21,500 |
| Sulfur (as nutrient) | 45 | 22,000 | 10,400 | 2,846 | 232 | 1,478 | 2,417 | 18,000 | 475 |
| Sulfur (for pH) | 720 | 3,143 | 473 | NC | NC | NC | NC | 319 | NC |
| Gypsum | 51 | 537 | 260 | 5,692 | 232 | 1,259 | 383 | 170 | 178 |
| Liming Materials[e] | 17 | 20 | 24 | 159 | 29 | 136 | 267 | 32 | 15 |

a) Sources: Tables 5-3a through 5-8a for yearly metal addition rates (kg/ha); Table 3-2 for soil metal concentration (mg/kg) Study 1 geometric means for Cd, Pb, Ni, Cu, Zn and Study 2 geometric means for As, Cr, Hg; equation 5-4 for conversion of kg/ha addition to mg/kg of soil concentration (kg of metal)/ha addition mg/(kg of soil) concentration
b) NA = Not applicable; zinc fertilizers are applied specifically to add zinc to the soil and/or crop
c) Shaded boxes indicate 45 or fewer years to double
d) NC = not calculated; no samples analyzed in this category
e) Based on lime application once every 3 years.

**Table 5-12a. Years to Double Soil Metals Levels using Fertilizer Metal Addition Rates from Single Highest Product Applied at the Nutrient Average Yearly Application Rate (footnotes a, b)**

| Fertilizer Type | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| **Years to Double Soil Level (years)** | | | | | | | | | |
| Zinc | 10[c] | 26 | 10,400 | 4,111 | 232 | 395 | 116,000 | 563 | NA[d] |
| $P_2O_5$ | 9 | 234 | 1,733 | 597 | 232 | 1,063 | 768 | 65 | 265 |
| NPK (for N) | 16 | 34 | 217 | 237 | 232 | 283 | 181 | 33 | 13 |
| Potash | 720 | 11,000 | 20,800 | 74,000 | 232 | 34,000 | 23,200 | 18,000 | 21,500 |
| Boron | 720 | 44,000 | 452 | 148,000 | 232 | 68,000 | 232,000 | 72,000 | 172,000 |
| Iron | 14 | 16 | 23 | NC[e] | NC | NC | NC | 275 | NC |
| NPK (for P) | 5 | 8 | 93 | 587 | 232 | 370 | 624 | 102 | 124 |
| Manganese | 720 | 22,000 | 20,800 | 148,000 | 232 | 34,000 | 232,000 | 72,000 | 86,000 |
| Sulfur (as nutrient) | 16 | 22,000 | 10,400 | 2,176 | 232 | 1,097 | 1,841 | 12,000 | 363 |
| Sulfur (for pH) | 720 | 2,750 | 612 | NC | NC | NC | NC | 367 | NC |
| Gypsum | 60 | 880 | 547 | 24,667 | 232 | 4,857 | 1,036 | 383 | 711 |
| Liming Materials[f] | 24 | 9 | 11 | 111 | 15 | 75 | 144 | 16 | 10 |

a) Sources: Tables 5-3b through 5-8b for yearly metal addition rates (kg/ha); Table 3-2 for soil metal concentration (mg/kg) Study 1 geometric means for Cd, Pb, Ni, Cu, Zn and Study 2 geometric means for As, Cr, Hg; equation 5-4 for conversion of kg/ha addition to mg/kg of soil concentration (kg of metal)/ha addition mg/(kg of soil) concentration

b) Note that some values in this table are the same as those in Table 5-11a. In some cases the concentration of a specific fertilizer type is based on a single sample so the average value and the maximum value are the same or all values were reported as below the limit of detection and this value was replaced with one-half the limit of detection.

c) Shaded boxes indicate 45 or fewer years to double

d) NA = Not applicable; zinc fertilizers are applied specifically to add zinc to the soil and/or crop

e) NC = not calculated; no samples analyzed in this category

f) Based on lime application once every 3 years.

**Table 5-12b. Years to Double Soil Metals Levels using Fertilizer Metal Addition Rates from Single Highest Product Applied at the Nutrient Maximum Yearly Application Rate (footnotes a, b)**

| Fertilizer Type | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| **Years to Double Soil Level (years)** | | | | | | | | | |
| Zinc | 3[c] | 6 | 1,733 | 1,028 | 232 | 99 | 23,200 | 141 | NA[d] |
| $P_2O_5$ | 3 | 78 | 578 | 199 | 232 | 358 | 257 | 22 | 89 |
| NPK (for N) | 5 | 10 | 64 | 71 | 116 | 85 | 54 | 10 | 4 |
| Potash | 180 | 1,833 | 5,200 | 10,571 | 116 | 8,500 | 4,833 | 2,769 | 3,739 |
| Boron | 720 | 44,000 | 221 | 148,000 | 232 | 68,000 | 116,000 | 72,000 | 86,000 |
| Iron | 5 | 5 | 8 | NC[e] | NC | NC | NC | 92 | NC |
| NPK (for P) | 2 | 3 | 31 | 196 | 232 | 124 | 208 | 34 | 41 |
| Manganese | 720 | 7,333 | 10,400 | 74,000 | 232 | 11,333 | 232,000 | 36,000 | 21,500 |
| Sulfur (as nutrient) | 5 | 5,500 | 5,200 | 718 | 232 | 362 | 611 | 4,500 | 121 |
| Sulfur (for pH) | 720 | 917 | 196 | NC | NC | NC | NC | 118 | NC |
| Gypsum | 16 | 222 | 137 | 5,692 | 232 | 1,259 | 259 | 96 | 178 |
| Liming Materials[f] | 7 | 2 | 3 | 30 | 4 | 20 | 38 | 4 | 3 |

a) Sources: Tables 5-3b through 5-8b for yearly metal addition rates (kg/ha); Table 3-2 for soil metal concentration (mg/kg) Study 1 geometric means for Cd, Pb, Ni, Cu, Zn and Study 2 geometric means for As, Cr, Hg; equation 5-4 for conversion of kg/ha addition to mg/kg of soil concentration (kg of metal)/ha addition mg/(kg of soil) concentration

b) Note that some values in this table are the same as those in Table 5-11b. In some cases the concentration of a specific fertilizer type is based on a single sample so the average value and the maximum value are the same or all values were reported as below the limit of detection and this value was replaced with one-half the limit of detection.

c) Shaded boxes indicate 45 or fewer years to double

d) NA = Not applicable; zinc fertilizers are applied specifically to add zinc to the soil and/or crop

e) NC = not calculated; no samples analyzed in this category

f) Based on lime application once every 3 years.

gives the highest yearly addition to soil is applied at the maximum nutrient application rate for the following combinations of metal and fertilizer product: Cd from zinc, $P_2O_5$, NPK-N, NPK-P, iron, sulfur (as nutrient), and lime products; Pb from zinc, NPK-N, NPK-P, iron, and lime products; As from iron and lime products; Hg from lime products; Cu from NPK-N and lime products; and Zn from NPK-N and lime products.

The estimates for doubling of the Hg background are limited to a great degree by the sensitivity of analytical methods used. Wherever analyses were carried out but Hg was not detected, one half the detection limit was used as the estimate of the Hg level. This approach may overestimate the levels of Hg in the fertilizer products. This approach may then result in an underestimate of the number of years required to double soil Hg levels.

## 5.6 ASSUMPTIONS, DATA GAPS AND QUESTIONS FOR FURTHER INVESTIGATION

In the process of performing the calculations on metal additions to soil following fertilizer application and comparing these values to appropriate standards and regulations, a number of assumptions had to be made.

Simplifying assumptions used for the calculations presented in Section 5.3 were:

- Fertilizer application rates chosen for the calculations in this report are for agricultural crops only. Fertilizer application rates for non-agricultural land (e.g., residential and public land), have only a limited amount of information. The variety of ornamentals, turf and garden vegetables requiring fertilizers and the variety of soil types makes it difficult to obtain specific data such as that available from the USDA for agricultural crops. Preliminary data on heavy metals in home garden fertilizers suggest that significant amounts of metals may be added to home gardens from use of some of these products.

- Metal additions to the soil were based on application of a single fertilizer type, and a single crop per year. In fact, many different fertilizers and liming materials may be applied to a field in a growing season. The concomitant addition of heavy metals from all sources was not assessed here.

- Calculations of heavy metal additions to soil from fertilizers were based on all available data. The representativeness of this data set with respect to all fertilizers is not known. There has not yet been a systematic investigation of all fertilizer types, or an investigation of the percentage of recycled industrial waste products with substantial levels of heavy metals in the fertilizer market.

- In only a few instances was the origin (e.g., natural ore or industrial by product) of the fertilizer product known. Although it may be instructive to compare heavy metal additions to soil from natural ores and products from industrial waste, such an exercise could not be undertaken on the basis of the available data.

- To simplify calculations, soil type and chemical nature, plant uptake, leaching and erosion were not considered in these calculations. All input of heavy metals was assumed to remain with the soil, and this may result in an overestimate of soil metals levels over a long time period.

The following list presents some areas where data are lacking, and questions remain for further investigation.

- Nationally-representative micronutrient application rates. Aggregate average application rates for micronutrients and liming materials by state, treated acres and crop type have not been assembled, as has been done for N, P and K fertilizer.

- Regional variability in concomitant use of NPK, micronutrient and liming materials on the same field. Statewide use data for each fertilizer type are available, but the overlap in application by crop has not been compiled. Some areas of the U.S. may receive higher input of heavy metals from fertilizers due to the combination of crop type and existing soil conditions.

- Contribution of fertilizer products derived from industrial wastes to total fertilizer market. While sources of industrial waste-derived fertilizers are fairly well known, the market share of these products in the total fertilizer market is not known.

- Nationally representative metal contaminant levels of all fertilizer types. Only a few studies exist that have measured contaminant levels in fertilizers, and these studies tend to represent either a single product type and/or products found in a specific state.

- Levels of other contaminants such as radionuclides and persistent organic chemicals in fertilizers and liming materials. Compared with the data on heavy metals in fertilizers, relatively little information exists on the levels of organic pollutants in fertilizers. Organics include dioxins, PCBs, pesticides and PAHs.

- The environmental fate of chemical additions to soil. This issue has been studied primarily for cadmium and lead, and most often under controlled laboratory or field conditions. All potential contaminants, soil types and crops have not been addressed. In addition, the fate of metals added to the soil as a result of fertilizer addition to non-agricultural land (e.g., range land and residential land) has not been adequately studied.

## 5.7 SUMMARY

Calculations of the additions of metals to soils from different fertilizer applications has been carried out here, but the interpretation of the data remains limited, due in part to the fact that few regulations exist that can be used for comparisons. It is unclear whether the U.S. biosolids standards are appropriate for comparison to inorganic fertilizer types because of differences in metal availability to the plant, organic matter content and plant uptake between biosolids fertilizers and inorganic fertilizers. The Canadian limits for metal additions to the soil are annualized long term (45 year) average values. The extent to which current data can be extrapolated to a 45 year trend is not known. Assuming an annual addition of a constant amount of the same type of fertilizer to the soil may not be realistic. Nonetheless, this report identifies several fertilizer types that exceed the annualized pollutant loading rates allowable in Canada, and, identifies a few product types that approach the U.S. biosolids limits when applied at maximum nutrient application rates.

Fertilizer products are compared in this report with respect to the amount of nine heavy metals the product would add to soil, assuming a single application of the product per year. This is termed the yearly soil addition rate of a metal (or "yearly addition of metal X", see Index of Terms). The yearly soil addition rate of a metal is the concentration of that heavy metal in the product per desired nutrient ingredient multiplied by the nutrient application rate, with all appropriate conversion factors applied. For those fertilizer products with lower nutrient content, a proportionally greater amount of the undesirable heavy metal will be added to the land in achieving a consistent nutrient application rate. Therefore, a fertilizer product may contribute high levels of heavy metals to soil when the heavy metal concentration in the product is high and/or when the desired plant nutrient is at a low level in the product.

For this report, the yearly addition of each metal was calculated for each individual product at three nutrient application rates- an average nutrient application rate, a high rate and at the maximum application rate recorded for this nutrient. An extended appendix of this report (Appendix G) contains the yearly soil addition rate of each metal in each product when applied at these three nutrient application rates. The aggregate of these individual yearly addition rates, then, produced the average soil metal addition rate for a fertilizer product category (e.g., $P_2O_5$ fertilizers) at the three different nutrient application rates. This aggregate is termed the product average yearly addition of metal X (see Index of Terms). This summary includes discussions of the yearly addition of metals in terms of both the individual product giving the highest yearly soil addition of a specific metal, and in terms of the product average yearly addition rates for metals.

The calculations performed here showed that the product average yearly addition rates of metals to soil would not exceed the U.S. biosolids annual pollutant loading rates for any fertilizer category evaluated. This finding applied to both natural ore-derived fertilizers and industrial by-product derived fertilizers.

The calculations also showed that the product average yearly addition rates of metals to soil rarely exceeded the annualized Canadian Fertilizers Act limits for metals additions. The particular instances when the product average addition rate of metal to soil exceeded the Canadian limits were found in the following combinations of heavy metal and fertilizer categories, and this occurred only at the maximum nutrient application rate:

Arsenic in: liming materials ($CaCO_3$ applied at 15,000 lbs/acre once every 3 years)
iron fertilizers (iron applied at 30 lbs/acre every year)

The Canadian standards are exceeded more frequently for **individual** fertilizer products, and are exceeded for metals other than arsenic. A total of 38 cases were identified where a particular heavy metal in an identified individual fertilizer product would exceed Canadian fertilizer standards when applied at the maximum nutrient application rate. These cases include:

| | |
|---|---|
| Cadmium in: | NPK fertilizers applied for $P_2O_5$ content [10 products of 91evaluated exceeded limits; 10 of 91]<br>Phosphate fertilizers [1 of 61]<br>Liming materials [3 of 10]<br>Zinc fertilizers [3 of 22] |
| Lead in : | NPK fertilizers applied for $P_2O_5$ content [4 of 91]<br>Liming materials [2 of 10]<br>Zinc fertilizers [6 of 63]<br>Iron fertilizers [1 of 3] |
| Arsenic in: | NPK fertilizers applied for $P_2O_5$ content [1 of 84]<br>Liming materials [3 of 10]<br>Iron fertilizers [1 of 3] |
| Mercury in: | Liming materials [1 of 8] |
| Nickel in: | Liming materials [1 of 8] |
| Zinc in: | NPK fertilizers applied for N content [1 of 49] |

Of the products listed above, 18 exceeded Canadian standards at the high nutrient application rate, and 8 exceeded the standards at the average nutrient application rate. Data were gathered here on 345 fertilizer products; 1389 combinations of fertilizer product and metal at three application rates (total of 4167 data points) were compared with Canadian standards. (Data on an additional 537 combinations of unregulated heavy metals in products were also gathered). Since some products exceeded standards in more than one metal, the number of individual products exceeding the standards for at least one metal is greater than 2.7% (38 of 1389), but less than 11% (38 of 345).

Figure 5-10 identifies those fertilizer categories where the product average yearly addition rate of a metal is likely to double the average level of that metal in background US soils in 45 or fewer years, when the nutrient is applied at either the average (open box) or maximum (closed box) application rate. Similarly, this figure also identifies those instances where at least one individual product within a category exists that may double the average background level in 45 or fewer years, when the nutrient is applied at either the average (open circle) or maximum (closed circle) application rate. These scenarios assume yearly applications, with exception of lime, which is applied once every three years. For example, the product average application rate of cadmium (Cd) from either NPK-P fertilizers (NPK fertilzers applied for $P_2O_5$ content) or from $P_2O_5$ fertilizers will double the average background Cd soil level in 45 or fewer years when either the average or maximum nutrient ($P_2O_5$) application rate is used every year. In addition, there were individual NPK-N, NPK-P and $P_2O_5$ products identified that would double background soil Cd levels in 45 or fewer years if applied each year. There were no potash ($K_2O$), gypsum, manganese (Mn), or boron (B) fertilizer products identified that would double the indicated soil metals levels in 45 or fewer years. In contrast, liming materials were identified that might double the soil levels of all nine metals with consistent use (application once every three years) within a 45 year time frame.

| Fertilizer Products | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| **Primary Nutrients** | | | | | | | | | |
| NPK-N | ■ ❍ ● | ❍ ● | | | | | | ❍ ● | ● |
| NPK-P | ❑ ■ ❍ ● | ❍ ● | ● | | | | | ● | ● |
| $P_2O_5$ | ❑ ■ ❍ ● | | | | | | | ● | |
| $K_2O$ | | | | | | | | | |
| **Secondary Nutrients** | | | | | | | | | |
| Gypsum | | | | | | | | | |
| Sulfur | ■ ❍ ● | | | | | | | | |
| **Soil pH Adjustment** | | | | | | | | | |
| Lime | ■ ❍ ● | ■ ❍ ● | ■ ❍ ● | ● | ■ ❍ ● | ● | ● | ■ ❍ ● | ■ ❍ ● |
| Sulfur | ❍ ● | | | | | | | | |
| **Micronutrients** | | | | | | | | | |
| Zn | ■ ❍ ● | ■ ❍ ● | | | | | | | |
| Fe | ■ ❍ ● | ❑ ■ ❍ ● | ■ ❍ ● | | | | | | |
| Mn | | | | | | | | | |
| B | | | | | | | | | |

❑ Product average yearly addition rate of metal to soil with nutrient applied at average application rate
■ Product average yearly addition rate of metal to soil with nutrient applied at maximum application rate
❍ Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at average application rate
● Individual fertilizer product giving highest addition rate of metal to soil with nutrient applied at maximum application rate

**Figure 5-10. Products That Double Average U.S. Soil Background Level of Indicated Metal in 45 or Fewer Years**

## 6.0 REFERENCES

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# APPENDIX A
# FERTILIZER CONSUMPTION IN THE U.S.

# Appendix A. Fertilizer Consumption in the U.S.

The tables in Appendix A have been abstracted from electronic files created by the Association of American Plant Food Control Officials (AAPFCO). The data in these tables are for the year ending June 30, 1996. Slight differences in reported values between the tables in this report and Commercial Fertilizers 1996 (AAPFCO and TFI) are due to the inclusion of liming materials and some minor differences in the definition of multiple nutrient fertilizers and "other" fertilizer groupings. Tables A-1 through A-5 contain the tons of different types of fertilizers and micronutrients consumed for each state and Puerto Rico. The tables are organized with the states grouped into geographic regions of the country. These tables are:

- A-1. East North Central (IN, IL, MI, OH, WI) and East South Central (KY, AL, MS, TN)
- A-2. West North Central (KS, IA, MN, MO, NB, ND, SD) and West South Central (LA, AR, OK, TX)
- A-3. New England (CN, ME, MA, NH, NY, RI, VT) and Middle Atlantic (DE, MD, NJ, PA, WV)
- A-4. South Atlantic (FL, GA, NC, SC, VA)
- A-5. Mountain (AZ, CO, ID, MT, NM, NV, UT, WY), Pacific (AK, CA, HI, OR, WA) and Puerto Rico

The total U.S. fertilizer consumption, by fertilizer type is presented in Table 2-1.

**Table A-1. Fertilizer Consumption (Tons) by State - East North Central and East South Central Regions**

| Description | IN | IL | MI | OH | WI | KY | AL | MS | TN |
|---|---|---|---|---|---|---|---|---|---|
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | |
| N-P-K | 382,542 | 198,220 | 370,204 | 214,942 | 175,351 | 147,369 | 233,519 | 205,200 | 151,031 |
| N-P | 259,966 | 707,763 | 109,463 | 376,472 | 182,628 | 177,311 | 46,223 | 57,380 | 163,898 |
| N-K | 14,618 | 4,840 | 28,419 | 2,519 | 6,062 | 3,015 | 21,162 | 13,921 | 3,202 |
| P-K | 94,532 | 12,264 | 9,321 | 26,930 | 6,243 | 6,953 | 13,324 | 24,009 | 1,333 |
| TOTAL | 751,658 | 923,087 | 517,407 | 620,862 | 370,284 | 334,649 | 314,229 | 300,510 | 319,464 |
| **NITROGEN FERTILIZERS** | | | | | | | | | |
| Ammonium Nitrate | 7,388 | 32,850 | 7,900 | 3,993 | 26,657 | 110,319 | 122,191 | 103,202 | 168,520 |
| Ammonium Nitrate Solution | 203 | 0 | 0 | 0 | 0 | 0 | 0 | 228 | 0 |
| Ammonium Nitrate-limestone Mixtures | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Nitrate-sulfate | 4,138 | 0 | 262 | 0 | 3 | 258 | 44 | 574 | 14 |
| Ammonium Polysulfide | 335 | 0 | 0 | 0 | 0 | 0 | 0 | 420 | 0 |
| Ammonium Sulfate | 12,180 | 20,606 | 15,093 | 27,297 | 33,429 | 446 | 12,848 | 11,988 | 3,331 |
| Ammonium Sulfate Solution | 5,885 | 135,422 | 107 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Sulfate-nitrate | 9,802 | 48 | 9,107 | 3,488 | 0 | 55 | 118 | 29 | 9 |
| Ammonium Sulfate-urea | 114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Thiosulfate | 779 | 11,549 | 252 | 1,138 | 1,337 | 49 | 331 | 7,610 | 2 |
| Anhydrous Ammonia | 194,582 | 609,003 | 61,777 | 101,303 | 53,647 | 61,525 | 1,513 | 18,906 | 15,035 |
| Aqua Ammonia | 9,699 | 0 | 0 | 0 | 2,348 | 0 | 0 | 273 | 0 |
| Calcium Ammonium Nitrate | 147 | 1,003 | 75 | 0 | 5 | 1 | 6 | 25 | 0 |
| Calcium Cyanamide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Nitrate | 233 | 43,791 | 3,438 | 141 | 191 | 171 | 90 | 221 | 286 |
| Calcium Nitrate-urea | 311 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ferrous Ammonium Sulfate | 103 | 25 | 25 | 2 | 0 | 1,638 | 0 | 12 | 14 |
| Magnesium Nitrate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nitric Acid | 1,346 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Nitrogen Solution 28% | 381,514 | 721,753 | 212,610 | 649,226 | 172,508 | 65,305 | 11,008 | 22,821 | 4,136 |

## Table A-1. (Continued)

| Description | IN | IL | MI | OH | WI | KY | AL | MS | TN |
|---|---|---|---|---|---|---|---|---|---|
| Nitrogen Solution 30% | 1,528 | 977 | 0 | 2,856 | 7 | 14,479 | 620 | 947 | 582 |
| Nitrogen Solution 32% | 27,235 | 155,188 | 4,517 | 22,108 | 19,546 | 28,779 | 37,726 | 140,241 | 45,784 |
| Nitrogen Solution <28% | 46,384 | 68,688 | 9,741 | 11,505 | 3,490 | 231 | 14,501 | 1,333 | 1,446 |
| Nitrogen Solution >32% | 156 | 305 | 0 | 0 | 396 | 89 | 129 | 14 | 686 |
| Sodium Nitrate | 1,130 | 44 | 93 | 52 | 124 | 515 | 629 | 1,563 | 2,632 |
| Sulfur Coated Urea | 689 | 0 | 702 | 78 | 4 | 3 | 8 | 41 | 4 |
| Urea | 71,864 | 109,168 | 84,740 | 128,658 | 119,738 | 104,979 | 20,380 | 95,679 | 74,749 |
| Urea Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 281 | 0 |
| Urea-formaldehyde | 719 | 5,339 | 1,565 | 616 | 314 | 16 | 3,020 | 153 | 52 |
| Zinc Ammonium Sulfate Solution | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 247 | 299 |
| Zinc Manganese Ammonium Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 13,879 | 4,508 | 35,424 | 22,148 | 345 | 7,079 | 43,796 | 9,877 | 7,428 |
| TOTAL | 792,344 | 1,920,268 | 447,429 | 974,608 | 434,091 | 395,936 | 268,956 | 416,684 | 325,010 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | |
| Ammonium Metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Phosphate | 30 | 0 | 9 | 0 | 0 | 30 | 0 | 68 | 0 |
| Ammonium Phosphate Nitrate | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 |
| Ammonium Phosphate Sulfate | 406 | 0 | 0 | 87 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Polyphosphate | 132 | 0 | 0 | 0 | 0 | 0 | 7 | 50 | 0 |
| Basic Lime Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Basic Slag | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,851 | 292 |
| Bone Meal, Raw | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 0 | 0 |
| Bone Meal, Steamed | 2 | 6 | 1 | 3 | 125 | 4 | 2 | 0 | 6 |
| Bone, Precipitated | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Metaphosphate | 0 | 0 | 0 | 0 | 0 | 112 | 2 | 0 | 1,711 |
| Colloidal Phosphate (Soft Phosphate) | 88 | 0 | 22 | 86 | 0 | 22 | 17 | 22 | 67 |
| Diammonium Phosphate | 111,288 | 575,531 | 38,217 | 248,811 | 154,576 | 162,455 | 35,350 | 45,924 | 160,104 |

## Table A-1. (Continued)

| Description | IN | IL | MI | OH | WI | KY | AL | MS | TN |
|---|---|---|---|---|---|---|---|---|---|
| Limestone, Phosphatic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Liquid Ammonium Polyphosphate | 104,347 | 34,352 | 36,686 | 85,822 | 15,883 | 5,850 | 2,611 | 8,578 | 2,300 |
| Magnesium Phosphate | 0 | 0 | 0 | 35 | 5 | 25 | 4 | 10 | 9 |
| Monoammonium Phosphate | 12,155 | 81,713 | 17,852 | 32,747 | 9,033 | 6,362 | 720 | 541 | 454 |
| Nitric Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phosphate Rock | 0 | 62 | 123 | 3 | 445 | 0 | 31 | 0 | 0 |
| Phosphoric Acid | 126 | 449 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Precipitated Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Superphosphate, Enriched | 5 | 0 | 24 | 0 | 5 | 0 | 28 | 0 | 0 |
| Superphosphate, Normal | 14 | 0 | 13 | 0 | 12,639 | 13 | 501 | 0 | 7 |
| Superphosphate, Triple | 40,368 | 49,033 | 4,738 | 92,925 | 11,310 | 19,981 | 6,913 | 14,581 | 8,621 |
| Superphosphoric Acid | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Other | 310 | 91,759 | 227 | 4 | 307 | 155 | 812 | 140 | 506 |
| TOTAL | 269,274 | 832,904 | 97,913 | 460,524 | 204,363 | 195,011 | 47,003 | 71,765 | 174,077 |
| **POTASH FERTILIZERS** | | | | | | | | | |
| Lime-potash Mixtures | 1,537 | 0 | 50 | 0 | 0 | 0 | 88 | 0 | 0 |
| Manure Salts | 464 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Muriate of Potash 60% (Pot. Chloride) | 335,046 | 877,049 | 161,547 | 412,906 | 655 | 157,955 | 43,942 | 116,361 | 185,802 |
| Muriate of Potash 62% | 38,184 | 95,057 | 76,437 | 94,428 | 372,350 | 3,761 | 2,188 | 15,499 | 2,116 |
| Potash Suspensions | 0 | 0 | 0 | 0 | 0 | 0 | 131 | 52 | 0 |
| Potassium Carbonate | 15 | 0 | 138 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potassium Nitrate | 409 | 2 | 1,569 | 119 | 1 | 8 | 1,963 | 628 | 253 |
| Potassium Sulfate | 1,967 | 600 | 2,840 | 1,879 | 2,866 | 35,121 | 539 | 1,063 | 5,533 |
| Potassium-magnesium Sulfate | 2,739 | 903 | 3,029 | 1,834 | 11,069 | 5,618 | 815 | 2,085 | 817 |
| Potassium-metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potassium-sodium Nitrate | 0 | 0 | 37 | 0 | 0 | 0 | 0 | 0 | 224 |
| Other | 11,680 | 5,843 | 4,357 | 1,933 | 2,864 | 137 | 4,943 | 2,388 | 3,419 |

## Table A-1. (Continued)

| Description | IN | IL | MI | OH | WI | KY | AL | MS | TN |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL | 392,040 | 979,455 | 250,003 | 513,099 | 389,805 | 202,600 | 54,610 | 138,074 | 198,164 |
| **ORGANIC FERTILIZERS** | | | | | | | | | |
| Blood, Dried | 3 | 0 | 0 | 0 | 121 | 0 | 3 | 0 | 0 |
| Castor Pomace | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cocoa Shell Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Compost | 0 | 0 | 3,961 | 0 | 13 | 0 | 0 | 0 | 0 |
| Cottonseed Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27 |
| Fish Scrap | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 989 |
| Guano | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manure | 401 | 0 | 698 | 0 | 3,848 | 0 | 1,398 | 3,885 | 1,546 |
| Peat | 1,083 | 0 | 25,607 | 0 | 0 | 0 | 0 | 0 | 2,338 |
| Sewage Sludge, Activated | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 0 | 198 |
| Sewage Sludge, Digested | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Heat Dried | 0 | 0 | 0 | 0 | 2,472 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soybean Meal | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Tankage, Animal | 0 | 0 | 0 | 0 | 37 | 0 | 0 | 0 | 0 |
| Tankage, Process | 0 | 0 | 0 | 0 | 281 | 0 | 0 | 0 | 154 |
| Other | 1,368 | 0 | 7,793 | 0 | 1,437 | 0 | 3 | 44 | 9,715 |
| TOTAL | 2,856 | 0 | 38,058 | 0 | 8,221 | 0 | 1,446 | 3,930 | 14,966 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | |
| Aluminum Sulfate | 0 | 0 | 1 | 0 | 0 | 0 | 27 | 384 | 30 |
| Borax | 71 | 0 | 281 | 0 | 1,110 | 0 | 104 | 1,454 | 2,132 |
| Calcium Chelate | 0 | 0 | 0 | 0 | 9,026 | 0 | 0 | 0 | 0 |
| Calcium Chloride | 0 | 0 | 0 | 0 | 1,331 | 0 | 1 | 0 | 8 |
| Calcium Sulfate (Hydrous) | 0 | 0 | 0 | 0 | 1,804 | 0 | 0 | 0 | 0 |
| Cobalt Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Chelate | 0 | 0 | 0 | 0 | 49 | 0 | 0 | 0 | 0 |

## Table A-1. (Continued)

| Description | IN | IL | MI | OH | WI | KY | AL | MS | TN |
|---|---|---|---|---|---|---|---|---|---|
| Copper Compound | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Oxide, Black | 0 | 0 | 0 | 0 | 36 | 0 | 0 | 0 | 0 |
| Copper Sulfate | 1 | 0 | 41 | 0 | 0 | 0 | 0 | 0 | 6 |
| Epsom Salt (Magnesium Sulfate) | 0 | 0 | 72 | 0 | 0 | 0 | 0 | 0 | 16 |
| Ferric Oxide | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 0 | 0 |
| Ferric Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ferrous Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| Gypsum (Calcium Sulfate) | 4,445 | 0 | 13,002 | 0 | 3,391 | 0 | 241 | 32 | 888 |
| Iron Chelate | 3 | 0 | 44 | 0 | 238 | 0 | 8 | 17 | 20 |
| Iron Compound | 0 | 0 | 3 | 0 | 2 | 0 | 0 | 16 | 0 |
| Lime Sulfur Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Magnesia (Magnesium Oxide) | 31 | 0 | 15 | 0 | 10 | 0 | 0 | 0 | 74 |
| Magnesium Chelate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 |
| Manganese Agstone | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manganese Chelate | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 2 |
| Manganese Oxide | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 21 |
| Manganese Slag | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manganese Sulfate | 36 | 0 | 39 | 0 | 0 | 0 | 15 | 0 | 1 |
| Manganous Oxide | 0 | 0 | 0 | 0 | 73 | 0 | 0 | 0 | 3 |
| Potting Soil | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Sodium Molybdate | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 200 | 0 |
| Soil Additive | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil Amendment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil Conditioner | 0 | 0 | 11,601 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sulfur | 569 | 0 | 664 | 0 | 3,726 | 0 | 731 | 1,469 | 1,899 |
| Sulfuric Acid | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Zinc Chelate | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 61 |
| Zinc Oxide | 0 | 0 | 3 | 0 | 669 | 0 | 0 | 173 | 186 |

## Table A-1. (Continued)

| Description | IN | IL | MI | OH | WI | KY | AL | MS | TN |
|---|---|---|---|---|---|---|---|---|---|
| Zinc Oxysulfate | 0 | 0 | 331 | 0 | 0 | 0 | 0 | 0 | 114 |
| Zinc Sulfate | 4 | 0 | 202 | 0 | 0 | 0 | 4 | 8 | 174 |
| Zinc Sulfate Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 2,238 | 0 | 7,307 | 19,816 | 1,054 | 9,922 | 1,526 | 504 | 255 |
| TOTAL | 7,400 | 0 | 33,612 | 19,816 | 22,528 | 9,922 | 2,912 | 4,273 | 5,918 |
| **LIMING MATERIALS** | | | | | | | | | |
| Calcitic Lime (75% Neutral) | 0 | 0 | 437 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Hydroxide (Hydrate) | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 41 |
| Calcium Oxide (Burnt) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dolomitic & Calcitic Blend (Pelletized) | 0 | 0 | 1,114 | 0 | 0 | 0 | 0 | 0 | 148 |
| Dolomitic Lime (75% Neutral) | 0 | 0 | 2 | 0 | 0 | 0 | 1,319 | 0 | 0 |
| Lime Suspensions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-lime Filler (Water, Sand, Etc.) | 0 | 0 | 0 | 0 | 1,097 | 0 | 0 | 0 | 0 |
| Standard Calcite | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 0 | 22,203 |
| Standard Dolomite | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 0 | 29 |
| Other | 4,501 | 0 | 3,513 | 0 | 12,131 | 0 | 1,094 | 84 | 649 |
| TOTAL | 4,501 | 0 | 5,071 | 0 | 13,228 | 0 | 2,464 | 84 | 23,070 |
| **ALL FERTILIZERS** | | | | | | | | | |
| **TOTAL** | 1,989,785 | 3,964,109 | 1,264,857 | 2,221,321 | 1,256,483 | 963,407 | 649,521 | 875,645 | 892,228 |

## Table A-2. Fertilizer Consumption (Tons) by State - West North Central and West South Central Regions

| Description | KS | IA | MN | MO | NB | ND | SD | LA | AR | OK | TX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | | | |
| N-P-K | 38,136 | 264,907 | 71,022 | 94,778 | 137,487 | 40 | 7,237 | 262,361 | 273,832 | 45,461 | 1,014,243 |
| N-P | 398,776 | 640,695 | 529,868 | 286,572 | 369,018 | 332,312 | 216,487 | 38,024 | 31,335 | 166,284 | 519,427 |
| N-K | 2,790 | 2,048 | 1,976 | 2,869 | 6,613 | 0 | 29 | 20,116 | 15,709 | 1,952 | 81,653 |
| P-K | 187 | 1,077 | 2,531 | 2,257 | 129 | 0 | 79 | 66,725 | 149,077 | 344 | 6,781 |
| TOTAL | 439,890 | 908,727 | 605,397 | 386,476 | 513,247 | 332,352 | 223,832 | 387,225 | 469,953 | 214,041 | 1,622,103 |
| **NITROGEN FERTILIZERS** | | | | | | | | | | | |
| Ammonium Nitrate | 76,603 | 31,697 | 9,122 | 277,326 | 33,246 | 11,433 | 2,846 | 69,206 | 80,626 | 73,201 | 156,672 |
| Ammonium Nitrate Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 |
| Ammonium Nitrate-limestone Mixtures | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Nitrate-sulfate | 4 | 18 | 0 | 2 | 15 | 0 | 0 | 2,036 | 1 | 173 | 18 |
| Ammonium Polysulfide | 26 | 0 | 0 | 0 | 0 | 79 | 11 | 0 | 0 | 51 | 0 |
| Ammonium Sulfate | 2,158 | 10,760 | 42,323 | 16,629 | 23,619 | 3,869 | 3,548 | 11,064 | 26,959 | 7,526 | 109,722 |
| Ammonium Sulfate Solution | 8 | 19,748 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 3 | 229 |
| Ammonium Sulfate-nitrate | 0 | 285 | 428 | 54 | 502 | 0 | 18 | 39 | 0 | 26 | 6,936 |
| Ammonium Sulfate-urea | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,183 | 0 | 0 | 0 |
| Ammonium Thiosulfate | 17,192 | 7,479 | 3,978 | 5,848 | 63,426 | 373 | 646 | 1,136 | 0 | 3,896 | 16,835 |
| Anhydrous Ammonia | 503,336 | 705,100 | 348,293 | 128,273 | 605,998 | 394,352 | 27,673 | 8,366 | 1,656 | 134,320 | 261,011 |
| Aqua Ammonia | 3,194 | 0 | 122 | 0 | 71 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Ammonium Nitrate | 0 | 49 | 756 | 6 | 42 | 0 | 1 | 0 | 0 | 0 | 454 |
| Calcium Cyanamide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Nitrate | 543 | 213 | 83 | 698 | 8 | 197 | 0 | 2 | 0 | 147 | 345 |
| Calcium Nitrate-urea | 0 | 0 | 282 | 0 | 330 | 0 | 0 | 0 | 0 | 1,934 | 0 |
| Ferrous Ammonium Sulfate | 0 | 34 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Magnesium Nitrate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nitric Acid | 9 | 0 | 0 | 0 | 735 | 4 | 0 | 25 | 0 | 145 | 0 |
| Nitrogen Solution 28% | 258,746 | 559,704 | 149,524 | 66,969 | 436,765 | 28,677 | 104,015 | 4,751 | 13,362 | 149,326 | 155,937 |
| Nitrogen Solution 30% | 84 | 4,224 | 13 | 4,349 | 0 | 0 | 0 | 32,606 | 76 | 141 | 12,258 |

## Table A-2. (Continued)

| Description | KS | IA | MN | MO | NB | ND | SD | LA | AR | OK | TX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen Solution 32% | 165,782 | 276,540 | 15,556 | 207,117 | 399,386 | 10 | 8,573 | 212,327 | 148,356 | 44,859 | 457,018 |
| Nitrogen Solution <28% | 5,157 | 8,841 | 1,379 | 1,649 | 3,813 | 54 | 701 | 4,995 | 0 | 629 | 25,452 |
| Nitrogen Solution >32% | 6,200 | 232 | 0 | 0 | 0 | 0 | 0 | 266 | 0 | 0 | 5,921 |
| Sodium Nitrate | 1 | 0 | 2 | 39 | 0 | 0 | 0 | 851 | 2,384 | 5 | 28 |
| Sulfur Coated Urea | 184 | 0 | 162 | 2 | 710 | 47 | 0 | 196 | 0 | 36 | 233 |
| Urea | 101,051 | 185,463 | 472,342 | 161,127 | 68,397 | 286,992 | 128,341 | 73,389 | 408,305 | 121,045 | 249,541 |
| Urea Solution | 0 | 0 | 1,277 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urea-formaldehyde | 101 | 67 | 663 | 420 | 2,900 | 312 | 0 | 9,017 | 1,891 | 420 | 4,177 |
| Zinc Ammonium Sulfate Solution | 158 | 0 | 0 | 0 | 5,518 | 0 | 16 | 0 | 0 | 0 | 0 |
| Zinc Manganese Ammonium Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 |
| Other | 7,889 | 9,393 | 1,313 | 1,980 | 4,896 | 0 | 5,781 | 14,387 | 35,336 | 327 | 33,462 |
| TOTAL | 1,148,425 | 1,819,846 | 1,047,618 | 872,531 | 1,650,375 | 726,398 | 282,183 | 446,844 | 718,953 | 538,244 | 1,496,248 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | | | |
| Ammonium Metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Phosphate | 0 | 0 | 250 | 0 | 16,978 | 0 | 0 | 0 | 0 | 0 | 296 |
| Ammonium Phosphate Nitrate | 244 | 0 | 0 | 5 | 989 | 0 | 0 | 0 | 0 | 0 | 15 |
| Ammonium Phosphate Sulfate | 67 | 0 | 1,172 | 140 | 1,990 | 0 | 19 | 0 | 0 | 56 | 7,771 |
| Ammonium Polyphosphate | 0 | 0 | 0 | 0 | 52,123 | 0 | 0 | 0 | 0 | 0 | 0 |
| Basic Lime Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Basic Slag | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bone Meal, Raw | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Bone Meal, Steamed | 7 | 0 | 0 | 18 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Bone, Precipitated | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| Calcium Metaphosphate | 0 | 0 | 253 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 |
| Colloidal Phosphate (Soft Phosphate) | 0 | 0 | 2 | 116 | 24 | 0 | 0 | 25 | 0 | 4 | 0 |
| Diammonium Phosphate | 163,170 | 424,465 | 402,007 | 233,123 | 57,197 | 205,055 | 132,690 | 18,293 | 22,102 | 127,577 | 45,248 |
| Limestone, Phosphatic | 5 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table A-2. (Continued)

| Description | KS | IA | MN | MO | NB | ND | SD | LA | AR | OK | TX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Liquid Ammonium Polyphosphate | 148,294 | 59,626 | 55,563 | 15,156 | 150,353 | 13,352 | 44,318 | 12,231 | 3,608 | 22,050 | 99,478 |
| Magnesium Phosphate | 0 | 0 | 0 | 22 | 968 | 0 | 0 | 0 | 0 | 0 | 149 |
| Monoammonium Phosphate | 84,557 | 138,492 | 61,202 | 33,082 | 75,877 | 113,905 | 21,036 | 150 | 145 | 11,671 | 35,497 |
| Nitric Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phosphate Rock | 0 | 149 | 0 | 3 | 130 | 53 | 0 | 0 | 0 | 0 | 150 |
| Phosphoric Acid | 198 | 172 | 0 | 3,329 | 176 | 739 | 189 | 80 | 0 | 9 | 201 |
| Precipitated Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Superphosphate, Enriched | 0 | 0 | 1 | 88 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Superphosphate, Normal | 248 | 0 | 0 | 26 | 8,664 | 40 | 0 | 2 | 1 | 0 | 1 |
| Superphosphate, Triple | 1,859 | 21,714 | 13,748 | 42,629 | 3,505 | 3,576 | 4,059 | 4,321 | 17,979 | 2,053 | 888 |
| Superphosphoric Acid | 1,690 | 2,880 | 2,589 | -157 | 3,428 | 0 | 0 | 0 | 0 | 0 | 893 |
| Other | 2,274 | 44 | 0 | 983 | 431 | 0 | 0 | 185 | 3,842 | 572 | 36 |
| TOTAL | 402,612 | 647,541 | 536,787 | 328,584 | 372,835 | 336,720 | 202,310 | 35,294 | 47,677 | 164,018 | 190,625 |
| **POTASH FERTILIZERS** | | | | | | | | | | | |
| Lime-potash Mixtures | 0 | 0 | 7 | 23 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Manure Salts | 866 | 0 | 313 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 |
| Muriate of Potash 60% (Pot. Chloride) | 54,092 | 614,535 | 444,579 | 280,795 | 30,407 | 40,439 | 23,868 | 33,920 | 44,645 | 43,257 | 18,591 |
| Muriate of Potash 62% | 12,362 | 79,579 | 0 | 93,263 | 6,897 | 2,283 | 1,790 | 1,192 | 0 | 381 | 2,521 |
| Potash Suspensions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potassium Carbonate | 27 | 207 | 0 | 0 | 58 | 0 | 0 | 40 | 0 | 0 | 37 |
| Potassium Nitrate | 35 | 0 | 88 | 75 | 0 | 0 | 2 | 15 | 305 | 2 | 854 |
| Potassium Sulfate | 119 | 285 | 766 | 529 | 28 | 125 | 6 | 3,126 | 92 | 72 | 2,521 |
| Potassium-magnesium Sulfate | 4,503 | 379 | 6,983 | 3,817 | 23,926 | 114 | 176 | 190 | 472 | 1,352 | 5,860 |
| Potassium-metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potassium-sodium Nitrate | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 0 |
| Other | 1,710 | 4,894 | 1,621 | 590 | 2,227 | 153 | 142 | 3,403 | 2,417 | 64 | 4,634 |
| TOTAL | 73,713 | 699,879 | 454,357 | 379,092 | 63,543 | 43,114 | 26,007 | 41,887 | 47,932 | 45,146 | 35,018 |
| **ORGANIC FERTILIZERS** | | | | | | | | | | | |

# Table A-2. (Continued)

| Description | KS | IA | MN | MO | NB | ND | SD | LA | AR | OK | TX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Blood, Dried | 81 | 0 | 0 | 0 | 0 | 0 | 91 | 1 | 0 | 0 | 0 |
| Castor Pomace | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cocoa Shell Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Compost | 0 | 0 | 0 | 0 | 492 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cottonseed Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fish Scrap | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Guano | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manure | 1,006 | 0 | 0 | 0 | 1,287 | 0 | 0 | 83 | 1,577 | 3,231 | 0 |
| Peat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Activated | 302 | 0 | 0 | 0 | 182 | 40 | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Digested | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Heat Dried | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 0 |
| Soybean Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tankage, Animal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tankage, Process | 0 | 0 | 0 | 0 | 0 | 61 | 0 | 0 | 0 | 0 | 0 |
| Other | 2,562 | 0 | 0 | 0 | 0 | 308 | 0 | 102 | 0 | 0 | 0 |
| TOTAL | 3,959 | 0 | 0 | 0 | 1,960 | 408 | 91 | 186 | 1,577 | 3,275 | 0 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | | | |
| Aluminum Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Borax | 148 | 190 | 210 | 1,474 | 302 | 6 | 10 | 118 | 11,499 | 0 | 0 |
| Calcium Chelate | 5 | 0 | 0 | 0 | 42 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Chloride | 390 | 3,164 | 4 | 0 | 1,427 | 0 | 4 | 0 | 0 | 0 | 0 |
| Calcium Sulfate (Hydrous) | 0 | 0 | 0 | 0 | 190 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cobalt Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Chelate | 6 | 0 | 13 | 0 | 55 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Compound | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Oxide, Black | 0 | 18 | 0 | 34 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Sulfate | 5 | 0 | 173 | 0 | 56 | 5 | 1 | 0 | 0 | 0 | 0 |
| Epsom Salt (Magnesium Sulfate) | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |

# Table A-2. (Continued)

| Description | KS | IA | MN | MO | NB | ND | SD | LA | AR | OK | TX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ferric Oxide | 0 | 0 | 0 | 1,480 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Ferric Sulfate | 1 | 25 | 7 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ferrous Sulfate | 15 | 0 | 4 | 0 | 397 | 1 | 3 | 0 | 0 | 0 | 0 |
| Gypsum (Calcium Sulfate) | 27 | 4,781 | 1,553 | 1,243 | 905 | 67 | 0 | 44 | 0 | 0 | 0 |
| Iron Chelate | 45 | 0 | 17 | 0 | 565 | 9 | 0 | 4 | 0 | 5 | 0 |
| Iron Compound | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lime Sulfur Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Magnesia (Magnesium Oxide) | 1 | 3 | 10 | 131 | 51 | 0 | 0 | 1 | 0 | 0 | 0 |
| Magnesium Chelate | 5 | 0 | 2 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| Manganese Agstone | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manganese Chelate | 17 | 0 | 25 | 0 | 39 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manganese Oxide | 0 | 0 | 0 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manganese Slag | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manganese Sulfate | 1 | 0 | 68 | 0 | 315 | 3 | 0 | 0 | 0 | 0 | 0 |
| Manganous Oxide | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potting Soil | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sodium Molybdate | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil Additive | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil Amendment | 0 | 0 | 0 | 0 | 0 | 60 | 0 | 3 | 0 | 0 | 0 |
| Soil Conditioner | 0 | 0 | 5 | 0 | 1,197 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sulfur | 826 | 4,989 | 1,307 | 1,940 | 4,307 | 591 | 363 | 169 | 359 | 102 | 0 |
| Sulfuric Acid | 0 | 0 | 190 | 0 | 1,058 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zinc Chelate | 1,223 | 0 | 245 | 0 | 1,399 | 19 | 69 | 87 | 488 | 71 | 0 |
| Zinc Oxide | 296 | 1,252 | 131 | 1,199 | 1,892 | 80 | 0 | 63 | 0 | 0 | 0 |
| Zinc Oxysulfate | 3 | 0 | 9 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zinc Sulfate | 244 | 0 | 2,008 | 0 | 8,890 | 1,430 | 74 | 99 | 0 | 42 | 0 |
| Zinc Sulfate Solution | 0 | 0 | 0 | 0 | 1,883 | 0 | 0 | 0 | 0 | 144 | 0 |
| Other | 910 | 3,853 | 8,824 | 7,504 | 4 | 111 | 120 | 676 | 27,430 | 3,057 | 108,073 |
| TOTAL | 4,200 | 18,295 | 14,806 | 15,059 | 25,009 | 2,382 | 645 | 1,280 | 39,775 | 3,421 | 108,073 |
| **LIMING MATERIALS** | | | | | | | | | | | |

## Table A-2.  (Continued)

| Description | KS | IA | MN | MO | NB | ND | SD | LA | AR | OK | TX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Calcitic Lime (75% Neutral) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,953 | 0 | 0 | 0 |
| Calcium Hydroxide (Hydrate) | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Calcium Oxide (Burnt) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dolomitic & Calcitic Blend (Pelletized) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dolomitic Lime (75% Neutral) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 174 | 0 | 0 | 0 |
| Lime Suspensions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-lime Filler (Water, Sand, Etc.) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Standard Calcite | 8 | 0 | 0 | 1,581 | 3,670 | 0 | 0 | 0 | 0 | 0 | 0 |
| Standard Dolomite | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 |
| Other | 65 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 115 | 0 |
| TOTAL | 73 | 0 | 0 | 1,581 | 3,670 | 2 | 0 | 3,154 | 0 | 115 | 0 |
| **ALL FERTILIZERS** | | | | | | | | | | | |
| TOTAL | 1,674,338 | 3,471,704 | 2,138,683 | 1,701,723 | 2,273,170 | 1,109,024 | 536,982 | 885,089 | 1,298,129 | 803,628 | 3,262,910 |

## Table A-3. Fertilizer Consumption (Tons) by State - New England and Middle Atlantic Regions

| Description | DE | CN | ME | MD | MA | NJ | NH | NY | RI | PA | VT | WV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | | | | |
| N-P-K | 34,844 | 34,218 | 73,202 | 125,085 | 87,020 | 254,804 | 18,459 | 201,816 | 9,755 | 261,834 | 16,184 | 27,757 |
| N-P | 7,035 | 947 | 5,634 | 88,410 | 2,931 | 7,043 | 506 | 39,230 | 1,112 | 34,837 | 6,625 | 4,296 |
| N-K | 4,771 | 1,538 | 587 | 10,491 | 3,164 | 7,052 | 1,078 | 7,914 | 110 | 13,731 | 849 | 151 |
| P-K | 867 | 866 | 21 | 2,092 | 500 | 1,704 | 47 | 4,427 | 21 | 17,657 | 528 | 410 |
| TOTAL | 47,517 | 37,569 | 79,443 | 226,078 | 93,615 | 270,603 | 20,090 | 253,387 | 10,998 | 328,058 | 24,186 | 32,614 |
| **NITROGEN FERTILIZERS** | | | | | | | | | | | | |
| Ammonium Nitrate | 1,827 | 58 | 2,993 | 3,362 | 139 | 1,190 | 46 | 6,324 | 42 | 8,401 | 69 | 706 |
| Ammonium Nitrate Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Ammonium Nitrate-limestone Mixtures | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 0 |
| Ammonium Nitrate-sulfate | 0 | 0 | 0 | 29 | 0 | 1,062 | 0 | 11 | 0 | 18 | 0 | 48 |
| Ammonium Polysulfide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Ammonium Sulfate | 7,733 | 87 | 720 | 12,652 | 221 | 1,365 | 70 | 9,713 | 14 | 13,819 | 145 | 255 |
| Ammonium Sulfate Solution | 75 | 0 | 0 | 330 | 0 | 0 | 0 | 5 | 0 | 97 | 0 | 0 |
| Ammonium Sulfate-nitrate | 49 | 0 | 0 | 360 | 0 | 0 | 0 | 0 | 0 | 393 | 0 | 0 |
| Ammonium Sulfate-urea | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 |
| Ammonium Thiosulfate | 3 | 1 | 0 | 584 | 0 | 32 | 1 | 425 | 3 | 2,194 | 0 | 1 |
| Anhydrous Ammonia | 30 | 0 | 0 | 10,057 | 2 | 30 | 0 | 2,837 | 0 | 2,855 | 0 | 727 |
| Aqua Ammonia | 0 | 0 | 0 | 323 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 101 |
| Calcium Ammonium Nitrate | 0 | 0 | 0 | 5 | 0 | 8 | 9 | 64 | 0 | 0 | 0 | 0 |
| Calcium Cyanamide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Nitrate | 17 | 180 | 239 | 441 | 263 | 862 | 188 | 1,447 | 132 | 695 | 50 | 23 |
| Calcium Nitrate-urea | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 |
| Ferrous Ammonium Sulfate | 1 | 0 | 0 | 33 | 11 | 14 | 6 | 28 | 0 | 0 | 0 | 2 |

## Table A-3. (Continued)

| Description | DE | CN | ME | MD | MA | NJ | NH | NY | RI | PA | VT | WV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Magnesium Nitrate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nitric Acid | 0 | 0 | 0 | 2 | 23 | 0 | 0 | 6 | 0 | 0 | 0 | 2 |
| Nitrogen Solution 28% | 1,569 | 41 | 691 | 538 | 29 | 24,790 | 1 | 731 | 0 | 11,944 | 0 | 813 |
| Nitrogen Solution 30% | 37,587 | 0 | 0 | 93,283 | 1 | 1,227 | 0 | 13,587 | 0 | 71,508 | 0 | 3,260 |
| Nitrogen Solution 32% | 1,128 | 176 | 502 | 206 | 598 | 2 | 167 | 24,345 | 1 | 6,726 | 1,664 | 0 |
| Nitrogen Solution <28% | 11,211 | 5 | 86 | 15,470 | 4 | 3,867 | 5 | 1,337 | 1 | 10,314 | 0 | 13 |
| Nitrogen Solution >32% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 165 | 0 | 45 | 0 | 0 |
| Sodium Nitrate | 11 | 3 | 4 | 95 | 6 | 210 | 2 | 66 | 1 | 9 | 325 | 17 |
| Sulfur Coated Urea | 4 | 1 | 0 | 14 | 1 | 16 | 0 | 298 | 0 | 97 | 4 | 0 |
| Urea | 573 | 1,806 | 4,156 | 8,980 | 2,400 | 4,457 | 1,445 | 28,796 | 361 | 49,761 | 3,269 | 2,657 |
| Urea Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urea-formaldehyde | 10 | 353 | 0 | 344 | 1,463 | 3,254 | 38 | 574 | 0 | 7,947 | 3 | 89 |
| Zinc Ammonium Sulfate Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zinc Manganese Ammonium Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| Other | 320 | 103 | 7 | 2,334 | 519 | 1,768 | 19 | 1,713 | 26 | 4,282 | 2,715 | 31 |
| TOTAL | 62,150 | 2,816 | 9,398 | 149,442 | 5,679 | 44,154 | 1,998 | 92,530 | 581 | 191,106 | 8,243 | 8,746 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | | | | |
| Ammonium Metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Phosphate | 0 | 0 | 0 | 891 | 1 | 0 | 0 | 20 | 0 | 0 | 0 | 0 |
| Ammonium Phosphate Nitrate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Phosphate Sulfate | 74 | 0 | 0 | 0 | 0 | 0 | 0 | 48 | 0 | 0 | 0 | 0 |
| Ammonium Polyphosphate | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 194 | 0 | 252 | 56 | 0 |
| Basic Lime Phosphate | 0 | 0 | 0 | 0 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table A-3. (Continued)

| Description | DE | CN | ME | MD | MA | NJ | NH | NY | RI | PA | VT | WV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Basic Slag | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bone Meal, Raw | 0 | 0 | 3 | 0 | 72 | 13 | 0 | 1 | 0 | 45 | 0 | 0 |
| Bone Meal, Steamed | 5 | 48 | 8 | 1 | 141 | 3 | 15 | 142 | 1 | 4 | 1 | 0 |
| Bone, Precipitated | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Colloidal Phosphate (Soft Phosphate) | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 45 | 0 | 0 |
| Diammonium Phosphate | 1,924 | 5 | 3,261 | 18,624 | 1,842 | 1,462 | 297 | 7,562 | 0 | 12,043 | 481 | 3,997 |
| Limestone, Phosphatic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Liquid Ammonium Polyphosphate | 3,348 | 0 | 1,677 | 4,075 | 41 | 1,119 | 73 | 9,523 | 6 | 5,255 | 168 | 206 |
| Magnesium Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 0 | 1 | 0 | 0 |
| Monoammonium Phosphate | 769 | 455 | 112 | 7,130 | 616 | 164 | 68 | 19,439 | 120 | 12,337 | 1,167 | 8 |
| Nitric Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phosphate Rock | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 4 | 0 | 0 | 7 | 0 |
| Phosphoric Acid | 1,322 | 0 | 0 | 420 | 0 | 0 | 0 | 0 | 0 | 577 | 0 | 0 |
| Precipitated Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Superphosphate, Enriched | 5 | 0 | 0 | 0 | 8 | 0 | 0 | 23 | 0 | 14 | 0 | 0 |
| Superphosphate, Normal | 53 | 12 | 3 | 11 | 95 | 1,014 | 31 | 27 | 2 | 95 | 2 | 1 |
| Superphosphate, Triple | 87 | 83 | 70 | 8,222 | 365 | 281 | 45 | 1,202 | 37 | 5,878 | 97 | 1,441 |
| Superphosphoric Acid | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 113 | 23 | 5 | 1,683 | 76 | 656 | 24 | 130 | 16 | 849 | 7 | 35 |
| TOTAL | 7,699 | 628 | 5,142 | 41,059 | 3,303 | 4,711 | 553 | 38,355 | 182 | 37,393 | 1,987 | 5,687 |
| **POTASH FERTILIZERS** | | | | | | | | | | | | |
| Lime-potash Mixtures | 0 | 0 | 0 | 0 | 36 | 0 | 0 | 5,568 | 0 | 0 | 10 | 0 |
| Manure Salts | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# Table A-3. (Continued)

| Description | DE | CN | ME | MD | MA | NJ | NH | NY | RI | PA | VT | WV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muriate of Potash 60% (Pot. Chloride) | 12,042 | 874 | 1,797 | 33,031 | 1,141 | 2,800 | 1,432 | 43,166 | 182 | 25,375 | 2,636 | 4,325 |
| Muriate of Potash 62% | 427 | 8 | 0 | 2,294 | 712 | 47 | 0 | 2,095 | 0 | 8,345 | 0 | 35 |
| Potash Suspensions | 0 | 13 | 0 | 0 | 20 | 0 | 24 | 303 | 5 | 2,449 | 0 | 0 |
| Potassium Carbonate | 0 | 0 | 0 | 250 | 28 | 48 | 0 | -246 | 0 | 25 | 0 | 0 |
| Potassium Nitrate | 3 | 42 | 0 | 1,396 | 289 | 141 | 31 | 96 | 0 | 8,490 | 0 | 0 |
| Potassium Sulfate | 9 | 26 | 2 | 302 | 79 | 210 | 18 | 370 | 4 | 1,721 | 95 | 131 |
| Potassium-magnesium Sulfate | 137 | 36 | 266 | 1,047 | 873 | 168 | 34 | 1,959 | 4 | 478 | 274 | 6 |
| Potassium-metaphosphate | 0 | 0 | 0 | 0 | 1 | 173 | 3 | 0 | 0 | 0 | 0 | 0 |
| Potassium-sodium Nitrate | 0 | 0 | 0 | 0 | 1 | 32 | 0 | 109 | 0 | 0 | 0 | 0 |
| Other | 1,580 | 74 | 35 | 713 | 444 | 2,804 | 130 | 8,355 | 14 | 720 | 81 | 69 |
| TOTAL | 14,199 | 1,074 | 2,100 | 39,033 | 3,625 | 6,423 | 1,672 | 61,776 | 209 | 47,605 | 3,097 | 4,566 |
| **ORGANIC FERTILIZERS** | | | | | | | | | | | | |
| Blood, Dried | 3 | 7 | 3 | 0 | 23 | 2 | 4 | 6 | 0 | 9 | 0 | 0 |
| Castor Pomace | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cocoa Shell Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Compost | 170 | 0 | 0 | 0 | 14,435 | 7,841 | 64 | 1,413 | 0 | 481 | 10 | 5,289 |
| Cottonseed Meal | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fish Scrap | 0 | 0 | 0 | 0 | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Guano | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manure | 386 | 28 | 18 | 4,731 | 676 | 4,041 | 45 | 1,084 | 0 | 1,205 | 53 | 1,612 |
| Peat | 0 | 0 | 0 | 73 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Activated | 0 | 458 | 124 | 0 | 613 | 279 | 46 | 5,028 | 0 | 1,311 | 0 | 0 |
| Sewage Sludge, Digested | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Heat Dried | 127 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table A-3. (Continued)

| Description | DE | CN | ME | MD | MA | NJ | NH | NY | RI | PA | VT | WV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sewage Sludge, Other | 33 | 0 | 0 | 0 | 0 | 4,004 | 86 | 1 | 0 | 0 | 0 | 0 |
| Soybean Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tankage, Animal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tankage, Process | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 353 | 0 | 0 | 1,099 | 8 | 3 | 0 | 1,369 | 0 | 5,013 | 20 | 0 |
| TOTAL | 1,072 | 494 | 147 | 5,903 | 15,806 | 16,190 | 245 | 8,902 | 0 | 8,019 | 84 | 6,902 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | | | | |
| Aluminum Sulfate | 22 | 4 | 0 | 1 | 12 | 2 | 1 | 8 | 3 | 5 | 400 | 0 |
| Borax | 27 | 2 | 74 | 153 | 1 | 40 | 14 | 443 | 2 | 113 | 30 | 24 |
| Calcium Chelate | 1 | 0 | 0 | 0 | 4 | 6 | 0 | 74 | 0 | 1 | 0 | 0 |
| Calcium Chloride | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 2 | 0 | 384 | 0 | 0 |
| Calcium Sulfate (Hydrous) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cobalt Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Chelate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Copper Compound | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Oxide, Black | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Sulfate | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 56 | 0 | 381 | 0 | 0 |
| Epsom Salt (Magnesium Sulfate) | 0 | 0 | 1 | 1 | 3 | 33 | 6 | 11 | 0 | 13 | 0 | 0 |
| Ferric Oxide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ferric Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 0 | 0 |
| Ferrous Sulfate | 1 | 0 | 0 | 0 | 6 | 0 | 0 | 6 | 0 | 14 | 0 | 0 |
| Gypsum (Calcium Sulfate) | 47 | 129 | 23 | 328 | 267 | 647 | 46 | 104 | 1 | 709 | 22 | 0 |
| Iron Chelate | 0 | 24 | 0 | 19 | 19 | 36 | 6 | 96 | 1 | 32 | 1 | 4 |
| Iron Compound | 0 | 2 | 0 | 10 | 4 | 6 | 0 | 45 | 1 | 0 | 0 | 0 |
| Lime Sulfur Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table A-3. (Continued)

| Description | DE | CN | ME | MD | MA | NJ | NH | NY | RI | PA | VT | WV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Magnesia (Magnesium Oxide) | 0 | 0 | 11 | 3 | 0 | 0 | 0 | 131 | 0 | 203 | 0 | 2 |
| Magnesium Chelate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 |
| Manganese Agstone | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manganese Chelate | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 5 | 0 | 1 | 0 | 0 |
| Manganese Oxide | 7 | 0 | 0 | 3 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Manganese Slag | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manganese Sulfate | 63 | 0 | 1 | 26 | 4 | 6 | 4 | 90 | 0 | 6 | 0 | 0 |
| Manganous Oxide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potting Soil | 14 | 0 | 0 | 0 | 0 | 360 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sodium Molybdate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil Additive | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil Amendment | 3 | 0 | 20,035 | 0 | 0 | 2 | 0 | 67 | 0 | 0 | 0 | 0 |
| Soil Conditioner | 0 | 0 | 0 | 0 | 0 | 7,135 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sulfur | 5 | 2 | 61 | 43 | 9 | 23 | 3 | 364 | 0 | 645 | 4 | 9 |
| Sulfuric Acid | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zinc Chelate | 5 | 0 | 0 | 30 | 1 | 0 | 0 | 55 | 0 | 4 | 0 | 0 |
| Zinc Oxide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 331 | 0 | 36 | 0 | 0 |
| Zinc Oxysulfate | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 49 | 0 | 8 | 0 | 0 |
| Zinc Sulfate | 37 | 0 | 7 | 61 | 0 | 12 | 0 | 165 | 3 | 23 | 9 | 0 |
| Zinc Sulfate Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 245 | 15 | 0 | 70 | 31 | 64 | 2 | 300 | 0 | 431 | 0 | 2 |
| TOTAL | 478 | 178 | 20,215 | 780 | 367 | 8,381 | 81 | 2,415 | 12 | 3,061 | 467 | 42 |
| **LIMING MATERIALS** | | | | | | | | | | | | |
| Calcitic Lime (75% Neutral) | 0 | 0 | 13,094 | 0 | 70 | 0 | 394 | 0 | 0 | 0 | 0 | 0 |
| Calcium Hydroxide (Hydrate) | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 |
| Calcium Oxide (Burnt) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table A-3. (Continued)

| Description | DE | CN | ME | MD | MA | NJ | NH | NY | RI | PA | VT | WV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dolomitic & Calcitic Blend (Pelletized) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dolomitic Lime (75% Neutral) | 0 | 510 | 11,294 | 0 | 2 | 10 | 0 | 0 | 71 | 0 | 0 | 0 |
| Lime Suspensions | 0 | 0 | 0 | 228 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-lime Filler (Water, Sand, Etc.) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 92 | 0 | 0 | 0 | 0 |
| Standard Calcite | 0 | 0 | 8,713 | 7,947 | 0 | 0 | 10 | 940 | 265 | 24 | 0 | 557 |
| Standard Dolomite | 0 | 0 | 353 | 0 | 984 | 0 | 442 | 34 | 5,498 | 0 | 29 | 0 |
| Other | 169 | 0 | 9,694 | 6,074 | 9 | 375 | 554 | 2,753 | 12 | 500 | 0 | 0 |
| TOTAL | 169 | 510 | 43,154 | 14,249 | 1,065 | 385 | 1,401 | 3,820 | 5,863 | 524 | 29 | 557 |
| **ALL FERTILIZERS** | | | | | | | | | | | | |
| TOTAL | 126,446 | 42,232 | 154,395 | 439,624 | 104,675 | 331,556 | 25,311 | 416,366 | 17,718 | 569,331 | 36,156 | 48,002 |

## Table A-4. Fertilizer Consumption (Tons) by State - South Atlantic Region

| Description | FL | GA | NC | SC | VA |
|---|---|---|---|---|---|
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | |
| N-P-K | 1,073,365 | 989,848 | 792,236 | 299,311 | 342,468 |
| N-P | 49,685 | 55,376 | 71,605 | 15,851 | 66,647 |
| N-K | 379,121 | 0 | 83,792 | 42,200 | 21,598 |
| P-K | 60,775 | 0 | 19,698 | 60,513 | 4,749 |
| TOTAL | 1,562,946 | 1,045,224 | 967,331 | 417,875 | 435,462 |
| **NITROGEN FERTILIZERS** | | | | | |
| Ammonium Nitrate | 33,591 | 81,043 | 38,198 | 17,564 | 12,511 |
| Ammonium Nitrate Solution | 3,294 | 0 | 0 | 382 | 38 |
| Ammonium Nitrate-limestone Mixtures | 5 | 0 | 392 | 0 | 0 |
| Ammonium Nitrate-sulfate | 6 | 0 | 11,793 | 54 | 844 |
| Ammonium Polysulfide | 1 | 0 | 2,916 | 606 | 98 |
| Ammonium Sulfate | 29,702 | 8,088 | 35,160 | 3,290 | 24,836 |
| Ammonium Sulfate Solution | 210 | 0 | 1 | 31 | 429 |
| Ammonium Sulfate-nitrate | 1,073 | 0 | 107 | 7 | 73 |
| Ammonium Sulfate-urea | 0 | 0 | 0 | 456 | 13 |
| Ammonium Thiosulfate | 843 | 0 | 253 | 65 | 253 |
| Anhydrous Ammonia | 5,535 | 8,734 | 5,187 | 2,215 | 782 |
| Aqua Ammonia | 27 | 0 | 308 | 0 | 265 |
| Calcium Ammonium Nitrate | 24 | 0 | 85 | 212 | 33 |
| Calcium Cyanamide | 0 | 0 | 1 | 2 | 0 |
| Calcium Nitrate | 10,914 | 0 | 6,997 | 1,342 | 822 |
| Calcium Nitrate-urea | 10 | 0 | 1,046 | 439 | 0 |
| Ferrous Ammonium Sulfate | 33 | 0 | 122 | 0 | 88 |
| Magnesium Nitrate | 3 | 0 | 0 | 0 | 0 |
| Nitric Acid | 0 | 0 | 1 | 16 | 974 |
| Nitrogen Solution 28% | 18,613 | 0 | 1,038 | 2,465 | 732 |
| Nitrogen Solution 30% | 290 | 332,803 | 290,404 | 66,162 | 82,872 |
| Nitrogen Solution 32% | 12,992 | 0 | 23,779 | 1,145 | 898 |
| Nitrogen Solution <28% | 26,999 | 0 | 86,347 | 73,959 | 45,074 |
| Nitrogen Solution >32% | 358 | 0 | 72 | 1,177 | 353 |
| Sodium Nitrate | 912 | 0 | 14,178 | 2,218 | 1,640 |
| Sulfur Coated Urea | 51 | 0 | 3 | 146 | 46 |
| Urea | 16,715 | 23,762 | 15,785 | 4,304 | 23,051 |
| Urea Solution | 159 | 0 | 0 | 143 | 0 |
| Urea-formaldehyde | 7,645 | 0 | 1,497 | 3,020 | 767 |
| Zinc Ammonium Sulfate Solution | 0 | 0 | 85 | 105 | 129 |
| Zinc Manganese Ammonium Sulfate | 5 | 0 | 7 | 0 | 63 |

## Table A-4. (Continued)

| Description | FL | GA | NC | SC | VA |
|---|---|---|---|---|---|
| Other | 25,758 | 27,930 | 5,317 | 7,966 | 1,416 |
| TOTAL | 195,767 | 482,360 | 541,078 | 189,492 | 199,101 |
| **PHOSPHATE FERTILIZERS** | | | | | |
| Ammonium Metaphosphate | 0 | 0 | 0 | 0 | 0 |
| Ammonium Phosphate | 2 | 0 | 0 | 0 | 2 |
| Ammonium Phosphate Nitrate | 1 | 0 | 0 | 0 | 0 |
| Ammonium Phosphate Sulfate | 0 | 0 | 0 | 16 | 8 |
| Ammonium Polyphosphate | 6 | 0 | 0 | 0 | 0 |
| Basic Lime Phosphate | 0 | 0 | 0 | 0 | 0 |
| Basic Slag | 2,869 | 0 | 119 | 0 | 0 |
| Bone Meal, Raw | 0 | 0 | 24 | 16 | 0 |
| Bone Meal, Steamed | 37 | 0 | 2 | 0 | 138 |
| Bone, Precipitated | 0 | 0 | 0 | 0 | 0 |
| Calcium Metaphosphate | 13 | 0 | 14 | 0 | 88 |
| Colloidal Phosphate (Soft Phosphate) | 393 | 0 | 56 | 1 | 50 |
| Diammonium Phosphate | 13,674 | 13,123 | 34,613 | 2,757 | 48,541 |
| Limestone, Phosphatic | 45 | 0 | 0 | 0 | 0 |
| Liquid Ammonium Polyphosphate | 8,055 | 42,253 | 22,673 | 9,882 | 6,661 |
| Magnesium Phosphate | 25 | 0 | 12 | 5 | 0 |
| Monoammonium Phosphate | 84 | 0 | 2,227 | 28 | 1,917 |
| Nitric Phosphate | 0 | 0 | 0 | 0 | 0 |
| Phosphate Rock | 0 | 0 | 0 | 0 | 24 |
| Phosphoric Acid | 2,945 | 0 | 156 | 1 | 100 |
| Precipitated Phosphate | 0 | 0 | 23 | 0 | 0 |
| Super Phosphate, Enriched | 25 | 0 | 16 | 26 | 19 |
| Super Phosphate, Normal | 1,737 | 0 | 158 | 561 | 211 |
| Super Phosphate, Triple | 4,260 | 5,171 | 10,850 | 2,313 | 6,064 |
| Super Phosphoric Acid | 2,219 | 0 | 0 | 0 | 0 |
| Other | 5,710 | 11,371 | 34 | 81 | 383 |
| TOTAL | 42,102 | 71,918 | 70,978 | 15,688 | 64,205 |
| **POTASH FERTILIZERS** | | | | | |
| Lime-potash Mixtures | 30 | 0 | 96 | 1 | 93 |
| Manure Salts | 1 | 0 | 478 | 1 | 24 |
| Muriate of Potash 60% (Pot. Chloride) | 10,570 | 29,836 | 77,488 | 11,619 | 63,405 |
| Muriate of Potash 62% | 738 | 0 | 5,121 | 2,914 | 4,170 |
| Potash Suspensions | 179 | 0 | 0 | 0 | 0 |
| Potassium Carbonate | 2 | 0 | 288 | 4 | 0 |
| Potassium Nitrate | 4,142 | 0 | 17,085 | 5,361 | 28 |

## Table A-4. (Continued)

| Description | FL | GA | NC | SC | VA |
|---|---|---|---|---|---|
| Potassium Sulfate | 9,313 | 0 | 4,883 | 2,626 | 873 |
| Potassium-magnesium Sulfate | 3,402 | 6,325 | 5,779 | 921 | 591 |
| Potassium-metaphosphate | 0 | 0 | 0 | 0 | 0 |
| Potassium-sodium Nitrate | 946 | 0 | 15,713 | 325 | 1,434 |
| Other | 11,405 | 12,594 | 3,605 | 4,813 | 4,655 |
| TOTAL | 40,727 | 48,755 | 130,537 | 28,586 | 75,273 |
| **ORGANIC FERTILIZERS** | | | | | |
| Blood, Dried | 5 | 0 | 125 | 0 | 66 |
| Castor Pomace | 0 | 0 | 8 | 0 | 0 |
| Cocoa Shell Meal | 0 | 0 | 11 | 0 | 0 |
| Compost | 3 | 0 | 12 | 1,586 | 19,263 |
| Cottonseed Meal | 1 | 0 | 39 | 0 | 0 |
| Fish Scrap | 0 | 0 | 18 | 0 | 0 |
| Guano | 0 | 0 | 0 | 0 | 0 |
| Manure | 4,010 | 0 | 42,046 | 3,573 | 7,679 |
| Peat | 0 | 0 | 8,399 | 0 | 62 |
| Sewage Sludge, Activated | 10,682 | 0 | 23 | 56 | 0 |
| Sewage Sludge, Digested | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Heat Dried | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Other | 0 | 0 | 6 | 0 | 253 |
| Soybean Meal | 0 | 0 | 0 | 0 | 0 |
| Tankage, Animal | 0 | 0 | 0 | 0 | 0 |
| Tankage, Process | 0 | 0 | 83 | 0 | 0 |
| Other | 996 | 29,314 | 143,494 | 1,397 | 12,226 |
| TOTAL | 15,695 | 29,314 | 194,265 | 6,612 | 39,548 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | |
| Aluminum Sulfate | 4 | 0 | 4 | 0 | 9 |
| Borax | 84 | 0 | 1,268 | 75 | 467 |
| Calcium Chelate | 222 | 0 | 3 | 0 | 2 |
| Calcium Chloride | 8 | 0 | 2 | 5 | 24 |
| Calcium Sulfate (Hydrous) | 13 | 0 | 0 | 0 | 0 |
| Cobalt Sulfate | 0 | 0 | 0 | 0 | 0 |
| Copper Chelate | 0 | 0 | 58 | 0 | 0 |
| Copper Compound | 4 | 0 | 0 | 3 | 0 |
| Copper Oxide, Black | 0 | 0 | 0 | 0 | 0 |
| Copper Sulfate | 175 | 0 | 35 | 4 | 3 |
| Epsom Salt (Magnesium Sulfate) | 859 | 0 | 2 | 8 | 5 |
| Ferric Oxide | 1 | 0 | 0 | 0 | 0 |
| Ferric Sulfate | 0 | 0 | 0 | 0 | 0 |

## Table A-4. (Continued)

| Description | FL | GA | NC | SC | VA |
|---|---|---|---|---|---|
| Ferrous Sulfate | 1,723 | 0 | 22 | 0 | 0 |
| Gypsum (Calcium Sulfate) | 22,357 | 79,514 | 130,820 | 9,506 | 92,203 |
| Iron Chelate | 553 | 0 | 69 | 0 | 7 |
| Iron Compound | 172 | 0 | 0 | 38 | 5 |
| Lime Sulfur Solution | 0 | 0 | 0 | 0 | 0 |
| Magnesia (Magnesium Oxide) | 160 | 0 | 46 | 47 | 13 |
| Magnesium Chelate | 21 | 0 | 0 | 0 | 3 |
| Manganese Agstone | 0 | 0 | 0 | 0 | 0 |
| Manganese Chelate | 38 | 0 | 80 | 0 | 1 |
| Manganese Oxide | 13 | 0 | 24 | -1 | 3 |
| Manganese Slag | 72 | 0 | 0 | 88 | 0 |
| Manganese Sulfate | 3,238 | 0 | 129 | 8 | 1 |
| Manganous Oxide | 0 | 0 | 0 | 0 | 0 |
| Potting Soil | 0 | 0 | 0 | 0 | 28,530 |
| Sodium Molybdate | 0 | 0 | 0 | 0 | 0 |
| Soil Additive | 1 | 0 | 0 | 0 | 0 |
| Soil Amendment | 0 | 0 | 0 | 0 | 5,036 |
| Soil Conditioner | 356 | 0 | 1 | 0 | 58 |
| Sulfur | 807 | 0 | 656 | 226 | 584 |
| Sulfuric Acid | 0 | 0 | 0 | 0 | 0 |
| Zinc Chelate | 15 | 0 | 27 | 0 | 41 |
| Zinc Oxide | 118 | 0 | 0 | 3 | 0 |
| Zinc Oxysulfate | 0 | 0 | 11 | 8 | 3 |
| Zinc Sulfate | 3 | 0 | 3 | 1 | 27 |
| Zinc Sulfate Solution | 0 | 0 | 0 | 0 | 0 |
| Other | 60,293 | 39,388 | 12,392 | 4,448 | 518 |
| TOTAL | 91,308 | 118,902 | 145,651 | 14,468 | 127,543 |
| **LIMING MATERIALS** | | | | | |
| Calcitic Lime (75% Neutral) | 25,124 | 0 | 0 | 0 | 0 |
| Calcium Hydroxide (Hydrate) | 231 | 0 | 0 | 0 | 0 |
| Calcium Oxide (Burnt) | 186 | 0 | 0 | 0 | 0 |
| Dolomitic & Calcitic Blend (Pelletized) | 775 | 0 | 0 | 0 | 115 |
| Dolomitic Lime (75% Neutral) | 111,666 | 0 | 0 | 0 | 197 |
| Lime Suspensions | 0 | 0 | 0 | 0 | 0 |
| Non-lime Filler (Water, Sand, Etc.) | 7 | 0 | 0 | 0 | 0 |
| Standard Calcite | 22,288 | 0 | 947,126 | 0 | 3,917 |
| Standard Dolomite | 36,218 | 0 | 0 | 0 | 6 |
| Other | 19,864 | 0 | 0 | 0 | 15,960 |
| TOTAL | 216,359 | 0 | 947,126 | 0 | 20,196 |

## Table A-4. (Continued)

| Description | FL | GA | NC | SC | VA |
|---|---|---|---|---|---|
| **ALL FERTILIZERS** | | | | | |
| TOTAL | 2,123,256 | 1,741,097 | 2,821,000 | 649,028 | 875,174 |

## Table A-5. Fertilizer Consumption (Tons) by State - Mountain and Pacific Region and Puerto Rico

| | AZ | AK | CA | CO | HI | ID | MT | NV | NM | OR | Puerto Rico | UT | WA | WY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | | | | | | |
| N-P-K | 0 | 2,379 | 1,248,781 | 23,218 | 45,031 | 0 | 4,383 | 5,679 | 6,651 | 20,353 | 66,807 | 13,565 | 67,305 | 6,476 |
| N-P | 59,497 | 585 | 206,474 | 74,704 | 6,297 | 213,955 | 166,831 | 6,912 | 36,594 | 101,923 | 30 | 16,551 | 144,203 | 53,239 |
| N-K | 1,853 | 0 | 24,219 | 891 | 0 | 0 | 238 | 170 | 460 | 5,553 | 1,572 | 152 | 5,636 | 732 |
| P-K | 0 | 0 | 60 | 0 | 0 | 0 | 0 | 18 | 0 | 315 | 13 | 0 | 1,011 | 5 |
| TOTAL | 61,351 | 2,964 | 1,479,534 | 98,813 | 51,328 | 213,955 | 171,452 | 12,778 | 43,704 | 128,144 | 68,422 | 30,268 | 218,155 | 60,452 |
| **NITROGEN FERTILIZERS** | | | | | | | | | | | | | | |
| Ammonium Nitrate | 2,416 | 15 | 92,968 | 53,971 | 0 | 126,896 | 56,557 | 1,700 | 1,827 | 32,335 | 132 | 36,433 | 52,065 | 28,354 |
| Ammonium Nitrate Solution | 0 | 0 | 67,364 | 0 | 0 | 0 | 0 | 50 | 0 | 2,700 | 0 | 0 | 0 | 0 |
| Ammonium Nitrate-limestone Mixtures | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Nitrate-sulfate | 0 | 0 | 0 | 0 | 0 | 6,508 | 0 | 0 | 48 | 26 | 0 | 0 | 2,464 | 1,036 |
| Ammonium Polysulfide | 7,155 | 0 | 9,125 | 0 | 0 | 900 | 0 | 301 | 989 | 3,489 | 0 | 792 | 12,433 | 0 |
| Ammonium Sulfate | 8,994 | 123 | 205,878 | 3,830 | 15,285 | 82,425 | 18,146 | 3,674 | 7,054 | 86,629 | 1,613 | 11,532 | 58,361 | 3,188 |
| Ammonium Sulfate Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 314 | 0 | 7 | 4 | 0 |
| Ammonium Sulfate-nitrate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,707 | 847 | 0 | 0 | 158 | 1 |
| Ammonium Sulfate-urea | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ammonium Thiosulfate | 0 | 0 | 8,977 | 7,853 | 0 | 13,972 | 1,660 | 326 | 2,347 | 11,596 | 0 | 480 | 39,528 | 1,788 |
| Anhydrous Ammonia | 18,877 | 0 | 154,673 | 50,381 | 0 | 44,552 | 75,716 | 559 | 13,750 | 32,545 | 0 | 1,799 | 78,143 | 84,839 |
| Aqua Ammonia | 1,408 | 0 | 204,931 | 200 | 0 | 6,672 | 426 | 0 | 6 | 9,179 | 0 | 0 | 134,951 | 158 |
| Calcium Ammonium Nitrate | 0 | 0 | 173,949 | 176 | 0 | 0 | 0 | 326 | 377 | 649 | 0 | 5 | 2,076 | 98 |
| Calcium Cyanamide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 248 | 0 |
| Calcium Nitrate | 1,309 | 0 | 95,323 | 626 | 0 | 0 | 0 | 18 | 1,136 | 3,889 | 0 | 0 | 13,476 | 545 |
| Calcium Nitrate-urea | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 87 |
| Ferrous Ammonium Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 1,805 | 0 |

# Table A-5. (Continued)

| | AZ | AK | CA | CO | HI | ID | MT | NV | NM | OR | Puerto Rico | UT | WA | WY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Magnesium Nitrate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nitric Acid | 0 | 0 | 0 | 188 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 4 | 0 | 0 |
| Nitrogen Solution 28% | 0 | 0 | 7,168 | 6,053 | 0 | 0 | 15,076 | 0 | 4,529 | 4,678 | 0 | 32 | 6,595 | 578 |
| Nitrogen Solution 30% | 0 | 0 | 0 | 252 | 0 | 0 | 0 | 0 | 106 | 0 | 0 | 0 | 16 | 65 |
| Nitrogen Solution 32% | 138,961 | 0 | 586,101 | 63,869 | 18,236 | 136,491 | 7,895 | 4,105 | 31,050 | 70,144 | 0 | 10,666 | 137,675 | 50,096 |
| Nitrogen Solution <28% | 41,408 | 0 | 975 | 9,458 | 0 | 2,002 | 0 | 376 | 401 | 403 | 0 | 244 | 16,542 | 110 |
| Nitrogen Solution >32% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 967 | 0 |
| Sodium Nitrate | 0 | 0 | 1,694 | 0 | 0 | 0 | 0 | 7 | 20 | 0 | 0 | 68 | 24 | 0 |
| Sulfur Coated Urea | 0 | 0 | 1,741 | 11 | 0 | 0 | 0 | 0 | 237 | 248 | 8 | 178 | 0 | 0 |
| Urea | 27,443 | 5,125 | 86,788 | 27,931 | 2,480 | 123,923 | 168,648 | 520 | 13,106 | 111,569 | 2,108 | 4,963 | 68,123 | 11,055 |
| Urea Solution | 0 | 0 | 8,437 | 0 | 0 | 0 | 0 | 63 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urea-formaldehyde | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 11 | 0 | 3,860 | 1 | 75 | 399 | 0 |
| Zinc Ammonium Sulfate Solution | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 64 |
| Zinc Manganese Ammonium Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 6,678 | 0 | 0 | 0 | 7,635 | 1,802 | 9,484 | 1 | 1,126 | 23,958 | 376 |
| TOTAL | 247,971 | 5,263 | 1,706,091 | 231,483 | 36,000 | 544,340 | 344,124 | 19,670 | 80,595 | 384,584 | 3,864 | 68,407 | 650,012 | 182,439 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | | | | | | |
| Ammonium Metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8,284 | 0 |
| Ammonium Phosphate | 37 | 0 | 0 | 0 | 3,215 | 201 | 0 | 0 | 0 | 116 | 0 | 0 | 353 | 0 |
| Ammonium Phosphate Nitrate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2,511 | 0 |
| Ammonium Phosphate Sulfate | 9,497 | 0 | 35,053 | 78 | 0 | 39,813 | 17,674 | 1,949 | 542 | 34,233 | 0 | 2,427 | 29,659 | 4,612 |
| Ammonium Polyphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3,706 | 0 |
| Basic Lime Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Basic Slag | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table A-5. (Continued)

| | AZ | AK | CA | CO | HI | ID | MT | NV | NM | OR | Puerto Rico | UT | WA | WY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bone Meal, Raw | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 82 | 0 |
| Bone Meal, Steamed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 374 | 0 |
| Bone, Precipitated | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 284 |
| Calcium Metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Colloidal Phosphate (Soft Phosphate) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 |
| Diammonium Phosphate | 1,737 | 585 | 18,104 | 3,998 | 0 | 49,045 | 47,927 | 58 | 3,120 | 7,963 | 30 | 1,363 | 10,414 | 22,378 |
| Limestone, Phosphatic | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Liquid Ammonium Polyphosphate | 19,153 | 0 | 74,203 | 11,328 | 3,081 | 10,277 | 3,211 | 644 | 17,212 | 8,361 | 0 | 1,508 | 39,510 | 1,572 |
| Magnesium Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 3 | 0 |
| Monoammonium Phosphate | 29,073 | 0 | 78,651 | 59,301 | 0 | 114,618 | 98,019 | 3,096 | 11,526 | 44,192 | 1 | 10,519 | 42,876 | 24,561 |
| Nitric Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,394 | 0 |
| Phosphate Rock | 0 | 0 | 0 | 232 | 11 | 0 | 0 | 0 | 0 | 2,804 | 0 | 1,185 | 65 | 0 |
| Phosphoric Acid | 3,737 | 0 | 10,668 | 451 | 0 | 5,626 | 0 | 24 | 0 | 1,440 | 0 | 32 | 3,047 | 64 |
| Precipitated Phosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 1,187 |
| Superphosphate, Enriched | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 194 | 0 | 56 | 362 | 0 |
| Superphosphate, Normal | 0 | 4 | 468 | 0 | 155 | 3,785 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| Superphosphate, Triple | 731 | 4 | 4,363 | 946 | 172 | 3,759 | 1,059 | 414 | 1,082 | 2,336 | 255 | 10,524 | 5,250 | 1,414 |
| Superphosphoric Acid | 0 | 0 | 1,533 | 0 | 0 | 13,069 | 0 | 0 | 635 | 10,582 | 0 | 0 | 462 | 4,619 |
| Other | 0 | 0 | 31 | 2,013 | 0 | 88 | 0 | 170 | 98 | 59 | 0 | 214 | 2,778 | 0 |
| TOTAL | 63,966 | 593 | 223,074 | 78,345 | 6,635 | 240,282 | 167,891 | 6,373 | 34,241 | 112,279 | 291 | 27,828 | 152,142 | 60,692 |
| **POTASH FERTILIZERS** | | | | | | | | | | | | | | |
| Lime-potash Mixtures | 0 | 0 | 0 | 0 | 0 | 237 | 0 | 0 | 307 | 0 | 0 | 0 | 0 | 0 |
| Manure Salts | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,530 | 0 | 0 | 0 | 0 | 0 |
| Muriate of Potash 60% (Pot. Chloride) | 3,776 | 30 | 52,170 | 3,418 | 494 | 44,162 | 31,808 | 227 | 14,671 | 32,666 | 68 | 3,569 | 64,250 | 2,823 |

## Table A-5. (Continued)

| | AZ | AK | CA | CO | HI | ID | MT | NV | NM | OR | Puerto Rico | UT | WA | WY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Muriate of Potash 62% | 0 | 0 | 0 | 5,221 | 0 | 494 | 0 | 0 | 13 | 10,917 | 0 | 211 | 73 | 70 |
| Potash Suspensions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,647 | 0 | 0 | 4,444 | 0 |
| Potassium Carbonate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 442 | 21 | 0 | 0 | 4 | 0 |
| Potassium Nitrate | 1,853 | 0 | 23,208 | 871 | 0 | 0 | 0 | 16 | 0 | 244 | 179 | 0 | 76 | 0 |
| Potassium Sulfate | 407 | 2 | 41,748 | 685 | 845 | 2,138 | 0 | 49 | 464 | 3,883 | 326 | 920 | 9,924 | 44 |
| Potassium-magnesium Sulfate | 95 | 0 | 12,705 | 322 | 0 | 0 | 0 | 0 | 5,241 | 7,666 | 0 | 0 | 9,930 | 156 |
| Potassium-metaphosphate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potassium-sodium Nitrate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Other | 0 | 0 | 319 | 1,396 | 16,328 | 17,395 | 0 | 289 | 66 | 533 | 0 | 212 | 10,245 | 1 |
| TOTAL | 6,131 | 32 | 130,149 | 11,913 | 17,667 | 64,426 | 31,808 | 581 | 22,732 | 58,576 | 573 | 4,913 | 98,947 | 3,095 |
| **ORGANIC FERTILIZERS** | | | | | | | | | | | | | | |
| Blood, Dried | 0 | 0 | 1,612 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 158 | 0 |
| Castor Pomace | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cocoa Shell Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Compost | 0 | 0 | 0 | 2,381 | 0 | 0 | 4,284 | 0 | 0 | 0 | 0 | 0 | 948 | 2,128 |
| Cottonseed Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 72 | 0 |
| Fish Scrap | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 377 | 0 |
| Guano | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 |
| Manure | 0 | 0 | 0 | 7,399 | 0 | 0 | 99 | 217 | 0 | 0 | 0 | 673 | 17,470 | 265 |
| Peat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 395 |
| Sewage Sludge, Activated | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 97 | 0 | 0 |
| Sewage Sludge, Digested | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Sewage Sludge, Heat Dried | 0 | 0 | 0 | 12,506 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sewage Sludge, Other | 0 | 0 | 77,169 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soybean Meal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table A-5.  (Continued)

| | AZ | AK | CA | CO | HI | ID | MT | NV | NM | OR | Puerto Rico | UT | WA | WY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tankage, Animal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 202 |
| Tankage, Process | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 371 | 0 |
| Other | 0 | 0 | 0 | 1,046 | 0 | 0 | 0 | 7 | 0 | 0 | 11 | 2 | 11,544 | 0 |
| TOTAL | 0 | 0 | 78,781 | 23,333 | 0 | 0 | 4,383 | 228 | 0 | 0 | 11 | 772 | 30,947 | 2,990 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | | | | | | |
| Aluminum Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 2 | 0 | 0 | 136 | 0 |
| Borax | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 15 | 0 | 788 | 0 | 21 | 3,491 | 10 |
| Calcium Chelate | 0 | 0 | 0 | 0 | 3,751 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Calcium Chloride | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Sulfate (Hydrous) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 179 | 0 |
| Cobalt Sulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Copper Chelate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 25 | 0 |
| Copper Compound | 0 | 0 | 342 | 0 | 0 | 0 | 0 | 0 | 0 | 240 | 0 | 0 | 0 | 0 |
| Copper Oxide, Black | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Copper Sulfate | 0 | 0 | 0 | 18 | 0 | 343 | 0 | 0 | 0 | 0 | 0 | 1 | 89 | 5 |
| Epsom Salt (Magnesium Sulfate) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 219 | 0 | 1,250 | 82 |
| Ferric Oxide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Ferric Sulfate | 492 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 2 | 4,073 | 0 |
| Ferrous Sulfate | 0 | 0 | 0 | 971 | 0 | 0 | 0 | 47 | 0 | 0 | 0 | 3 | 1,159 | 400 |
| Gypsum (Calcium Sulfate) | 26,043 | 0 | 1,170,333 | 1,493 | 0 | 3,703 | 261 | 5,831 | 0 | 12,736 | 0 | 238 | 22,513 | 0 |
| Iron Chelate | 0 | 0 | 0 | 18 | 0 | 310 | 0 | 1 | 0 | 7 | 0 | 37 | 155 | 0 |
| Iron Compound | 0 | 0 | 4,736 | 0 | 0 | 0 | 0 | 5 | 0 | 2,284 | 0 | 22 | 0 | 0 |
| Lime Sulfur Solution | 716 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| Magnesia (Magnesium Oxide) | 0 | 0 | 0 | 0 | 240 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| Magnesium Chelate | 0 | 0 | 0 | 0 | 0 | 415 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 0 |
| Manganese Agstone | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table A-5.  (Continued)

| | AZ | AK | CA | CO | HI | ID | MT | NV | NM | OR | Puerto Rico | UT | WA | WY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manganese Chelate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 105 | 0 |
| Manganese Oxide | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 59 | 0 | 0 | 12 | 0 |
| Manganese Slag | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Manganese Sulfate | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 15 | 293 | 37 |
| Manganous Oxide | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potting Soil | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 0 | 0 |
| Sodium Molybdate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 0 |
| Soil Additive | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil Amendment | 0 | 0 | 0 | 339 | 0 | 0 | 0 | 0 | 0 | 316 | 0 | 0 | 0 | 0 |
| Soil Conditioner | 0 | 0 | 0 | 10,817 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sulfur | 2,168 | 0 | 57,043 | 2,786 | 137 | 17,672 | 788 | 852 | 8 | 2,440 | 0 | 694 | 7,155 | 1,287 |
| Sulfuric Acid | 13,814 | 0 | 117,877 | 1,177 | 0 | 0 | 0 | 24 | 0 | 223 | 0 | 0 | 0 | 0 |
| Zinc Chelate | 0 | 0 | 0 | 121 | 0 | 4,859 | 0 | 2 | 0 | 0 | 0 | 5 | 790 | 1 |
| Zinc Oxide | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,066 | 0 | 132 | 417 | 111 |
| Zinc Oxysulfate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 0 |
| Zinc Sulfate | 0 | 0 | 0 | 818 | 15 | 31 | 0 | 26 | 0 | 0 | 0 | 96 | 3,499 | 555 |
| Zinc Sulfate Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 |
| Other | 2,028 | 0 | 246,465 | 72 | 0 | 4,799 | 1,865 | 82 | 6,782 | 497 | 81 | 285 | 85,422 | 32 |
| TOTAL | 45,261 | 0 | 1,596,796 | 18,682 | 4,144 | 32,134 | 2,920 | 6,911 | 6,790 | 20,671 | 307 | 1,599 | 130,861 | 2,538 |

## Table A-5. (Continued)

| | AZ | AK | CA | CO | HI | ID | MT | NV | NM | OR | Puerto Rico | UT | WA | WY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LIMING MATERIALS** | | | | | | | | | | | | | | |
| Calcitic Lime (75% Neutral) | 0 | 0 | 0 | 0 | 8,696 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calcium Hydroxide (Hydrate) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 171 | 0 | 0 | 1,793 | 0 |
| Calcium Oxide (Burnt) | 0 | 0 | 0 | 0 | 96 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dolomitic & Calcitic Blend (Pelletized) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dolomitic Lime (75% Neutral) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Lime Suspensions | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-lime Filler (Water, Sand, Etc.) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Standard Calcite | 0 | 180 | 0 | 516 | 0 | 0 | 48 | 0 | 0 | 147,919 | 0 | 0 | 12,832 | 0 |
| Standard Dolomite | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20,473 | 0 | 0 | 13,959 | 0 |
| Other | 0 | 0 | 621,915 | 0 | 0 | 37 | 0 | 0 | 0 | 24,161 | 0 | 0 | 54,705 | 0 |
| TOTAL | 0 | 180 | 621,915 | 516 | 8,792 | 37 | 48 | 0 | 0 | 192,724 | 0 | 0 | 83,289 | 1 |
| **ALL FERTILIZERS** | | | | | | | | | | | | | | |
| TOTAL | 363,329 | 8,447 | 5,529,952 | 364,291 | 118,269 | 881,219 | 551,412 | 40,538 | 155,629 | 801,869 | 73,259 | 117,199 | 1,205,189 | 256,092 |

# APPENDIX B
# CROP-SPECIFIC FERTILIZER USE IN THE UNITED STATES

## Appendix B.  Crop-Specific Fertilizer Use in the United States

The USDA ERS-NASS data presented in this appendix come from the most recent surveys of field, fruit and vegetable crops.  These surveys, the sampling methodology, coverage and data collection are described in Agricultural Resources and Environmental Indicators (AREI) Production Management Appendix (1997).

Fruit and vegetable data were abstracted from the Chemical Use Surveys that were initially funded under the 1989 President's Food Safety Initiative.  These surveys are conducted by NASS "using personal enumeration of a stratified systematic sample of growers who produce at least one acre of the targeted crops."  The information collected on fertilizer use, acreage planted, and application rates are survey data for the major crop producing states and do not represent the totality of farms in the U.S. raising these crops.  Surveys are conducted odd years for fruit (latest available survey performed in 1995, representing the crop year 1995, and reported in 1996) and even years for vegetable crops (latest available survey is for the crop year, 1994 reported in 1995).

The latest field crop usage data, covering 70 to 90% of the total U.S. crop, are from the Agricultural Resources Management Survey (ARMS) of 1996 which combines the former Cropping Practices Surveys with the Farm Costs and Returns Survey.  This survey has three phases.  Phase II, conducted in the autumn, for the preceeding crop year, collects data on agricultural production practices, resource and input use, and production.  In this survey, "a multi-frame, stratified sampling procedure is used.  Results are weighted and aggregated to develop state, regional and national estimates."   Note that there are some crops (strawberries, cantaloupe, honeydew melon and watermelon) in the vegetable survey that are commonly considered fruits.

Detailed descriptions of the survey procedures are presented in the following documents available on the internet from http://mann77.mannlib.cornell.edu.:

1. Agricultural Chemical Usage, 1995 Fruits Summary, USDA, NASS, ERS, July 1996, Ag Ch 1 (96)
2. Agricultural Chemical Usage, Vegetables, 1996 Summary, USDA, NASS, ERS, July, 1997, Ag Ch 1 (97)
3. Agricultural Chemical Usage, 1996 Field Crops Summary, USDA, NASS, ERS, September, 1997, Ag Ch 1 (97)

## Table B-1. Fertilizer Use on Field Crops for the 1996 Crop Year[a]

| | | | Total Applied (million lbs/year) | | | Application Rate per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State** | **Acres Planted (1,000 acres)** | **N** | **P** | **K** | **N** | **P** | **K** |
| **Corn** | IL | 11,000 | 1,823.9 | 737.5 | 1,056.0 | 166 | 85 | 116 |
| | IN | 5,600 | 774.7 | 346.1 | 542.4 | 138 | 64 | 110 |
| | IA | 12,700 | 1,631.7 | 627.7 | 786.1 | 132 | 60 | 76 |
| | KS | 2,500 | 416.5 | 79.5 | 26.1 | 170 | 38 | 36 |
| | KY | 1,300 | 186.9 | 87.2 | 94.1 | 146 | 78 | 82 |
| | MI | 2,650 | 307.9 | 112.7 | 226.5 | 116 | 47 | 101 |
| | MN | 7,500 | 784.4 | 375.6 | 420.9 | 108 | 53 | 65 |
| | MO | 2,750 | 398.5 | 132.7 | 163.5 | 149 | 55 | 69 |
| | NE | 8,500 | 1,174.0 | 227.6 | 75.0 | 140 | 34 | 22 |
| | NC | 1,000 | 113.1 | 53.6 | 88.7 | 114 | 59 | 100 |
| | OH | 2,900 | 425.4 | 245.8 | 244.0 | 147 | 87 | 98 |
| | PA | 1,450 | 112.2 | 67.0 | 43.6 | 79 | 58 | 40 |
| | SC | 400 | 46.0 | 21.8 | 42.3 | 115 | 57 | 106 |
| | SD | 4,000 | 312.3 | 105.7 | 31.8 | 89 | 34 | 20 |
| | TX | 2,100 | 284.5 | 61.6 | 25.4 | 137 | 37 | 28 |
| | WI | 3,900 | 297.0 | 134.6 | 209.7 | 81 | 39 | 61 |
| | Total | 70,250 | 9,089.0 | 3,416.7 | 4,076.1 | 133 | 57 | 79 |
| **Upland Cotton** | AZ | 315 | 45.8 | 6.6 | 1.6 | 148 | 49 | 44 |
| | AR | 1,000 | 94.0 | 25.2 | 49.3 | 97 | 38 | 70 |
| | CA | 1,000 | 168.1 | 30.6 | 9.5 | 175 | 83 | 58 |
| | GA | 1,350 | 139.3 | 76.7 | 139.1 | 104 | 57 | 106 |
| | LA | 890 | 60.1 | 25.7 | 39.5 | 74 | 45 | 67 |
| | MS | 1,120 | 110.4 | 14.0 | 63.4 | 100 | 47 | 100 |
| | TN | 540 | 47.8 | 32.0 | 47.1 | 89 | 60 | 88 |
| | TX | 5,700 | 252.2 | 105.2 | 23.6 | 80 | 39 | 21 |

## Table B-1. (Continued)

| | | | Total Applied (million lbs/year) | | | Application Rate per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State** | **Acres Planted (1,000 acres)** | **N** | **P** | **K** | **N** | **P** | **K** |
| | Total | 11,915 | 917.7 | 316.0 | 373.1 | 100 | 48 | 73 |
| **Fall Potatoes** | ID | 410 | 84.4 | 80.6 | 40.7 | 206 | 198 | 116 |
| | ME | 78 | 13.0 | 13.4 | 13.6 | 167 | 174 | 175 |
| | WA | 163 | 44.3 | 39.4 | 30.2 | 285 | 195 | 204 |
| | RR[b] | 146 | 12.3 | 11.0 | 14.4 | 84 | 78 | 105 |
| | Total | 797 | 154.0 | 134.4 | 98.9 | 195 | 173 | 139 |
| **Soybeans** | AR | 3,550 | 8.2 | 76.4 | 90.5 | 26 | 48 | 60 |
| | IL | 9,900 | 32.4 | 128.3 | 329.6 | 22 | 56 | 99 |
| | IN | 5,400 | 37.9 | 79.1 | 240.7 | 31 | 45 | 102 |
| | IA | 9,500 | 19.5 | 55.2 | 99.3 | 26 | 49 | 76 |
| | LA | 1,100 | 0.7 | 17.1 | 26.0 | 14 | 43 | 70 |
| | MN | 5,950 | 9.2 | 38.4 | 42.9 | 15 | 47 | 69 |
| | MS | 1,800 | 2.5 | 14.0 | 19.4 | 13 | 42 | 62 |
| | MO | 4,100 | 20.5 | 54.9 | 81.3 | 21 | 54 | 71 |
| | NE | 3,050 | 10.2 | 64.4 | 5.3 | 12 | 42 | 17 |
| | OH | 4,500 | 30.4 | 50.1 | 164.8 | 34 | 46 | 102 |
| | TN | 1,200 | 12.8 | 27.5 | 51.5 | 40 | 53 | 82 |
| | Total | 50,050 | 184.3 | 605.4 | 1,151.3 | 24 | 49 | 85 |
| **Flue-cured Tobacco** | GA | 46 | 5.0 | 5.2 | 13.0 | 108 | 114 | 284 |
| | NC | 280 | 24.0 | 25.3 | 54.7 | 86 | 91 | 197 |
| | SC | 51 | 4.1 | 3.3 | 8.8 | 80 | 67 | 172 |
| | VA | 38 | 3.3 | 4.2 | 7.1 | 90 | 116 | 193 |
| | Total | 415 | 36.4 | 38.0 | 83.6 | 88 | 93 | 203 |
| **Winter Wheat** | CO | 2,200 | 70.2 | 18.0 | NA[c] | 41 | 21 | NA |

## Table B-1. (Continued)

| | | | Total Applied (million lbs/year) | | | Application Rate per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State** | **Acres Planted (1,000 acres)** | **N** | **P** | **K** | **N** | **P** | **K** |
| | ID | 860 | 96.2 | 22.1 | 5.0 | 115 | 53 | 40 |
| | KS | 8,800 | 461.6 | 162.3 | NA | 56 | 28 | NA |
| | MT | 1,980 | 84.7 | 46.9 | 4.3 | 53 | 30 | 17 |
| | NE | 2,100 | 78.6 | 34.8 | NA | 43 | 32 | NA |
| | OK | 4,900 | 199.2 | 70.8 | 26.1 | 54 | 32 | 49 |
| | OR | 850 | 65.0 | 2.5 | 1.1 | 77 | 30 | 28 |
| | SD | 1,580 | 60.8 | 29.2 | NA | 49 | 28 | NA |
| | TX | 2,900 | 183.6 | 39.4 | NA | 81 | 44 | NA |
| | WA | 2,350 | 194.9 | 12.2 | 5.4 | 83 | 20 | 24 |
| | Total | 28,520 | 1,494.8 | 438.2 | 53.0 | 61 | 30 | 29 |
| **Durum Wheat** | ND | 3,000 | 168.6 | 50.9 | 4.9 | 60 | 23 | 21 |
| **Other Spring Wheat** | MN | 2,550 | 227.0 | 82.1 | 33.8 | 91 | 37 | 28 |
| | MT | 4,200 | 173.5 | 89.6 | 3.6 | 50 | 27 | 9 |
| | ND | 9,600 | 582.9 | 227.4 | 46.0 | 68 | 30 | 20 |
| | Total | 16,350 | 983.4 | 399.1 | 83.4 | 67 | 31 | 21 |

a) Source: USDA, ERS, September, 1997
b) RR = Red River Valley includes the counties of Clay, Clearwater, Kittson, Mahnomen, Marshall, Norman, Pennington, Polk, Red Lake, Roseau and Wilkin in Minnesota and Cass, Grand Forks, Pembina, Richland, Steele, Traill and Walsh in North Dakota
c) NA = Insufficient reports to publish data

## Table B-2. Fertilizer Use on Vegetable Crops[a] for the 1994 Crop Year

| Crop | State | Acres Planted | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | N | P | K |
| Asparagus | CA | 34,500 | 3,091 | 380 | 522 | 136 | 66 | 51 |
| | IL | 750 | 36 | 48 | 9 | 64 | 85 | 88 |
| | MI | 19,500 | 1,290 | 110 | 2,505 | 68 | 44 | 134 |
| | NJ | 900 | 72 | 85 | 123 | 85 | 101 | 145 |
| | WA | 25,000 | 2,737 | 568 | 344 | 128 | 52 | 50 |
| | Total | 80,650 | 7,226 | 1,191 | 3,504 | 100 | 57 | 110 |
| Beans, Lima (fresh) | GA | 6,500 | 654 | 364 | 565 | 101 | 56 | 87 |
| Beans, Lima (processing) | 6 States | 33,500 | 1,704 | 959 | 834 | 68 | 61 | 71 |
| Beans, Snap (fresh) | CA | 7,500 | 636 | 387 | 173 | 101 | 104 | 106 |
| | FL | 26,900 | 2,288 | 2,439 | 3,173 | 86 | 99 | 120 |
| | GA | 18,000 | 1,623 | 1,006 | 1,946 | 100 | 66 | 132 |
| | MI | 2,200 | 76 | 118 | 147 | 39 | 64 | 72 |
| | NJ | 4,200 | 214 | 274 | 286 | 53 | 68 | 70 |
| | NY | 5,200 | 199 | 237 | 234 | 40 | 47 | 46 |
| | NC | 7,300 | 435 | 493 | 540 | 61 | 69 | 79 |
| | Total | 71,300 | 5,471 | 4,954 | 6,498 | 85 | 88 | 115 |
| Beans, Snap (processing) | CA | ND[b] | ND | ND | ND | 154 | 96 | 73 |
| | IL | 15,800 | 1,081 | 567 | 1,073 | 72 | 52 | 101 |
| | MI | 23,000 | 1,072 | 839 | 1,179 | 47 | 40 | 67 |
| | NJ | ND | ND | ND | ND | 77 | 40 | 51 |
| | NY | 18,000 | 624 | 1,348 | 1,159 | 35 | 75 | 65 |
| | NC | ND | ND | ND | ND | 47 | 102 | 88 |
| | OR | 23,200 | 2,016 | 2,838 | 1,475 | 88 | 128 | 71 |
| | WA | ND | ND | ND | ND | 86 | 49 | NE[b] |
| | WI | 84,800 | 4,983 | 3,964 | 5,096 | 59 | 48 | 63 |
| | Total | 173,400 | 10,695 | 10,192 | 10,354 | 64 | 64 | 68 |
| Broccoli | AZ | 9,400 | 2,322 | 1,827 | 11 | 247 | 199 | 8 |
| | CA | 94,500 | 18,593 | 6,556 | 3,970 | 203 | 88 | 61 |
| | OR | 3,200 | 613 | 505 | 348 | 193 | 159 | 131 |
| | TX | 3,800 | 244 | 191 | 16 | 92 | 88 | 14 |
| | Total | 110,900 | 21,772 | 9,087 | 4,345 | 206 | 109 | 62 |

a) Source: USDA, NASS, ERS Agricultural Chemical Usage Vegetables 1996.
b) ND = USDA did not publish data to avoid disclosure.
c) NE = Absence of data is not explained in the USDA report.

## Table B-2. (Continued)

| Crop | State | Acres Planted | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | N | P | K |
| **Cabbage (fresh)** | CA | 10,500 | 1,567 | 874 | 406 | 162 | 97 | 70 |
| | FL | 9,300 | 2,395 | 874 | 2,527 | 258 | 94 | 272 |
| | GA | 11,000 | 2,274 | 1,246 | 2,202 | 207 | 119 | 200 |
| | MI | 2,200 | 303 | 206 | 357 | 138 | 101 | 164 |
| | NJ | 2,300 | 377 | 271 | 342 | 168 | 121 | 152 |
| | NY | 12,300 | 1,425 | 1,314 | 2,111 | 117 | 110 | 173 |
| | NC | 5,400 | 814 | 797 | 991 | 152 | 149 | 186 |
| | TX | 11,900 | 1,425 | 803 | 110 | 120 | 86 | 18 |
| | WI | 5,000 | 1,078 | 526 | 677 | 218 | 106 | 137 |
| | Total | 69,900 | 11,658 | 6,910 | 9,724 | 167 | 106 | 163 |
| **Cabbage (processing)** | NY | 2,100 | 223 | 201 | 363 | 106 | 96 | 173 |
| | WI | 3,500 | 509 | 325 | 782 | 146 | 93 | 224 |
| | Total | 5,600 | 733 | 525 | 1,145 | 126 | 94 | 198 |
| **Carrots** | AZ | 2,200 | NA[a] | NA | NA | NA | NA | NA |
| | CA | 58,500 | 13,664 | 11,298 | 3,000 | 234 | 200 | 68 |
| | FL | 7,600 | 178 | 229 | 562 | 24 | 31 | 77 |
| | MI | 8,000 | 1,114 | 761 | 1,766 | 141 | 97 | 223 |
| | NY | 1,400 | 107 | 106 | 162 | 80 | 95 | 145 |
| | OR | 1,400 | 146 | 158 | 127 | 112 | 116 | 96 |
| | TX | 9,000 | 867 | 247 | 54 | 102 | 55 | 17 |
| | WA | 8,200 | 1,631 | 1,020 | 1,853 | 200 | 128 | 235 |
| | WI | 4,400 | 324 | 601 | 1,413 | 90 | 148 | 340 |
| | Total | 100,700 | 18,347 | 14,954 | 8,983 | 182 | 166 | 110 |
| **Cauliflower** | AZ | 5,700 | 1,795 | 1,344 | NA | 315 | 236 | |
| | CA | 41,500 | 8,661 | 3,243 | 1,799 | 219 | 85 | 57 |
| | MI | 800 | 102 | 60 | 127 | 127 | 92 | 159 |
| | NY | 1,600 | 159 | 158 | 172 | 101 | 101 | 111 |
| | OR | 3,300 | 631 | 392 | 279 | 192 | 129 | 94 |
| | TX | 950 | 127 | 43 | 5 | 234 | 96 | 25 |
| | Total | 53,850 | 11,474 | 5,239 | 2,382 | 230 | 121 | 69 |
| **Celery** | CA | 24,500 | 7,749 | 5,559 | 5,033 | 317 | 228 | 207 |
| | FL | 7,200 | 962 | 1,149 | 3,003 | 134 | 160 | 417 |
| | MI | 2,800 | 408 | 330 | 1,019 | 151 | 126 | 377 |
| | TX | 1,400 | NA | NA | NA | NA | NA | NA |
| | Total | 35,900 | 9,119 | 7,037 | 9,055 | 240 | 195 | 292 |

a) NA = Insufficient reports to publish data.

## Table B-2. (Continued)

| | | Acres Planted | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State** | | **N** | **P** | **K** | **N** | **P** | **K** |
| **Corn, Sweet (fresh)** | CA | 21,600 | 4,632 | 2,385 | 950 | 219 | 129 | 68 |
| | FL | 42,900 | 3,634 | 3,257 | 9,273 | 95 | 78 | 216 |
| | GA | 19,500 | 5,055 | 933 | 3,467 | 268 | 50 | 186 |
| | IL | 8,700 | 903 | 452 | 604 | 106 | 68 | 89 |
| | MI | 13,500 | 1,217 | 705 | 1,226 | 97 | 65 | 102 |
| | NJ | 9,500 | 1,352 | 916 | 880 | 146 | 102 | 98 |
| | NY | 25,500 | 2,557 | 1,921 | 2,431 | 101 | 76 | 96 |
| | NC | 6,000 | 615 | 375 | 646 | 105 | 68 | 112 |
| | OR | 2,300 | 470 | 221 | 146 | 208 | 100 | 66 |
| | TX | 3,500 | 931 | 264 | 229 | 274 | 83 | 85 |
| | WA | 2,900 | 416 | 163 | 136 | 145 | 71 | 83 |
| | WI | 8,000 | 774 | 308 | 540 | 98 | 40 | 72 |
| | Total | 163,900 | 22,557 | 11,899 | 20,528 | 125 | 81 | 137 |
| **Corn, Sweet (processing)** | IL | 36,700 | 5,033 | 1,842 | 3,100 | 139 | 60 | 93 |
| | MI | 7,100 | 1,120 | 269 | 441 | 158 | 47 | 77 |
| | MN | 143,000 | 16,087 | 5,882 | 7,566 | 113 | 48 | 68 |
| | NY | 32,500 | 2,706 | 1,986 | 2,190 | 86 | 68 | 85 |
| | OR | 48,600 | 9,750 | 6,214 | 4,226 | 202 | 134 | 94 |
| | WA | 74,700 | 16,583 | 4,599 | 4,731 | 227 | 68 | 98 |
| | WI | 160,800 | 17,804 | 7,684 | 13,657 | 112 | 49 | 89 |
| | Total | 503,400 | 69,084 | 28,476 | 35,912 | 135 | 63 | 85 |
| **Cucumbers (fresh)** | CA | 5,000 | 399 | 296 | 200 | 81 | 61 | 56 |
| | FL | 13,300 | 1,529 | 1,035 | 1,533 | 115 | 137 | 119 |
| | GA | 13,000 | 1,788 | 1,108 | 2,018 | 139 | 89 | 156 |
| | MI | 5,800 | 722 | 385 | 838 | 125 | 69 | 145 |
| | NJ | 2,400 | 302 | 198 | 236 | 127 | 84 | 100 |
| | NY | 3,300 | 318 | 304 | 305 | 97 | 93 | 94 |
| | NC | 6,000 | 725 | 540 | 811 | 121 | 91 | 136 |
| | TX | 2,600 | 242 | 84 | 45 | 99 | 47 | 28 |
| | Total | 51,400 | 6,025 | 3,950 | 5,985 | 115 | 89 | 115 |

## Table B-2. (Continued)

| | | Acres Planted | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| Crop | State | | N | P | K | N | P | K |
| **Cucumbers (processing)** | CA | 5,000 | 772 | 266 | 248 | 155 | 56 | 55 |
| | FL | 2,100 | 206 | 82 | 241 | 98 | 40 | 115 |
| | GA | ND[a] | ND | ND | ND | 61 | 55 | 63 |
| | MI | 24,500 | 1,786 | 1,143 | 2,511 | 73 | 48 | 109 |
| | NC | 25,500 | 2,356 | 1,064 | 2,475 | 93 | 47 | 102 |
| | OR | ND | ND | ND | ND | 87 | 115 | 83 |
| | TX | 13,900 | 1,555 | 1,330 | 822 | 112 | 101 | 67 |
| | WA | ND | ND | ND | ND | 107 | 147 | 123 |
| | WI | 6,200 | 679 | 334 | 721 | 110 | 54 | 116 |
| | Total | 82,600 | 7,866 | 4,809 | 7,472 | 94 | 60 | 100 |
| **Eggplant** | FL | 2,500 | 301 | 219 | 301 | 121 | 124 | 120 |
| | NJ | 1,000 | 141 | 127 | 156 | 153 | 137 | 168 |
| | Total | 3,500 | 442 | 346 | 456 | 133 | 130 | 140 |
| **Lettuce, Head** | AZ | 52,100 | 18,562 | 12,668 | | 357 | 252 | |
| | CA | 128,500 | 27,014 | 14,251 | 5,487 | 210 | 147 | 73 |
| | FL | 7,400 | NA[b] | NA | NA | | | |
| | NJ | 1,900 | 276 | 187 | 277 | 146 | 99 | 146 |
| | NY | 1,100 | 101 | 90 | 134 | 93 | 84 | 124 |
| | Total | 191,000 | 45,953 | 27,196 | 5,898 | 262 | 190 | 77 |
| **Lettuce, Other** | AZ | 7,700 | 2,582 | 1,813 | | 335 | 237 | |
| | CA | 51,000 | 6,772 | 3,846 | 2,220 | 163 | 107 | 71 |
| | FL | 1,420 | 105 | 48 | 105 | 75 | 34 | 75 |
| | Total | 60,120 | 9,459 | 5,706 | 2,325 | 194 | 134 | 71 |
| **Cantaloupe** | AZ | 14,400 | 2,440 | 1,413 | 82 | 170 | 103 | 9 |
| | CA | 59,300 | 5,279 | 2,528 | 574 | 90 | 86 | 47 |
| | GA | 9,000 | 918 | 688 | 1,097 | 104 | 79 | 124 |
| | MI | 1,100 | 105 | 85 | 115 | 97 | 85 | 111 |
| | TX | 13,900 | 1,039 | 1,157 | 472 | 80 | 93 | 42 |
| | Total | 97,700 | 9,781 | 5,870 | 2,341 | 104 | 93 | 41 |
| **Honeydew Melon** | AZ | 2,600 | 534 | 182 | NA | 206 | 93 | NA |
| | CA | 18,100 | 1,068 | 986 | 247 | 59 | 68 | 119 |
| | TX | 5,000 | 583 | 933 | 196 | 120 | 192 | NA |
| | Total | 25,700 | 2,184 | 2,101 | 444 | 83 | 96 | 68 |

a) ND = USDA did not publish data to avoid disclosure.
b) NA = Insufficient reports to publish data.

## Table B-2. (Continued)

| | | Acres Planted | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State** | | **N** | **P** | **K** | **N** | **P** | **K** |
| **Watermelon** | AZ | 6,800 | 2,774 | 678 | NA[a] | 414 | 123 | NA |
| | CA | 16,700 | 2,863 | 1,910 | 862 | 175 | 163 | 96 |
| | FL | 40,000 | 5,731 | 4,330 | 7,209 | 145 | 123 | 182 |
| | GA | 37,000 | 3,930 | 3,142 | 4,941 | 108 | 87 | 136 |
| | NC | 9,500 | 910 | 465 | 1,093 | 98 | 51 | 119 |
| | TX | 56,000 | 138 | 3,150 | 1,701 | 61 | 65 | 46 |
| | Total | 166,000 | 19,347 | 13,676 | 15,806 | 120 | 94 | 119 |
| **Onions, Dry** | AZ | 1,700 | 458 | 288 | 2 | 269 | 188 | 16 |
| | CA | 38,200 | 9,172 | 5,452 | 1,085 | 247 | 163 | 95 |
| | GA | 11,000 | 2,087 | 2,201 | 2,665 | 204 | 217 | 266 |
| | MI | 7,400 | 1,051 | 1,060 | 1,502 | 143 | 145 | 221 |
| | NY | 13,200 | 1,494 | 1,652 | 2,228 | 113 | 128 | 175 |
| | OR | 19,800 | 5,292 | 2,709 | 1,520 | 268 | 147 | 98 |
| | TX | 22,100 | 2,301 | 1,466 | 509 | 107 | 73 | 32 |
| | WA | 12,400 | 2,691 | 1,671 | 603 | 218 | 142 | 157 |
| | WI | 2,000 | 251 | 222 | 365 | 126 | 111 | 183 |
| | Total | 127,800 | 24,798 | 16,721 | 11,479 | 186 | 137 | 139 |
| **Peas, Green (processing)** | IL | 13,400 | 393 | 584 | 1,170 | 36 | 54 | 102 |
| | MN | 84,900 | 1,413 | 2,163 | 3,175 | 25 | 40 | 58 |
| | NY | 10,200 | 423 | 754 | 849 | 42 | 75 | 87 |
| | OR | 37,100 | 856 | 586 | 362 | 24 | 52 | 40 |
| | WA | 61,800 | 1,270 | 3,696 | 3,334 | 32 | 108 | 110 |
| | WI | 73,400 | 2,565 | 2,442 | 4,665 | 39 | 41 | 72 |
| | Total | 280,800 | 6,920 | 10,225 | 13,555 | 30 | 55 | 73 |
| **Peppers, Bell** | CA | 19,000 | 5,451 | 4,419 | 2,618 | 320 | 405 | 286 |
| | FL | 22,100 | 6,274 | 2,707 | 8,675 | 284 | 139 | 393 |
| | MI | 2,700 | 257 | 182 | 283 | 95 | 73 | 105 |
| | NJ | 5,400 | 1,002 | 801 | 963 | 190 | 152 | 183 |
| | NC | 7,000 | 871 | 472 | 1,246 | 125 | 69 | 178 |
| | TX | 4,800 | 585 | 518 | 176 | 122 | 124 | 50 |
| | Total | 61,000 | 14,440 | 9,098 | 13,961 | 239 | 189 | 263 |

a) NA = Insufficient reports to publish data.

## Table B-2. (Continued)

| | | Acres Planted | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State** | | N | P | K | N | P | K |
| **Spinach (fresh)** | CA | 5,800 | 704 | 323 | 237 | 159 | 92 | 75 |
| | NJ | 2,300 | 349 | 202 | 282 | 155 | 90 | 126 |
| | TX | 2,600 | 290 | 276 | 39 | 116 | 114 | 24 |
| | Total | 10,700 | 1,344 | 801 | 558 | 149 | 97 | 79 |
| **Spinach (processing)** | TX | 8,600 | 882 | 834 | 127 | 103 | 97 | 30 |
| **Strawberries** | CA | 23,300 | 4,621 | 2,063 | 2,380 | 199 | 94 | 112 |
| | FL | 5,800 | 676 | 286 | 890 | 117 | 58 | 156 |
| | MI | 2,100 | 203 | 125 | 190 | 100 | 67 | 95 |
| | NJ | 500 | 31 | 19 | 190 | 68 | 49 | 52 |
| | NY | 2,600 | 133 | 74 | 21 | 85 | 62 | 65 |
| | NC | 2,500 | 340 | 255 | 78 | 142 | 111 | 119 |
| | OR | 6,300 | 416 | 822 | 275 | 72 | 144 | 113 |
| | WA | 1,400 | 55 | 183 | 607 | 43 | 144 | 132 |
| | WI | 1,300 | 75 | 65 | 146 | 62 | 71 | 101 |
| | Total | 45,800 | 6,548 | 3,891 | 95 | 153 | 95 | 116 |
| **Tomatoes (fresh)** | CA | 36,500 | 6,906 | 3,530 | 2,346 | 193 | 120 | 91 |
| | FL | 47,900 | 14,902 | 9,114 | 25,572 | 311 | 201 | 534 |
| | GA | 4,000 | 1,140 | 429 | 1,304 | 286 | 109 | 327 |
| | MI | 2,800 | 229 | 155 | 341 | 83 | 64 | 124 |
| | NJ | 4,800 | 452 | 532 | 599 | 103 | 121 | 136 |
| | NY | 2,700 | 469 | 436 | 468 | 183 | 172 | 185 |
| | NC | 1,700 | 189 | 202 | 214 | 113 | 122 | 128 |
| | TX | 3,500 | 296 | 234 | 186 | 95 | 78 | 65 |
| | Total | 103,900 | 24,584 | 14,632 | 31,030 | 264 | 174 | 408 |
| **Tomatoes (processing)** | CA | 318,000 | 51,149 | 30,449 | 6,662 | 164 | 103 | 40 |
| | MI | 4,600 | 412 | 456 | 1,280 | 91 | 110 | 289 |
| | Total | 322,600 | 51,561 | 30,905 | 7,941 | 163 | 103 | 49 |

**Table B-3. Fertilizer Use on Fruit Crops for Crop Year 1995[a]**

| | | Acres Planted | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State** | | **N** | **P** | **K** | **N** | **P** | **K** |
| **Oranges** | CA | 191,000 | 21,731 | 834 | 1,321 | 119 | 46 | 61 |
| | FL | 562,800 | 100,286 | 14,733 | 100,109 | 179 | 42 | 182 |
| | Total | 753,800 | 122,017 | 15,576 | 101,430 | 164 | 43 | 177 |
| **Grapefruit** | CA | 18,400 | 1,670 | 283 | 152 | 102 | 81 | 55 |
| | FL | 127,300 | 16,456 | 5,539 | 18,350 | 132 | 54 | 147 |
| | Total | 145,700 | 18,123 | 5,822 | 18,502 | 128 | 56 | 146 |
| **Lemons** | CA | 45,700 | 5,492 | 202 | 314 | 128 | 41 | 26 |
| **Limes** | FL | 1,900 | 262 | 71 | 281 | 149 | 61 | 160 |
| **Tangelos** | FL | 12,400 | 2,095 | 551 | 2,106 | 170 | 65 | 172 |
| **Tangerines** | CA | 8,500 | 716 | 80 | 72 | 88 | 38 | 44 |
| | FL | 20,100 | 3,776 | 504 | 3,879 | 191 | 33 | 197 |
| | Total | 28,600 | 4,492 | 584 | 3,951 | 159 | 34 | 185 |
| **Temples** | FL | 6,800 | 1,067 | 132 | 1,110 | 157 | 40 | 172 |
| **Apples** | CA | 35,000 | 1,518 | 334 | 396 | 76 | 55 | 60 |
| | GA | 2,400 | 79 | 46 | 46 | 42 | 55 | 55 |
| | MI | 54,000 | 2,359 | 850 | 2,072 | 54 | 43 | 69 |
| | NJ | 4,100 | 95 | 60 | 123 | 36 | 28 | 45 |
| | NY | 57,500 | 2,539 | 475 | 3,163 | 53 | 32 | 69 |
| | OR | 8,600 | 426 | 80 | 62 | 75 | 31 | 24 |
| | PA | 22,000 | 521 | 332 | 363 | 35 | 31 | 35 |
| | SC | 3,700 | 176 | 141 | 227 | 51 | 60 | 75 |
| | WA | 153,000 | 8,616 | 1,996 | 1,649 | 71 | 30 | 35 |
| | Total | 340,300 | 16,329 | 4,314 | 8,146 | 62 | 34 | 54 |
| **Apricots** | CA | 19,800 | 1,213 | 604 | 574 | 92 | 101 | 96 |
| **Avocados** | CA | 67,200 | 7,753 | 1,810 | 1,699 | 120 | 71 | 55 |
| | FL | 5,800 | 954 | 315 | 1,032 | 171 | 68 | 185 |
| | Total | 73,000 | 8,707 | 2,125 | 2,731 | 124 | 71 | 74 |
| **Blueberries** | GA | 3,800 | 182 | 119 | 143 | 54 | 36 | 43 |
| | MI | 16,300 | 1,098 | 193 | 600 | 72 | 29 | 51 |
| | NJ | 7,700 | 481 | 369 | 477 | 66 | 51 | 66 |
| | OR | 1,950 | 243 | 109 | 94 | 138 | 69 | 61 |
| | Total | 29,750 | 2,004 | 790 | 1,314 | 72 | 42 | 55 |

a) Source USDA, ERS, NASS Agricultural Chemical Usage 1995 Fruits Summary.

## Table B-3. (Continued)

| Crop | State | Acres Planted | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year (lbs/acre) | | |
|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | N | P | K |
| **Blackberries** | OR | 4,900 | 409 | 361 | 353 | 86 | 78 | 76 |
| **Raspberries** | OR | 5,200 | 419 | 447 | 406 | 82 | 89 | 80 |
| | WA | 5,900 | 522 | 694 | 705 | 91 | 121 | 123 |
| | Total | 11,100 | 941 | 1,141 | 1,111 | 87 | 106 | 103 |
| **Cherries, Sweet** | CA | 12,500 | 653 | 148 | 406 | 73 | 36 | 85 |
| | MI | 7,300 | 500 | 124 | 321 | 76 | 42 | 73 |
| | OR | 10,400 | 696 | 62 | 65 | 73 | 34 | 39 |
| | WA | 14,800 | 1,267 | 197 | 198 | 97 | 31 | 34 |
| | Total | 45,000 | 3,116 | 531 | 990 | 82 | 35 | 61 |
| **Cherries, Tart** | MI | 30,000 | 1,969 | 309 | 1,060 | 76 | 41 | 72 |
| | NY | 4,000 | 255 | 9 | 285 | 73 | 40 | 90 |
| | OR | 1,600 | 111 | 16 | 16 | 84 | 55 | 56 |
| | PA | 1,500 | 27 | 9 | 7 | 26 | 17 | 23 |
| | Total | 37,100 | 2,362 | 343 | 1,368 | 74 | 40 | 74 |
| **Dates** | CA | 5,500 | 409 | 113 | NA[a] | 99 | 92 | |
| **Figs** | CA | 15,000 | 783 | 137 | 225 | 81 | 46 | 55 |
| **Grapes** | CA | 645,200 | 34,529 | 10,276 | 26,199 | 64 | 56 | 104 |
| | MI | 11,800 | 1,091 | 219 | 1,393 | 97 | 58 | 149 |
| | NY | 33,000 | 3,003 | 272 | 1,899 | 100 | 89 | 151 |
| | OR | 5,600 | 34 | 18 | 23 | 27 | 32 | 43 |
| | PA | 11,000 | 1,261 | 110 | 1,226 | 117 | 57 | 157 |
| | WA | 34,000 | 1,766 | 675 | 1,425 | 70 | 46 | 80 |
| | Total | 740,600 | 41,684 | 11,570 | 32,165 | 67 | 55 | 107 |
| **Kiwifruit** | CA | 6,600 | 427 | 41 | 128 | 77 | 57 | 102 |
| **Nectarines** | CA | 32,400 | 3,398 | 892 | 1,550 | 114 | 54 | 92 |
| **Olives** | CA | 33,700 | 1,884 | 83 | 124 | 72 | 44 | 51 |
| **Peaches** | CA | 60,600 | 5,396 | 542 | 1,040 | 104 | 32 | 52 |
| | GA | 21,000 | 1,395 | 298 | 1,332 | 67 | 31 | 66 |
| | MI | 5,500 | 311 | 36 | 162 | 60 | 36 | 59 |
| | NJ | 10,800 | 570 | 210 | 507 | 56 | 43 | 63 |
| | NY | 1,600 | 69 | 4 | 87 | 55 | 27 | 87 |
| | PA | 6,800 | 157 | 63 | 80 | 29 | 30 | 34 |
| | SC | 23,000 | 1,674 | 836 | 2,742 | 74 | 50 | 124 |
| | WA | 2,500 | 225 | 24 | 19 | 109 | 32 | 31 |
| | Total | 131,800 | 9,797 | 2,013 | 5,969 | 84 | 38 | 76 |

a) NA = Insufficient reports to publish data.

## Table B-3. (Continued)

| | | Acres Planted | Total Applied (1000 lbs/year) | | | Application Rate Per Crop Year | | |
|---|---|---|---|---|---|---|---|---|
| **Crop** | **State** | | **N** | **P** | **K** | **N** | **P** | **K** |
| **Pears** | CA | 23,900 | 3,135 | 280 | 618 | 134 | 54 | 102 |
| | NY | 2,500 | 60 | 8 | 113 | 39 | 25 | 76 |
| | OR | 17,000 | 1,491 | 290 | 244 | 108 | 42 | 38 |
| | WA | 24,200 | 1,766 | 264 | 152 | 86 | 32 | 28 |
| | Total | 67,600 | 6,452 | 842 | 1,127 | 109 | 41 | 58 |
| **Plums** | CA | 42,000 | 3,008 | 243 | 536 | 95 | 28 | 56 |
| **Prunes** | CA | 78,800 | 8,396 | 989 | 5,110 | 122 | 59 | 149 |

# APPENDIX C
# FERTILIZER CONSUMPTION BY USE

## Appendix C.  Fertilizer Consumption by Use

The AAPFCO data set, described in Appendix A, contains a variable for farm versus non-farm use.  The tables in this Appendix present fertilizer consumption by state and region for farm and non-farm use.  Non-farm use includes application to residential and recreational properties. Note that there are five states for which the variable "use" was left blank.  These states (Arkansas, Iowa, Kentucky, Ohio and Texas) have been excluded from the following tables.  The use codes are 1 = farm and 2 = non-farm.  For several states the non-farm code (2) was not used.  NA is inserted in the Appendix tables for non-farm use for these states although it is unclear whether there was no non-farm use or the the two uses could not be separated out based on data collected by the individual states.

The following tables are included in this appendix:

Table C-1.	Fertilizer Consumption by Use, East North Central States, 1996 (tons)

These states are: IN, IL, MI, WI

Table C-2.	Fertilizer Consumption by Use, East South Central States, 1996 (tons)

These states are: AL, MS, TN

Table C-3.	Fertilizer Consumption by Use, West North Central States, 1996 (tons)

These states are: KS, MN, MO, NB, ND, SD

Table C-4.	Fertilizer Consumption by Use, West South Central States, 1996 (tons)

These states are: LA, OK

Table C-5.	Fertilizer Consumption by Use, New England States, 1996 (tons)

These states are: CT, ME, MA, NH, RI, VT

Table C-6.	Fertilizer Consumption by Use, Middle Atlantic States, 1996 (tons)

These states are: DE, MD, NJ, NY, PA, WV

Table C-7.	Fertilizer Consumption by Use, South Atlantic States, 1996 (tons)

Thee states are: FL, GA, NC, SC, VA

Table C-8.	Fertilizer Consumption by Use, Mountain States, 1996 (tons)

These states are: AZ, CO, ID, MT, NM, NV, UT, WY

Table C-9.	Fertilizer Consumption by Use, Pacific States (and Puerto Rico), 1996 (tons)

These states are: AK, CA, HI, OR, WA and Puerto Rico

## Table C-1.  Fertilizer Consumption by Use, East North Central States, 1996 (tons)

| Description | Indiana | | Illinois | | Michigan | | Wisconsin | |
|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | |
| N-P-K | 340,148 | 42,394 | 133,642 | 64,578 | 281,054 | 89,150 | 140,902 | 34,449 |
| N-P | 258,925 | 1,041 | 706,214 | 1,549 | 107,444 | 2,019 | 182,607 | 21 |
| N-K | 10,085 | 4,534 | 2,385 | 2,455 | 25,446 | 2,973 | 3,139 | 2,923 |
| P-K | 94,371 | 161 | 12,203 | 60 | 9,311 | 11 | 6,126 | 116 |
| **TOTAL** | 703,529 | 48,129 | 854,444 | 68,642 | 423,254 | 94,152 | 332,774 | 37,510 |
| **NITROGEN FERTILIZERS** | | | | | | | | |
| Ammonium Nitrate | 7,351 | 37 | 32,817 | 33 | 7,843 | 58 | 26,642 | 14 |
| Ammonium Nitrate Solution | 203 | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Nitrate-limestone Mixtures | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Nitrate-sulfate | 4,138 | NA | NA | NA | 242 | 20 | 3 | NA |
| Ammonium Polysulfide | 335 | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Sulfate | 12,128 | 52 | 20,534 | 72 | 14,984 | 109 | 33,422 | 7 |
| Ammonium Sulfate Solution | 5,885 | NA | 135,421 | 1 | 107 | NA | NA | NA |
| Ammonium Sulfate-nitrate | 9,802 | NA | 48 | NA | 9,107 | NA | NA | NA |
| Ammonium Sulfate-urea | 114 | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Thiosulfate | 658 | 121 | 11,533 | 16 | 249 | 3 | 1,337 | NA |
| Anhydrous Ammonia | 193,582 | 999 | 609,003 | NA | 61,777 | NA | 53,647 | NA |
| Aqua Ammonia | 9,699 | NA | NA | NA | NA | NA | 2,348 | NA |
| Calcium Ammonium Nitrate | 147 | NA | 1,003 | NA | 75 | NA | 5 | NA |
| Calcium Cyanamide | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Nitrate | 233 | NA | 43,777 | 15 | 3,406 | 32 | 191 | NA |
| Calcium Nitrate-urea | 311 | NA | NA | NA | NA | NA | NA | NA |
| Ferrous Ammonium Sulfate | 101 | 2 | NA | 25 | 22 | 3 | NA | NA |
| Magnesium Nitrate | NA | NA | NA | NA | NA | NA | NA | NA |
| Nitric Acid | 1,330 | 16 | NA | NA | NA | NA | NA | NA |
| Nitrogen Solution 28% | 381,031 | 484 | 721,731 | 22 | 212,610 | NA | 172,502 | 7 |

## Table C-1. (Continued)

| Description | Indiana | | Illinois | | Michigan | | Wisconsin | |
|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Nitrogen Solution 30% | 1,528 | NA | 967 | 11 | NA | NA | 7 | NA |
| Nitrogen Solution 32% | 26,795 | 440 | 155,188 | NA | 4,517 | NA | 19,543 | 3 |
| Nitrogen Solution <28% | 43,752 | 2,632 | 68,529 | 160 | 9,552 | 189 | 3,465 | 25 |
| Nitrogen Solution >32% | 149 | 7 | 305 | NA | NA | NA | 396 | NA |
| Sodium Nitrate | 1,129 | 1 | 40 | 4 | 89 | 4 | 119 | 5 |
| Sulfur Coated Urea | 689 | NA | NA | NA | 701 | NA | 4 | NA |
| Urea | 70,196 | 1,669 | 107,515 | 1,653 | 84,342 | 398 | 119,480 | 258 |
| Urea Solution | NA | NA | NA | NA | NA | NA | NA | NA |
| Urea-formaldehyde | 700 | 19 | 500 | 4,839 | 1,345 | 220 | 59 | 256 |
| Zinc Ammonium Sulfate Solution | NA | NA | NA | NA | NA | NA | 2 | NA |
| Zinc Manganese Ammonium Sulfate | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 13,158 | 721 | 3,811 | 697 | 35,247 | 177 | 16 | 328 |
| **TOTAL** | 785,144 | 7,200 | 1,912,720 | 7,548 | 446,215 | 1,214 | 433,188 | 903 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | |
| Ammonium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate | 30 | NA | NA | NA | 9 | NA | NA | NA |
| Ammonium Phosphate Nitrate | 1 | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate Sulfate | 406 | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Polyphosphate | 132 | NA | NA | NA | NA | NA | NA | NA |
| Basic Lime Phosphate | NA | NA | NA | NA | NA | NA | NA | NA |
| Basic Slag | NA | NA | NA | NA | NA | NA | NA | NA |
| Bone Meal, Raw | NA | NA | NA | NA | NA | NA | 35 | NA |
| Bone Meal, Steamed | NA | 2 | NA | 6 | 1 | NA | 125 | NA |
| Bone, Precipitated | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA |
| Colloidal Phosphate (Soft Phosphate) | 88 | NA | NA | NA | 22 | NA | NA | NA |

## Table C-1.  (Continued)

| Description | Indiana | | Illinois | | Michigan | | Wisconsin | |
|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Diammonium Phosphate | 111,262 | 26 | 575,347 | 184 | 38,184 | 32 | 154,576 | NA |
| Limestone, Phosphatic | NA | NA | NA | NA | NA | NA | NA | NA |
| Liquid Ammonium Polyphosphate | 104,273 | 74 | 34,351 | NA | 36,686 | NA | 15,883 | NA |
| Magnesium Phosphate | NA | NA | NA | NA | NA | NA | NA | 5 |
| Monoammonium Phosphate | 12,155 | NA | 81,693 | 20 | 17,840 | 12 | 9,031 | 2 |
| Nitric Phosphate | NA | NA | NA | NA | NA | NA | NA | NA |
| Phosphate Rock | NA | NA | 62 | NA | 121 | 1 | 445 | NA |
| Phosphoric Acid | 126 | NA | 449 | NA | NA | 2 | NA | NA |
| Precipitated Phosphate | NA | NA | NA | NA | NA | NA | NA | NA |
| Superphosphate, Enriched | 5 | NA | NA | NA | 24 | NA | 4 | 1 |
| Superphosphate, Normal | 14 | NA | NA | NA | NA | 13 | 12,639 | NA |
| Superphosphate, Triple | 40,324 | 44 | 48,990 | 43 | 4,623 | 115 | 11,310 | NA |
| Superphosphoric Acid | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 260 | 49 | 91,685 | 74 | 42 | 185 | 270 | 37 |
| **TOTAL** | 269,078 | 195 | 832,576 | 327 | 97,552 | 360 | 204,318 | 46 |
| **POTASH FERTILIZERS** | | | | | | | | |
| Lime-potash Mixtures | 1,528 | 9 | NA | NA | 50 | NA | NA | NA |
| Manure Salts | 436 | 28 | NA | NA | NA | NA | NA | NA |
| Muriate of Potash 60% (Pot. Chloride) | 334,986 | 60 | 876,895 | 154 | 161,490 | 57 | 655 | NA |
| Muriate of Potash 62% | 37,944 | 239 | 94,988 | 68 | 75,907 | 529 | 372,336 | 14 |
| Potash Suspensions | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium Carbonate | 15 | NA | NA | NA | 138 | NA | NA | NA |
| Potassium Nitrate | 399 | 10 | 2 | NA | 1,218 | 351 | NA | 1 |
| Potassium Sulfate | 1,911 | 56 | 540 | 59 | 2,825 | 14 | 2,863 | 3 |
| Potassium-magnesium Sulfate | 2,739 | NA | 893 | 10 | 2,992 | 37 | 11,064 | 5 |
| Potassium-metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-1. (Continued)

| Description | Indiana | | Illinois | | Michigan | | Wisconsin | |
|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Potassium-sodium Nitrate | NA | NA | NA | NA | 37 | NA | NA | NA |
| Other | 11,586 | 93 | 5,052 | 791 | 4,194 | 163 | 2,754 | 110 |
| **TOTAL** | 391,544 | 496 | 978,371 | 1,083 | 248,852 | 1,151 | 389,671 | 134 |
| **ORGANIC FERTILIZERS** | | | | | | | | |
| Blood, Dried | NA | 3 | NA | NA | NA | NA | 121 | NA |
| Castor Pomace | NA | 1 | NA | NA | NA | NA | NA | NA |
| Cocoa Shell Meal | NA | NA | NA | NA | NA | NA | NA | NA |
| Compost | NA | NA | NA | NA | NA | 3,961 | 13 | NA |
| Cottonseed Meal | NA | NA | NA | NA | NA | NA | NA | NA |
| Fish Scrap | NA | NA | NA | NA | NA | NA | 12 | NA |
| Guano | NA | NA | NA | NA | NA | NA | NA | NA |
| Manure | 370 | 31 | NA | NA | NA | 698 | 3,848 | NA |
| Peat | NA | 1,083 | NA | NA | 2,552 | 23,055 | NA | NA |
| Sewage Sludge, Activated | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Digested | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Heat Dried | NA | NA | NA | NA | NA | NA | 2,472 | NA |
| Sewage Sludge, Other | NA | NA | NA | NA | NA | NA | NA | NA |
| Soybean Meal | NA | NA | NA | NA | NA | NA | 1 | NA |
| Tankage, Animal | NA | NA | NA | NA | NA | NA | 37 | NA |
| Tankage, Process | NA | NA | NA | NA | NA | NA | 281 | NA |
| Other | 205 | 1,163 | NA | NA | NA | 7,793 | 1,437 | NA |
| **TOTAL** | 575 | 2,281 | NA | NA | 2,552 | 35,507 | 8,221 | NA |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | |
| Aluminum Sulfate | NA | NA | NA | NA | NA | 1 | NA | NA |
| Borax | 71 | NA | NA | NA | 273 | 8 | 1,110 | NA |
| Calcium Chelate | NA | NA | NA | NA | NA | NA | 9,026 | NA |
| Calcium Chloride | NA | NA | NA | NA | NA | NA | 1,331 | NA |
| Calcium Sulfate (Hydrous) | NA | NA | NA | NA | NA | NA | 1,804 | NA |
| Cobalt Sulfate | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Chelate | NA | NA | NA | NA | NA | NA | 49 | NA |
| Copper Compound | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Oxide, Black | NA | NA | NA | NA | NA | NA | 36 | NA |

## Table C-1. (Continued)

| Description | Indiana | | Illinois | | Michigan | | Wisconsin | |
|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Copper Sulfate | 1 | NA | NA | NA | 39 | 2 | NA | NA |
| Epsom Salt (Magnesium Sulfate) | NA | NA | NA | NA | 62 | 9 | NA | NA |
| Ferric Oxide | NA | NA | NA | NA | NA | NA | NA | NA |
| Ferric Sulfate | NA | NA | NA | NA | NA | NA | NA | NA |
| Ferrous Sulfate | NA | NA | NA | NA | NA | NA | NA | NA |
| Gypsum (Calcium Sulfate) | 4,445 | NA | NA | NA | 4,863 | 8,140 | 3,391 | NA |
| Iron Chelate | NA | 3 | NA | NA | NA | 44 | 238 | NA |
| Iron Compound | NA | NA | NA | NA | NA | 3 | 2 | NA |
| Lime Sulfur Solution | NA | NA | NA | NA | NA | NA | NA | NA |
| Magnesia (Magnesium Oxide) | 31 | NA | NA | NA | 15 | NA | 10 | NA |
| Magnesium Chelate | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Agstone | 1 | NA | NA | NA | NA | NA | NA | NA |
| Manganese Chelate | 1 | NA | NA | NA | NA | NA | NA | NA |
| Manganese Oxide | 1 | NA | NA | NA | 2 | NA | NA | NA |
| Manganese Slag | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Sulfate | 36 | NA | NA | NA | 39 | NA | NA | NA |
| Manganous Oxide | NA | NA | NA | NA | NA | NA | 73 | NA |
| Potting Soil | NA | NA | NA | NA | NA | NA | NA | NA |
| Sodium Molybdate | NA | NA | NA | NA | NA | NA | 9 | NA |
| Soil Additive | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Amendment | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Conditioner | NA | NA | NA | NA | NA | 11,601 | NA | NA |
| Sulfur | 569 | NA | NA | NA | 653 | 11 | 3,705 | 21 |
| Sulfuric Acid | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Chelate | NA | NA | NA | NA | 3 | NA | NA | NA |
| Zinc Oxide | NA | NA | NA | NA | 3 | NA | 669 | NA |
| Zinc Oxysulfate | NA | NA | NA | NA | 331 | NA | NA | NA |
| Zinc Sulfate | 4 | NA | NA | NA | 197 | 5 | NA | NA |
| Zinc Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 2,238 | NA | NA | NA | 7,105 | 202 | 1,054 | NA |

## Table C-1. (Continued)

| Description | Indiana | | Illinois | | Michigan | | Wisconsin | |
|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| **TOTAL** | 7,397 | 3 | NA | NA | 13,586 | 20,027 | 22,507 | 21 |
| **LIMING MATERIALS** | | | | | | | | |
| Calcitic Lime (75% Neutral) | NA | NA | NA | NA | 437 | NA | NA | NA |
| Calcium Hydroxide (Hydrate) | NA | NA | NA | NA | NA | 5 | NA | NA |
| Calcium Oxide (Burnt) | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic & Calcitic Blend (Pelletized) | NA | NA | NA | NA | 997 | 117 | NA | NA |
| Dolomitic Lime (75% Neutral) | NA | NA | NA | NA | 2 | NA | NA | NA |
| Lime Suspensions | NA | NA | NA | NA | NA | NA | NA | NA |
| Non-lime Filler (Water, Sand, Etc.) | NA | NA | NA | NA | NA | NA | 1,097 | NA |
| Standard Calcite | NA | NA | NA | NA | NA | NA | NA | NA |
| Standard Dolomite | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 4,501 | NA | NA | NA | 3,411 | 102 | 12,131 | NA |
| **TOTAL** | 4,501 | NA | NA | NA | 4,847 | 223 | 13,228 | NA |
| **ALL FERTILIZERS** | | | | | | | | |
| **TOTAL** | 1,932,735 | 57,049 | 3,886,719 | 77,391 | 1,140,332 | 124,526 | 1,217,874 | 38,609 |

1. Data for Ohio was not divided into farm and non-farm use.

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

## Table C-2. Fertilizer Consumption by Use, Alabama, East South Central States of Mississippi and Tennessee, 1996 (tons)

| Description | Alabama | | Mississippi | | Tennessee | |
|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | |
| N-P-K | 233,473 | 45 | 181,634 | 23,566 | 113,802 | 37,230 |
| N-P | 46,223 | NA | 52,073 | 5,308 | 163,058 | 840 |
| N-K | 21,162 | NA | 13,336 | 584 | 2,256 | 946 |
| P-K | 13,324 | NA | 23,564 | 445 | 1,314 | 19 |
| **TOTAL** | 314,182 | 45 | 270,606 | 29,903 | 280,430 | 39,034 |
| **NITROGEN FERTILIZERS** | | | | | | |
| Ammonium Nitrate | 122,191 | NA | 101,199 | 2,003 | 165,627 | 2,893 |
| Ammonium Nitrate Solution | NA | NA | 228 | NA | NA | NA |
| Ammonium Nitrate-limestone Mixtures | NA | NA | NA | NA | NA | NA |
| Ammonium Nitrate-sulfate | 44 | NA | 574 | NA | 14 | NA |
| Ammonium Polysulfide | NA | NA | 420 | NA | NA | NA |
| Ammonium Sulfate | 12,848 | NA | 11,752 | 236 | 2,957 | 374 |
| Ammonium Sulfate Solution | NA | NA | NA | NA | NA | NA |
| Ammonium Sulfate-nitrate | 118 | NA | 29 | NA | 9 | NA |
| Ammonium Sulfate-urea | NA | NA | NA | NA | NA | NA |
| Ammonium Thio Sulfate | 331 | NA | 7,347 | 263 | 2 | NA |
| Anhydrous Ammonia | 1,513 | NA | 18,906 | NA | 15,035 | NA |
| Aqua Ammonia | NA | NA | 273 | NA | NA | NA |
| Calcium Ammonium Nitrate | 6 | NA | 25 | NA | NA | NA |
| Calcium Cyanamide | NA | NA | NA | NA | NA | NA |
| Calcium Nitrate | 90 | NA | 44 | 178 | 282 | 4 |
| Calcium Nitrate-urea | NA | NA | NA | NA | NA | NA |
| Ferrous Ammonium Sulfate | NA | NA | 12 | NA | 14 | NA |
| Magnesium Nitrate | NA | NA | NA | NA | NA | NA |
| Nitricacid | NA | NA | NA | NA | 1 | NA |
| Nitrogen Solution 28% | 10,983 | 26 | 22,584 | 237 | 4,085 | 52 |
| Nitrogen Solution 30% | 620 | NA | 947 | NA | 582 | NA |
| Nitrogen Solution 32% | 37,726 | NA | 140,067 | 174 | 45,505 | 279 |
| Nitrogen Solution < 28% | 14,501 | NA | 1,329 | 4 | 1,419 | 27 |
| Nitrogen Solution > 32% | 129 | NA | 14 | NA | 422 | 265 |
| Sodium Nitrate | 629 | NA | 1,561 | 2 | 2,630 | 2 |
| Sulfur Coated Urea | 8 | NA | 41 | NA | 4 | NA |
| Urea | 20,380 | NA | 89,587 | 6,092 | 74,047 | 701 |
| Urea Solution | NA | NA | 281 | NA | NA | NA |
| Urea-formaldehyde | 3,020 | NA | 99 | 55 | 25 | 27 |
| Zinc Ammonium Sulfate Solution | NA | NA | 247 | NA | 299 | NA |

## Table C-2. (Continued)

| Description | Alabama | | Mississippi | | Tennessee | |
|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Zinc Manganese Ammonium Sulfate | NA | NA | NA | NA | NA | NA |
| Other | 43,796 | NA | 9,826 | 51 | 7,265 | 163 |
| **TOTAL** | 268,931 | 26 | 407,389 | 9,295 | 320,223 | 4,787 |
| **PHOSPHATE FERTILIZERS** | | | | | | |
| Ammonium Metaphosphate | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate | NA | NA | 68 | NA | NA | NA |
| Ammonium Phosphate Nitrate | 5 | NA | NA | NA | NA | NA |
| Ammonium Phosphate Sulfate | NA | NA | NA | NA | NA | NA |
| Ammonium Polyphosphate | 7 | NA | 50 | NA | NA | NA |
| Basic Limephosphate | NA | NA | NA | NA | NA | NA |
| Basic Slag | NA | NA | 1,851 | NA | 177 | 115 |
| Bone Meal Raw | NA | NA | NA | NA | NA | NA |
| Bone Meal Steamed | 2 | NA | NA | NA | NA | 6 |
| Bone Precipitated | NA | NA | NA | NA | NA | NA |
| Calcium Metaphosphate | 2 | NA | NA | NA | 1,711 | NA |
| Colloidal Phosphate (Softphosphate) | 17 | NA | 22 | NA | 67 | NA |
| Diammonium Phosphate | 35,350 | NA | 40,745 | 5,179 | 159,458 | 646 |
| Limestone Phosphatic | NA | NA | NA | NA | NA | NA |
| Liquid Ammonium Polyphosphate | 2,611 | NA | 8,578 | NA | 2,193 | 107 |
| Magnesium Phosphate | 4 | NA | NA | 10 | NA | 9 |
| Monoammonium Phosphate | 720 | NA | 541 | NA | 448 | 7 |
| Nitric Phosphate | NA | NA | NA | NA | NA | NA |
| Phosphate Rock | 31 | NA | NA | NA | NA | NA |
| Phosphoric Acid | NA | NA | NA | NA | NA | NA |
| Precipitated Phosphate | NA | NA | NA | NA | NA | NA |
| Super Phosphate Enriched | 28 | NA | NA | NA | NA | NA |
| Super Phosphate Normal | 501 | NA | NA | NA | 4 | 3 |
| Super Phosphate Triple | 6,913 | NA | 13,900 | 681 | 8,617 | 4 |
| Super Phosphoric Acid | NA | NA | NA | NA | NA | NA |
| Other | 812 | NA | 59 | 81 | 240 | 266 |
| **TOTAL** | 47,003 | NA | 65,814 | 5,951 | 172,915 | 1,162 |
| **POTASH FERTILIZERS** | | | | | | |
| Lime-potash Mixtures | 88 | NA | NA | NA | NA | NA |
| Manure Salts | NA | NA | NA | NA | NA | NA |
| Muriate of Potash 60% (Pot.chloride) | 43,942 | NA | 108,907 | 7,453 | 184,406 | 1,395 |
| Muriate of Potash 62% | 2,188 | NA | 15,292 | 207 | 2,111 | 5 |
| Potash Suspensions | 131 | NA | 52 | NA | NA | NA |
| Potassium Carbonate | NA | NA | NA | NA | NA | NA |

## Table C-2. (Continued)

| Description | Alabama | | Mississippi | | Tennessee | |
|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Potassium Nitrate | 1,963 | NA | 600 | 28 | 253 | NA |
| Potassium Sulfate | 539 | NA | 1,056 | 7 | 5,533 | NA |
| Potassium-magnesium Sulfate | 815 | NA | 2,066 | 19 | 816 | 1 |
| Potassium-meta Phosphate | NA | NA | NA | NA | NA | NA |
| Potassium-sodium Nitrate | NA | NA | NA | NA | 224 | NA |
| Other | 4,943 | NA | 2,386 | 2 | 3,285 | 134 |
| **TOTAL** | 54,610 | NA | 130,359 | 7,716 | 196,628 | 1,536 |
| **ORGANIC FERTILIZERS** | | | | | | |
| Blood Dried | 3 | NA | NA | NA | NA | NA |
| Castor Pomace | NA | NA | NA | NA | NA | NA |
| Cocoa Shell Meal | NA | NA | NA | NA | NA | NA |
| Compost | NA | NA | NA | NA | NA | NA |
| Cottonseed Meal | NA | NA | NA | NA | 27 | NA |
| Fish Scrap | NA | NA | NA | NA | 122 | 866 |
| Guano | NA | NA | NA | NA | NA | NA |
| Manure | 1,398 | NA | NA | 3,885 | 29 | 1,518 |
| Peat | NA | NA | NA | NA | NA | 2,338 |
| Sewage Sludge Activated | 43 | NA | NA | NA | NA | 198 |
| Sewage Sludge Digested | NA | NA | NA | NA | NA | NA |
| Sewage Sludge Heat Dried | NA | NA | NA | NA | NA | NA |
| Sewage Sludge Other | NA | NA | NA | NA | NA | NA |
| Soybean Meal | NA | NA | NA | NA | NA | NA |
| Tankage Animal | NA | NA | NA | NA | NA | NA |
| Tankage Process | NA | NA | NA | NA | 154 | NA |
| Other | 3 | NA | NA | 44 | 1,074 | 8,641 |
| **TOTAL** | 1,446 | NA | NA | 3,930 | 1,406 | 13,561 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | |
| Aluminum Sulfate | 27 | NA | 384 | NA | 27 | 4 |
| Borax | 104 | NA | 1,440 | 14 | 2,088 | 44 |
| Calcium Chelate | NA | NA | NA | NA | NA | NA |
| Calcium Chloride | 1 | NA | NA | NA | 8 | NA |
| Calcium Sulfate (Hydrous) | NA | NA | NA | NA | NA | NA |
| Cobalt Sulfate | NA | NA | NA | NA | NA | NA |
| Copper Chelate | NA | NA | NA | NA | NA | NA |
| Copper Compound | NA | NA | NA | NA | NA | NA |
| Copper Oxide Black | NA | NA | NA | NA | NA | NA |
| Copper Sulfate | NA | NA | NA | NA | 6 | NA |
| Epsom Salt (Magnesium Sulfate) | NA | NA | NA | NA | 16 | NA |

## Table C-2. (Continued)

| Description | Alabama | | Mississippi | | Tennessee | |
|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Ferric Oxide | 255 | NA | NA | NA | NA | NA |
| Ferric Sulfate | NA | NA | NA | NA | NA | NA |
| Ferrous Sulfate | NA | NA | NA | NA | 23 | 2 |
| Gypsum (Calcium Sulfate) | 241 | NA | 22 | 10 | 767 | 121 |
| Iron Chelate | 8 | NA | 17 | NA | 2 | 18 |
| Iron Compound | NA | NA | 16 | NA | NA | NA |
| Lime Sulfur Solution | NA | NA | NA | NA | NA | NA |
| Magnesia (Magnesium Oxide) | NA | NA | NA | NA | 74 | NA |
| Magnesium Chelate | NA | NA | 7 | NA | NA | NA |
| Manganese Agstone | NA | NA | NA | NA | NA | NA |
| Manganese Chelate | NA | NA | 8 | NA | 2 | NA |
| Manganese Oxide | NA | NA | NA | NA | 21 | NA |
| Manganese Slag | NA | NA | NA | NA | NA | NA |
| Manganese Sulfate | 15 | NA | NA | NA | 1 | NA |
| Manganous Oxide | NA | NA | NA | NA | 3 | NA |
| Potting Soil | NA | NA | 2 | NA | NA | NA |
| Sodium Molybdate | NA | NA | 200 | NA | NA | NA |
| Soil Additive | NA | NA | NA | NA | NA | NA |
| Soil Amendment | NA | NA | NA | NA | NA | NA |
| Soil Conditioner | NA | NA | NA | NA | NA | NA |
| Sulfur | 731 | NA | 1,468 | 1 | 1,894 | 5 |
| Sulfuric Acid | NA | NA | NA | NA | 2 | NA |
| Zinc Chelate | NA | NA | NA | NA | 61 | NA |
| Zinc Oxide | NA | NA | 173 | NA | 186 | NA |
| Zinc Oxysulfate | NA | NA | NA | NA | 114 | NA |
| Zinc Sulfate | 4 | NA | 8 | NA | 174 | NA |
| Zinc Sulfate Solution | NA | NA | NA | NA | NA | NA |
| Other | 1,526 | NA | 439 | 65 | 194 | 61 |
| **TOTAL** | 2,912 | NA | 4,183 | 90 | 5,662 | 255 |

## Table C-2. (Continued)

| Description | Alabama | | Mississippi | | Tennessee | |
|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| **LIMING MATERIALS** | | | | | | |
| Calciticlime (75%neutral) | NA | NA | NA | NA | NA | NA |
| Calcium Hydroxide (Hydrate) | NA | NA | NA | NA | 41 | NA |
| Calcium Oxide (Burnt) | NA | NA | NA | NA | NA | NA |
| Dolomitic & Calcitic Blend (Pelletized) | NA | NA | NA | NA | 147 | 1 |
| Dolomitic Lime (75% Neutral) | 1,319 | NA | NA | NA | NA | NA |
| Lime Suspensions | NA | NA | NA | NA | NA | NA |
| Non-lime Filler (Water, Sand, Etc.) | NA | NA | NA | NA | NA | NA |
| Standard Calcite | 23 | NA | NA | NA | 22,164 | 39 |
| Standard Dolomite | 27 | NA | NA | NA | NA | 29 |
| Other | 1,094 | NA | 84 | NA | 632 | 17 |
| **TOTAL** | 2,464 | NA | 84 | NA | 22,984 | 86 |
| **ALL FERTILIZERS** | | | | | | |
| **TOTAL** | 649,449 | 71 | 827,853 | 47,792 | 837,492 | 54,736 |

1. Data for Kentucky was not divided into farm and non-farm use.

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

## Table C-3. Fertilizer Consumption by Use, West North Central States, 1996 (tons)

| Description | Kansas | | Minnesota | | Missouri | | Nebraska | | North Dakota | | South Dakota |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm |
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | | | |
| N-P-K | 38,126 | 10 | 71,022 | NA | 63,276 | 31,502 | 137,462 | 25 | 40 | NA | 7,237 |
| N-P | 398,776 | NA | 529,868 | NA | 285,925 | 647 | 369,018 | NA | 332,312 | NA | 216,487 |
| N-K | 2,790 | NA | 1,976 | NA | 1,872 | 997 | 6,613 | NA | NA | NA | 29 |
| P-K | 187 | NA | 2,531 | NA | 1,900 | 357 | 129 | NA | NA | NA | 79 |
| **TOTAL** | 439,879 | 10 | 605,397 | NA | 352,973 | 33,503 | 513,222 | 25 | 332,352 | NA | 223,832 |
| **NITROGEN FERTILIZERS** | | | | | | | | | | | |
| Ammonium Nitrate | 76,603 | NA | 9,122 | NA | 277,277 | 49 | 33,246 | NA | 11,433 | NA | 2,846 |
| Ammonium Nitrate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Nitrate-limestone Mixtures | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Nitrate-sulfate | 4 | NA | NA | NA | 2 | NA | 15 | NA | NA | NA | NA |
| Ammonium Polysulfide | 26 | NA | NA | NA | NA | NA | NA | NA | 79 | NA | 11 |
| Ammonium Sulfate | 2,158 | NA | 42,323 | NA | 16,472 | 157 | 23,619 | NA | 3,869 | NA | 3,548 |
| Ammonium Sulfate Solution | 8 | NA | NA | NA | 9 | NA | NA | NA | NA | NA | NA |
| Ammonium Sulfate-nitrate | NA | NA | 428 | NA | 50 | 4 | 502 | NA | NA | NA | 18 |
| Ammonium Sulfate-urea | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Thiosulfate | 17,192 | NA | 3,978 | NA | 5,848 | NA | 63,426 | NA | 373 | NA | 646 |
| Anhydrous Ammonia | 503,336 | NA | 348,293 | NA | 128,273 | NA | 605,595 | 403 | 394,352 | NA | 27,673 |
| Aqua Ammonia | 3,194 | NA | 122 | NA | NA | NA | 71 | NA | NA | NA | NA |
| Calcium Ammonium Nitrate | NA | NA | 756 | NA | 6 | NA | 42 | NA | NA | NA | 1 |
| Calcium Cyanamide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Nitrate | 543 | NA | 83 | NA | 641 | 56 | 8 | NA | 197 | NA | NA |
| Calcium Nitrate-urea | NA | NA | 282 | NA | NA | NA | 330 | NA | NA | NA | NA |
| Ferrous Ammonium Sulfate | NA | NA | NA | NA | NA | 33 | NA | NA | NA | NA | NA |
| Magnesium Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-3. (Continued)

| Description | Kansas | | Minnesota | | Missouri | | Nebraska | | North Dakota | | South Dakota |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm |
| Nitric Acid | 9 | NA | NA | NA | NA | NA | 735 | NA | 4 | NA | NA |
| Nitrogen Solution 28% | 258,746 | NA | 149,524 | NA | 66,893 | 76 | 436,765 | NA | 28,677 | NA | 104,015 |
| Nitrogen Solution 30% | 84 | NA | 13 | NA | 4,349 | NA | NA | NA | NA | NA | NA |
| Nitrogen Solution 32% | 165,782 | NA | 15,556 | NA | 207,117 | NA | 399,386 | NA | 10 | NA | 8,573 |
| Nitrogen Solution <28% | 5,157 | NA | 1,379 | NA | 1,649 | NA | 3,813 | NA | 54 | NA | 701 |
| Nitrogen Solution >32% | 6,200 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sodium Nitrate | 1 | NA | 2 | NA | 38 | 1 | NA | NA | NA | NA | NA |
| Sulfur Coated Urea | 184 | NA | 162 | NA | NA | 2 | 710 | NA | 47 | NA | NA |
| Urea | 101,051 | NA | 472,342 | NA | 160,563 | 565 | 68,397 | NA | 286,992 | NA | 128,341 |
| Urea Solution | NA | NA | 1,277 | NA | NA | NA | NA | NA | NA | NA | NA |
| Urea-formaldehyde | 101 | NA | 663 | NA | 237 | 183 | 2,900 | NA | 312 | NA | NA |
| Zinc Ammonium Sulfate Solution | 158 | NA | NA | NA | NA | NA | 5,518 | NA | NA | NA | 16 |
| Zinc Manganese Ammonium Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 15 |
| Other | 7,889 | NA | 1,313 | NA | 1,486 | 495 | 4,896 | NA | NA | NA | 5,781 |
| **TOTAL** | 1,148,425 | NA | 1,047,618 | NA | 870,911 | 1,620 | 1,649,972 | 403 | 726,398 | NA | 282,183 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | | | |
| Ammonium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate | NA | NA | 250 | NA | NA | NA | 16,978 | NA | NA | NA | NA |
| Ammonium Phosphate Nitrate | 244 | NA | NA | NA | 5 | NA | 989 | NA | NA | NA | NA |
| Ammonium Phosphate Sulfate | 67 | NA | 1,172 | NA | 140 | NA | 1,990 | NA | NA | NA | 19 |
| Ammonium Polyphosphate | NA | NA | NA | NA | NA | NA | 52,123 | NA | NA | NA | NA |
| Basic Lime Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Basic Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bone Meal, Raw | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bone Meal, Steamed | 7 | NA | NA | NA | 18 | 1 | NA | NA | NA | NA | NA |
| Bone, Precipitated | NA | NA | NA | NA | NA | 2 | NA | NA | NA | NA | NA |

## Table C-3. (Continued)

| Description | Kansas | | Minnesota | | Missouri | | Nebraska | | North Dakota | | South Dakota |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm |
| Calcium Metaphosphate | NA | NA | 253 | NA | NA | NA | NA | NA | NA | NA | NA |
| Colloidal Phosphate (Soft Phosphate) | NA | NA | 2 | NA | 93 | 23 | 24 | NA | NA | NA | NA |
| Diammonium Phosphate | 163,170 | NA | 402,007 | NA | 233,104 | 19 | 57,197 | NA | 205,055 | NA | 132,690 |
| Limestone, Phosphatic | 5 | NA | NA | NA | 18 | NA | NA | NA | NA | NA | NA |
| Liquid Ammonium Polyphosphate | 148,294 | NA | 55,563 | NA | 15,156 | NA | 150,353 | NA | 13,352 | NA | 44,318 |
| Magnesium Phosphate | NA | NA | NA | NA | 22 | NA | 968 | NA | NA | NA | NA |
| Monoammonium Phosphate | 84,557 | NA | 61,202 | NA | 33,075 | 6 | 75,877 | NA | 113,905 | NA | 21,036 |
| Nitric Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Phosphate Rock | NA | NA | NA | NA | NA | 3 | 130 | NA | 53 | NA | NA |
| Phosphoric Acid | 198 | NA | NA | NA | 3,329 | NA | 176 | NA | 739 | NA | 189 |
| Precipitated Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Superphosphate, Enriched | NA | NA | 1 | NA | 88 | NA | NA | NA | NA | NA | NA |
| Superphosphate, Normal | 248 | NA | NA | NA | 26 | NA | 8,664 | NA | 40 | NA | NA |
| Superphosphate, Triple | 1,859 | NA | 13,748 | NA | 42,520 | 110 | 3,505 | NA | 3,576 | NA | 4,059 |
| Superphosphoric Acid | 1,690 | NA | 2,589 | NA | -157 | NA | 3,428 | NA | NA | NA | NA |
| Other | 2,274 | NA | NA | NA | 855 | 127 | 431 | NA | NA | NA | NA |
| **TOTAL** | 402,612 | NA | 536,787 | NA | 328,292 | 292 | 372,835 | NA | 336,720 | NA | 202,310 |
| **POTASH FERTILIZERS** | | | | | | | | | | | |
| Lime-potash Mixtures | NA | NA | 7 | NA | NA | 23 | NA | NA | NA | NA | NA |
| Manure Salts | 866 | NA | 313 | NA | NA | NA | NA | NA | NA | NA | NA |
| Muriate of Potash 60% (Pot. Chloride) | 54,092 | NA | 444,579 | NA | 280,669 | 126 | 30,407 | NA | 40,439 | NA | 23,868 |
| Muriate of Potash 62% | 12,362 | NA | NA | NA | 93,152 | 110 | 6,897 | NA | 2,283 | NA | 1,790 |
| Potash Suspensions | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium Carbonate | 27 | NA | NA | NA | NA | NA | 58 | NA | NA | NA | NA |
| Potassium Nitrate | 35 | NA | 88 | NA | 71 | 4 | NA | NA | NA | NA | 2 |

## Table C-3. (Continued)

| Description | Kansas | | Minnesota | | Missouri | | Nebraska | | North Dakota | | South Dakota |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm |
| Potassium Sulfate | 119 | NA | 766 | NA | 480 | 49 | 28 | NA | 125 | NA | 6 |
| Potassium-magnesium Sulfate | 4,503 | NA | 6,983 | NA | 3,811 | 6 | 23,926 | NA | 114 | NA | 176 |
| Potassium-metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium-sodium Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 23 |
| Other | 1,710 | NA | 1,621 | NA | 537 | 53 | 2,227 | NA | 153 | NA | 142 |
| **TOTAL** | 73,713 | NA | 454,357 | NA | 378,720 | 372 | 63,543 | NA | 43,114 | NA | 26,007 |
| **ORGANIC FERTILIZERS** | | | | | | | | | | | |
| Blood, Dried | 81 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 91 |
| Castor Pomace | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cocoa Shell Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Compost | NA | NA | NA | NA | NA | NA | 492 | NA | NA | NA | NA |
| Cottonseed Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Fish Scrap | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Guano | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manure | 1,006 | NA | NA | NA | NA | NA | 1,287 | NA | NA | NA | NA |
| Peat | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Activated | 302 | NA | NA | NA | NA | NA | 182 | NA | 40 | NA | NA |
| Sewage Sludge, Digested | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Heat Dried | 8 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Other | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soybean Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tankage, Animal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tankage, Process | NA | NA | NA | NA | NA | NA | NA | NA | 61 | NA | NA |
| Other | 2,562 | NA | NA | NA | NA | NA | NA | NA | 308 | NA | NA |
| **TOTAL** | 3,959 | NA | NA | NA | NA | NA | 1,960 | NA | 408 | NA | 91 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | | | |
| Aluminum Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-3. (Continued)

| Description | Kansas | | Minnesota | | Missouri | | Nebraska | | North Dakota | | South Dakota |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm |
| Borax | 148 | NA | 210 | NA | 1,474 | NA | 302 | NA | 6 | NA | 10 |
| Calcium Chelate | 5 | NA | NA | NA | NA | NA | 42 | NA | NA | NA | NA |
| Calcium Chloride | 390 | NA | 4 | NA | NA | NA | 1,427 | NA | NA | NA | 4 |
| Calcium Sulfate (Hydrous) | NA | NA | NA | NA | NA | NA | 190 | NA | NA | NA | NA |
| Cobalt Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Chelate | 6 | NA | 13 | NA | NA | NA | 55 | NA | NA | NA | NA |
| Copper Compound | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Oxide, Black | NA | NA | NA | NA | 34 | NA | 1 | NA | NA | NA | NA |
| Copper Sulfate | 5 | NA | 173 | NA | NA | NA | 56 | NA | 5 | NA | 1 |
| Epsom Salt (Magnesium Sulfate) | NA | NA | NA | NA | NA | NA | 1 | NA | NA | NA | NA |
| Ferric Oxide | NA | NA | NA | NA | 1,463 | 17 | NA | NA | NA | NA | 2 |
| Ferric Sulfate | 1 | NA | 7 | NA | NA | NA | 4 | NA | NA | NA | NA |
| Ferrous Sulfate | 15 | NA | 4 | NA | NA | NA | 397 | NA | 1 | NA | 3 |
| Gypsum (Calcium Sulfate) | 27 | NA | 1,553 | NA | 1,158 | 86 | 905 | NA | 67 | NA | NA |
| Iron Chelate | 45 | NA | 17 | NA | NA | NA | 565 | NA | 9 | NA | NA |
| Iron Compound | 32 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Lime Sulfur Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Magnesia (Magnesium Oxide) | NA | 1 | 10 | NA | 120 | 11 | 51 | NA | NA | NA | NA |
| Magnesium Chelate | 5 | NA | 2 | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Agstone | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Chelate | 17 | NA | 25 | NA | NA | NA | 39 | NA | NA | NA | NA |
| Manganese Oxide | NA | NA | NA | NA | 39 | 15 | NA | NA | NA | NA | NA |
| Manganese Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Sulfate | 1 | NA | 68 | NA | NA | NA | 315 | NA | 3 | NA | NA |
| Manganous Oxide | NA | NA | NA | NA | NA | NA | 3 | NA | NA | NA | NA |
| Potting Soil | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-3.  (Continued)

| Description | Kansas | | Minnesota | | Missouri | | Nebraska | | North Dakota | | South Dakota |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm |
| Sodium Molybdate | NA | NA | 1 | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Additive | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Amendment | NA | NA | NA | NA | NA | NA | NA | NA | 60 | NA | NA |
| Soil Conditioner | NA | NA | 5 | NA | NA | NA | 1,197 | NA | NA | NA | NA |
| Sulfur | 826 | NA | 1,307 | NA | 1,931 | 9 | 4,307 | NA | 591 | NA | 363 |
| Sulfuric Acid | NA | NA | 190 | NA | NA | NA | 1,058 | NA | NA | NA | NA |
| Zinc Chelate | 1,223 | NA | 245 | NA | NA | NA | 1,399 | NA | 19 | NA | 69 |
| Zinc Oxide | 296 | NA | 131 | NA | 1,199 | NA | 1,892 | NA | 80 | NA | NA |
| Zinc Oxysulfate | 3 | NA | 9 | NA | NA | NA | 27 | NA | NA | NA | NA |
| Zinc Sulfate | 244 | NA | 2,008 | NA | NA | NA | 8,890 | NA | 1,430 | NA | 74 |
| Zinc Sulfate Solution | NA | NA | NA | NA | NA | NA | 1,883 | NA | NA | NA | NA |
| Other | 910 | NA | 8,824 | NA | 323 | 7,181 | 4 | NA | 111 | NA | 120 |
| **TOTAL** | 4,199 | 1 | 14,806 | NA | 7,741 | 7,318 | 25,009 | NA | 2,382 | NA | 645 |
| **LIMING MATERIALS** | | | | | | | | | | | |
| Calcitic Lime (75% Neutral) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Hydroxide (Hydrate) | NA | NA | NA | NA | NA | NA | NA | NA | 2 | NA | NA |
| Calcium Oxide (Burnt) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic & Calcitic Blend (Pelletized) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic Lime (75% Neutral) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Lime Suspensions | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Non-lime Filler (Water, Sand, Etc.) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Standard Calcite | 8 | NA | NA | NA | 1,228 | 353 | 3,670 | NA | NA | NA | NA |
| Standard Dolomite | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 65 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **TOTAL** | 73 | NA | NA | NA | 1,228 | 353 | 3,670 | NA | 2 | NA | NA |
| **ALL FERTILIZERS** | | | | | | | | | | | |

**Table C-3. (Continued)**

| Description | Kansas | | Minnesota | | Missouri | | Nebraska | | North Dakota | | South Dakota |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm |
| **TOTAL** | 1,674,326 | 11 | 2,138,683 | NA | 1,658,295 | 43,428 | 2,272,742 | 428 | 1,109,024 | NA | 536,982 |

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

**Table C-4. Fertilizer Consumption by Use, West South Central States of Oklahoma and Louisiana, 1996 (tons)**

| Description | Louisiana | | Oklahoma | |
|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm |
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | |
| N-P-K | 245,831 | 16,530 | 23,164 | 22,297 |
| N-P | 30,545 | 7,479 | 165,937 | 347 |
| N-K | 19,733 | 382 | 1,333 | 619 |
| P-K | 66,686 | 38 | 204 | 140 |
| **TOTAL** | 362,796 | 24,429 | 190,638 | 23,403 |
| **NITROGEN FERTILIZERS** | | | | |
| Ammonium Nitrate | 67,390 | 1,817 | 71,385 | 1,816 |
| Ammonium Nitrate Solution | NA | NA | 25 | 9 |
| Ammonium Nitrate-limestone Mixtures | NA | NA | NA | NA |
| Ammonium Nitrate-sulfate | 2,036 | NA | 172 | 1 |
| Ammonium Polysulfide | NA | NA | 26 | 25 |
| Ammonium Sulfate | 11,035 | 29 | 6,871 | 655 |
| Ammonium Sulfate Solution | NA | NA | 3 | NA |
| Ammonium Sulfate-nitrate | 39 | NA | 26 | NA |
| Ammonium Sulfate-urea | 2,171 | 12 | NA | NA |
| Ammonium Thiosulfate | 1,132 | 4 | 3,895 | 1 |
| Anhydrous Ammonia | 8,207 | 160 | 134,320 | NA |
| Aqua Ammonia | NA | NA | NA | NA |
| Calcium Ammonium Nitrate | NA | NA | NA | NA |
| Calcium Cyanamide | NA | NA | NA | NA |
| Calcium Nitrate | 1 | 2 | 136 | 11 |
| Calcium Nitrate-urea | NA | NA | 1,920 | 13 |
| Ferrous Ammonium Sulfate | NA | NA | NA | NA |
| Magnesium Nitrate | NA | NA | NA | NA |
| Nitric Acid | 22 | 3 | 145 | NA |
| Nitrogen Solution 28% | 4,751 | NA | 149,326 | NA |
| Nitrogen Solution 30% | 32,606 | NA | 141 | NA |
| Nitrogen Solution 32% | 212,002 | 325 | 44,859 | NA |
| Nitrogen Solution <28% | 4,979 | 16 | 629 | NA |

**Table C-4. (Continued)**

| Description | Louisiana | | Oklahoma | |
|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm |
| Nitrogen Solution >32% | 266 | NA | NA | NA |
| Sodium Nitrate | 838 | 13 | NA | 5 |
| Sulfur Coated Urea | 196 | NA | 7 | 29 |
| Urea | 73,134 | 256 | 119,786 | 1,259 |
| Urea Solution | NA | NA | NA | NA |
| Urea-formaldehyde | 9,005 | 12 | 402 | 17 |
| Zinc Ammonium Sulfate Solution | NA | NA | NA | NA |
| Zinc Manganese Ammonium Sulfate | NA | NA | NA | NA |
| Other | 14,201 | 186 | 274 | 54 |
| **TOTAL** | 444,010 | 2,834 | 534,348 | 3,896 |
| **PHOSPHATE FERTILIZERS** | | | | |
| Ammonium Metaphosphate | NA | NA | NA | NA |
| Ammonium Phosphate | NA | NA | NA | NA |
| Ammonium Phosphate Nitrate | NA | NA | NA | NA |
| Ammonium Phosphate Sulfate | NA | NA | 52 | 3 |
| Ammonium Polyphosphate | NA | NA | NA | NA |
| Basic Lime Phosphate | NA | NA | NA | NA |
| Basic Slag | NA | NA | NA | NA |
| Bone Meal, Raw | NA | NA | NA | 2 |
| Bone Meal, Steamed | NA | 2 | NA | NA |
| Bone, Precipitated | 5 | NA | NA | NA |
| Calcium Metaphosphate | NA | NA | 25 | NA |
| Colloidal Phosphate (Soft Phosphate) | 25 | NA | NA | 4 |
| Diammonium Phosphate | 10,859 | 7,434 | 127,336 | 240 |
| Limestone, Phosphatic | NA | NA | NA | NA |
| Liquid Ammonium Polyphosphate | 12,230 | 2 | 22,050 | NA |
| Magnesium Phosphate | NA | NA | NA | NA |
| Monoammonium Phosphate | 148 | 2 | 11,671 | NA |
| Nitric Phosphate | NA | NA | NA | NA |

**Table C-4. (Continued)**

| Description | Louisiana | | Oklahoma | |
|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm |
| Phosphate Rock | NA | NA | NA | NA |
| Phosphoric Acid | 80 | NA | 9 | NA |
| Precipitated Phosphate | NA | NA | NA | NA |
| Superphosphate, Enriched | NA | NA | NA | NA |
| Superphosphate, Normal | NA | 2 | NA | NA |
| Superphosphate, Triple | 4,312 | 9 | 2,006 | 47 |
| Superphosphoric Acid | NA | NA | NA | NA |
| Other | 5 | 180 | 529 | 43 |
| **TOTAL** | 27,664 | 7,630 | 163,678 | 339 |
| **POTASH FERTILIZERS** | | | | |
| Lime-potash Mixtures | NA | NA | 1 | NA |
| Manure Salts | NA | NA | 18 | NA |
| Muriate of Potash 60% (Pot. Chloride) | 33,863 | 58 | 43,164 | 93 |
| Muriate of Potash 62% | 1,189 | 3 | 339 | 41 |
| Potash Suspensions | NA | NA | NA | NA |
| Potassium Carbonate | 40 | NA | NA | NA |
| Potassium Nitrate | 15 | NA | NA | 2 |
| Potassium Sulfate | 3,126 | NA | 63 | 9 |
| Potassium-magnesium Sulfate | 190 | NA | 1,351 | 1 |
| Potassium-metaphosphate | NA | NA | NA | NA |
| Potassium-sodium Nitrate | NA | NA | NA | NA |
| Other | 3,376 | 27 | 51 | 13 |
| **TOTAL** | 41,799 | 88 | 44,987 | 159 |
| **ORGANIC FERTILIZERS** | | | | |
| Blood, Dried | NA | 1 | NA | NA |
| Castor Pomace | NA | NA | NA | NA |
| Cocoa Shell Meal | NA | NA | NA | NA |
| Compost | NA | NA | NA | NA |
| Cottonseed Meal | NA | NA | NA | NA |
| Fish Scrap | NA | NA | NA | NA |
| Guano | NA | NA | NA | NA |
| Manure | NA | 83 | NA | 3,231 |

## Table C-4. (Continued)

| Description | Louisiana | | Oklahoma | |
|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm |
| Peat | NA | NA | NA | NA |
| Sewage Sludge, Activated | NA | NA | NA | NA |
| Sewage Sludge, Digested | NA | NA | NA | NA |
| Sewage Sludge, Heat Dried | NA | NA | NA | NA |
| Sewage Sludge, Other | NA | NA | NA | 44 |
| Soybean Meal | NA | NA | NA | NA |
| Tankage, Animal | NA | NA | NA | NA |
| Tankage, Process | NA | NA | NA | NA |
| Other | 102 | NA | NA | NA |
| **TOTAL** | 102 | 84 | NA | 3,275 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | |
| Aluminum Sulfate | NA | 3 | NA | NA |
| Borax | 118 | NA | NA | NA |
| Calcium Chelate | NA | NA | NA | NA |
| Calcium Chloride | NA | NA | NA | NA |
| Calcium Sulfate (Hydrous) | NA | NA | NA | NA |
| Cobalt Sulfate | NA | NA | NA | NA |
| Copper Chelate | NA | NA | NA | NA |
| Copper Compound | NA | NA | NA | NA |
| Copper Oxide, Black | NA | NA | NA | NA |
| Copper Sulfate | NA | NA | NA | NA |
| Epsom Salt (Magnesium Sulfate) | 1 | NA | NA | NA |
| Ferric Oxide | NA | NA | NA | NA |
| Ferric Sulfate | NA | NA | NA | NA |
| Ferrous Sulfate | NA | NA | NA | NA |
| Gypsum (Calcium Sulfate) | 44 | NA | NA | NA |
| Iron Chelate | NA | 4 | NA | 5 |
| Iron Compound | NA | NA | NA | NA |
| Lime Sulfur Solution | NA | NA | NA | NA |
| Magnesia (Magnesium Oxide) | 1 | NA | NA | NA |
| Magnesium Chelate | 12 | NA | NA | NA |
| Manganese Agstone | NA | NA | NA | NA |

**Table C-4. (Continued)**

| Description | Louisiana | | Oklahoma | |
|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm |
| Manganese Chelate | NA | NA | NA | NA |
| Manganese Oxide | NA | NA | NA | NA |
| Manganese Slag | NA | NA | NA | NA |
| Manganese Sulfate | NA | NA | NA | NA |
| Manganous Oxide | NA | NA | NA | NA |
| Potting Soil | NA | NA | NA | NA |
| Sodium Molybdate | NA | NA | NA | NA |
| Soil Additive | NA | NA | NA | NA |
| Soil Amendment | 3 | NA | NA | NA |
| Soil Conditioner | NA | NA | NA | NA |
| Sulfur | 159 | 10 | 100 | 2 |
| Sulfuric Acid | NA | NA | NA | NA |
| Zinc Chelate | 87 | NA | 64 | 7 |
| Zinc Oxide | 63 | NA | NA | NA |
| Zinc Oxysulfate | NA | NA | NA | NA |
| Zinc Sulfate | 98 | NA | 42 | NA |
| Zinc Sulfate Solution | NA | NA | 144 | NA |
| Other | 673 | 3 | 1,458 | 1,599 |
| **TOTAL** | 1,259 | 21 | 1,808 | 1,613 |
| **LIMING MATERIALS** | | | | |
| Calcitic Lime (75% Neutral) | 2,953 | NA | NA | NA |
| Calcium Hydroxide (Hydrate) | NA | NA | NA | NA |
| Calcium Oxide (Burnt) | NA | NA | NA | NA |
| Dolomitic & Calcitic Blend (Pelletized) | NA | NA | NA | NA |
| Dolomitic Lime (75% Neutral) | 174 | NA | NA | NA |
| Lime Suspensions | NA | NA | NA | NA |
| Non-lime Filler (Water, Sand, Etc.) | NA | NA | NA | NA |
| Standard Calcite | NA | NA | NA | NA |
| Standard Dolomite | 27 | NA | NA | NA |
| Other | NA | NA | 113 | 2 |
| **TOTAL** | 3,154 | NA | 113 | 2 |

**Table C-4. (Continued)**

| Description | Louisiana | | Oklahoma | |
|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm |
| **ALL FERTILIZERS** | | | | |
| **TOTAL** | 857,526 | 27,563 | 774,463 | 29,165 |

1. Data for Arkansas and Texas was not divided into farm versus non-farm use.

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

## Table C-5. Fertilizer Consumption by Use, New England States, 1996 (tons)

| Description | Connecticut | Maine | | Massachusettes | | New Hampshire | | Rhode Island | Vermont | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonarm |
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | | |
| N-P-K | 34,218 | 64,146 | 9,056 | 86,482 | 538 | 18,447 | 12 | 9,755 | 12,525 | 3,659 |
| N-P | 947 | 5,633 | 1 | 2,931 | NA | 506 | NA | 1,112 | 1,924 | 4,701 |
| N-K | 1,538 | 488 | 99 | 3,164 | NA | 1,078 | NA | 110 | 820 | 29 |
| P-K | 866 | 2 | 18 | 500 | NA | 47 | NA | 21 | 518 | 10 |
| TOTAL | 37,569 | 70,269 | 9,175 | 93,077 | 538 | 20,078 | 12 | 10,998 | 15,787 | 8,399 |
| **NITROGEN FERTILIZERS** | | | | | | | | | | |
| Ammonium Nitrate | 58 | 2,988 | 4 | 139 | NA | 46 | NA | 42 | 69 | NA |
| Ammonium Nitrate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Nitrate-limestone Mixtures | NA | NA | 1 | NA | NA | 1 | NA | NA | NA | NA |
| Ammonium Nitrate-sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Polysulfide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Sulfate | 87 | 700 | 20 | 221 | NA | 70 | NA | 14 | 141 | 4 |
| Ammonium Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Sulfate-nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Sulfate-urea | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Thiosulfate | 1 | NA | NA | NA | NA | 1 | NA | 3 | NA | NA |
| Anhydrous Ammonia | NA | NA | NA | 2 | NA | NA | NA | NA | NA | NA |
| Aqua Ammonia | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Ammonium Nitrate | NA | NA | NA | NA | NA | 9 | NA | NA | NA | NA |
| Calcium Cyanamide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Nitrate | 180 | 238 | 1 | 263 | NA | 188 | NA | 132 | 50 | NA |
| Calcium Nitrate-urea | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-5. (Continued)

| Description | Connecticut | Maine | | Massachusettes | | New Hampshire | | Rhode Island | Vermont | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonarm |
| Ferrous Ammonium Sulfate | NA | NA | NA | 11 | NA | 6 | NA | NA | NA | NA |
| Magnesium Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Nitric Acid | NA | NA | NA | 23 | NA | NA | NA | NA | NA | NA |
| Nitrogen Solution 28% | 41 | 632 | 58 | 29 | NA | 1 | NA | NA | NA | NA |
| Nitrogen Solution 30% | NA | NA | NA | 1 | NA | NA | NA | NA | NA | NA |
| Nitrogen Solution 32% | 176 | 502 | NA | 598 | NA | 167 | NA | 1 | 1,664 | NA |
| Nitrogen Solution <28% | 5 | NA | 86 | 4 | NA | 5 | NA | 1 | NA | NA |
| Nitrogen Solution >32% | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sodium Nitrate | 3 | NA | 4 | 6 | NA | 2 | NA | 1 | 27 | 298 |
| Sulfur Coated Urea | 1 | NA | NA | 1 | NA | NA | NA | NA | 4 | NA |
| Urea | 1,806 | 2,917 | 1,239 | 2,400 | NA | 1,445 | NA | 361 | 3,262 | 7 |
| Urea Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Urea-formaldehyde | 353 | NA | NA | 1,463 | NA | 38 | NA | NA | 2 | 1 |
| Zinc Ammonium Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Manganese Ammonium Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 103 | 5 | 2 | 519 | NA | 19 | NA | 26 | 10 | 2,704 |
| TOTAL | 2,816 | 7,982 | 1,416 | 5,679 | NA | 1,998 | NA | 581 | 5,228 | 3,015 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | | |
| Ammonium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate | NA | NA | NA | 1 | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Polyphosphate | NA | NA | NA | 5 | NA | NA | NA | NA | 56 | NA |
| Basic Lime Phosphate | NA | NA | NA | 37 | NA | NA | NA | NA | NA | NA |

## Table C-5. (Continued)

| Description | Connecticut | Maine | | Massachusettes | | New Hampshire | | Rhode Island | Vermont | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonarm |
| Basic Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bone Meal, Raw | NA | 3 | NA | 72 | NA | NA | NA | NA | NA | NA |
| Bone Meal, Steamed | 48 | 8 | NA | 141 | NA | 15 | NA | 1 | NA | 1 |
| Bone, Precipitated | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Colloidal Phosphate (Soft Phosphate) | NA | NA | NA | 4 | NA | NA | NA | NA | NA | NA |
| Diammonium Phosphate | 5 | 3,261 | NA | 1,842 | NA | 297 | NA | NA | 481 | NA |
| Limestone, Phosphatic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Liquid Ammonium Polyphosphate | NA | 1,677 | NA | 41 | NA | 73 | NA | 6 | 168 | NA |
| Magnesium Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Monoammonium Phosphate | 455 | 112 | NA | 616 | NA | 68 | NA | 120 | 1,167 | NA |
| Nitric Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Phosphate Rock | NA | 3 | NA | NA | NA | NA | NA | NA | NA | 7 |
| Phosphoric Acid | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Precipitated Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Superphosphate, Enriched | NA | NA | NA | 8 | NA | NA | NA | NA | NA | NA |
| Superphosphate, Normal | 12 | NA | 3 | 95 | NA | 18 | 13 | 2 | 2 | NA |
| Superphosphate, Triple | 83 | 62 | 8 | 365 | NA | 45 | NA | 37 | 97 | NA |
| Superphosphoric Acid | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 23 | NA | 5 | 76 | NA | 24 | NA | 16 | 4 | 3 |
| TOTAL | 628 | 5,125 | 16 | 3,303 | NA | 540 | 13 | 182 | 1,976 | 11 |
| **POTASH FERTILIZERS** | | | | | | | | | | |
| Lime-potash Mixtures | NA | NA | NA | 36 | NA | NA | NA | NA | 10 | NA |
| Manure Salts | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-5. (Continued)

| Description | Connecticut | Maine | | Massachusettes | | New Hampshire | | Rhode Island | Vermont | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonarm |
| Muriate of Potash 60% (Pot. Chloride) | 874 | 1,775 | 23 | 1,141 | NA | 1,432 | NA | 182 | 2,633 | 3 |
| Muriate of Potash 62% | 8 | NA | NA | 712 | NA | NA | NA | NA | NA | NA |
| Potash Suspensions | 13 | NA | NA | 20 | NA | 24 | NA | 5 | NA | NA |
| Potassium Carbonate | NA | NA | NA | 28 | NA | NA | NA | NA | NA | NA |
| Potassium Nitrate | 42 | NA | NA | 289 | NA | 31 | NA | NA | NA | NA |
| Potassium Sulfate | 26 | 2 | NA | 79 | NA | 18 | NA | 4 | 91 | 4 |
| Potassium-magnesium Sulfate | 36 | 245 | 21 | 873 | NA | 34 | NA | 4 | 267 | 7 |
| Potassium-metaphosphate | NA | NA | NA | 1 | NA | 3 | NA | NA | NA | NA |
| Potassium-sodium Nitrate | NA | NA | NA | 1 | NA | NA | NA | NA | NA | NA |
| Other | 74 | 6 | 29 | 444 | NA | 130 | NA | 14 | 78 | 3 |
| TOTAL | 1,074 | 2,028 | 73 | 3,625 | NA | 1,672 | NA | 209 | 3,079 | 17 |
| **ORGANIC FERTILIZERS** | | | | | | | | | | |
| Blood, Dried | 7 | 3 | NA | 23 | NA | 4 | NA | NA | NA | NA |
| Castor Pomace | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cocoa Shell Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Compost | NA | NA | NA | 14,435 | NA | 64 | NA | NA | 10 | NA |
| Cottonseed Meal | NA | 1 | NA | 4 | NA | NA | NA | NA | NA | NA |
| Fish Scrap | NA | NA | NA | 48 | NA | NA | NA | NA | NA | NA |
| Guano | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manure | 28 | 6 | 11 | 676 | NA | 45 | NA | NA | NA | 53 |
| Peat | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Activated | 458 | NA | 124 | 613 | NA | 46 | NA | NA | NA | NA |
| Sewage Sludge, Digested | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Heat Dried | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-5.  (Continued)

| Description | Connecticut | Maine | | Massachusettes | | New Hampshire | | Rhode Island | Vermont | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonarm |
| Sewage Sludge, Other | NA | NA | NA | NA | NA | 86 | NA | NA | NA | NA |
| Soybean Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tankage, Animal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tankage, Process | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | NA | NA | NA | 8 | NA | NA | NA | NA | NA | 20 |
| TOTAL | 494 | 11 | 136 | 15,806 | NA | 245 | NA | NA | 10 | 73 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | | |
| Aluminum Sulfate | 4 | NA | NA | 12 | NA | 1 | NA | 3 | NA | 400 |
| Borax | 2 | 73 | 1 | 1 | NA | 14 | NA | 2 | 30 | NA |
| Calcium Chelate | NA | NA | NA | 4 | NA | NA | NA | NA | NA | NA |
| Calcium Chloride | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Sulfate (Hydrous) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cobalt Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Chelate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Compound | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Oxide, Black | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Sulfate | NA | 1 | NA | NA | NA | NA | NA | NA | NA | NA |
| Epsom Salt (Magnesium Sulfate) | NA | 1 | NA | 3 | NA | 6 | NA | NA | NA | NA |
| Ferric Oxide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ferric Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ferrous Sulfate | NA | NA | NA | 6 | NA | NA | NA | NA | NA | NA |
| Gypsum (Calcium Sulfate) | 129 | 19 | 3 | 267 | NA | 46 | NA | 1 | 10 | 12 |
| Iron Chelate | 24 | NA | NA | 19 | NA | 6 | NA | 1 | NA | 1 |
| Iron Compound | 2 | NA | NA | 4 | NA | NA | NA | 1 | NA | NA |

## Table C-5.  (Continued)

| Description | Connecticut | Maine | | Massachusettes | | New Hampshire | | Rhode Island | Vermont | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonarm |
| Lime Sulfur Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Magnesia (Magnesium Oxide) | NA | 11 | NA | NA | NA | NA | NA | NA | NA | NA |
| Magnesium Chelate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Agstone | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Chelate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Oxide | NA | NA | NA | 4 | NA | NA | NA | NA | NA | NA |
| Manganese Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Sulfate | NA | 1 | NA | 4 | NA | 4 | NA | NA | NA | NA |
| Manganous Oxide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potting Soil | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sodium Molybdate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Additive | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Amendment | NA | 20,035 | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Conditioner | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sulfur | 2 | 61 | NA | 9 | NA | 3 | NA | NA | 4 | NA |
| Sulfuric Acid | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Chelate | NA | NA | NA | 1 | NA | NA | NA | NA | NA | NA |
| Zinc Oxide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Oxysulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Sulfate | NA | 7 | NA | NA | NA | NA | NA | 3 | 9 | NA |
| Zinc Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 15 | NA | NA | 31 | NA | 2 | NA | NA | NA | NA |
| TOTAL | 178 | 20,210 | 5 | 367 | NA | 81 | NA | 12 | 54 | 413 |
| **LIMING MATERIALS** | | | | | | | | | | |
| Calcitic Lime (75% Neutral) | NA | 11,253 | 1,841 | 70 | NA | 394 | NA | NA | NA | NA |

## Table C-5. (Continued)

| Description | Connecticut | Maine | | Massachusettes | | New Hampshire | | Rhode Island | Vermont | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonarm |
| Calcium Hydroxide (Hydrate) | NA | NA | 7 | NA | NA | NA | NA | 17 | NA | NA |
| Calcium Oxide (Burnt) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic & Calcitic Blend (Pelletized) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic Lime (75% Neutral) | 510 | 10,936 | 358 | 2 | NA | NA | NA | 71 | NA | NA |
| Lime Suspensions | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Non-lime Filler (Water, Sand, Etc.) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Standard Calcite | NA | 8,713 | NA | NA | NA | 10 | NA | 265 | NA | NA |
| Standard Dolomite | NA | NA | 353 | 984 | NA | 442 | NA | 5,498 | NA | 29 |
| Other | NA | 9,410 | 284 | 9 | NA | 554 | NA | 12 | NA | NA |
| TOTAL | 510 | 40,312 | 2,843 | 1,065 | NA | 1,401 | NA | 5,863 | NA | 29 |
| ALL FERTILIZERS | | | | | | | | | | |
| TOTAL | 42,232 | 140,869 | 13,526 | 104,137 | 538 | 25,286 | 25 | 17,718 | 24,252 | 11,904 |

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

# Table C-6. Fertilizer Consumption by Use, Middle Atlantic States, 1996 (tons)

| Description | Delaware | | Maryland | | New Jersey | | New York | | Pennsylvania | | West Virginia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | | | | |
| N-P-K | 31,133 | 3,711 | 82,347 | 42,738 | 145,535 | 109,268 | 137,783 | 64,033 | 190,246 | 71,588 | 19,605 | 8,152 |
| N-P | 6,888 | 148 | 53,063 | 35,347 | 2,960 | 4,084 | 37,364 | 1,866 | 32,949 | 1,888 | 4,100 | 195 |
| N-K | 4,304 | 467 | 9,539 | 952 | 4,926 | 2,126 | 6,408 | 1,507 | 12,098 | 1,632 | 52 | 99 |
| P-K | 867 | NA | 2,038 | 54 | 1,659 | 45 | 4,220 | 207 | 17,485 | 172 | 410 | NA |
| TOTAL | 43,191 | 4,325 | 146,987 | 79,091 | 155,081 | 115,523 | 185,775 | 67,612 | 252,779 | 75,280 | 24,168 | 8,447 |
| **NITROGEN FERTILIZERS** | | | | | | | | | | | | |
| Ammonium Nitrate | 1,788 | 39 | 2,946 | 416 | 1,013 | 177 | 6,173 | 152 | 8,257 | 143 | 676 | 30 |
| Ammonium Nitrate Solution | NA | NA | NA | NA | NA | NA | 1 | NA | NA | NA | NA | NA |
| Ammonium Nitrate-limestone Mixtures | NA | NA | NA | NA | NA | NA | 5 | NA | NA | NA | NA | NA |
| Ammonium Nitrate-sulfate | NA | NA | 29 | NA | 1,061 | 1 | 11 | NA | 18 | NA | 48 | NA |
| Ammonium Polysulfide | NA | NA | NA | NA | NA | NA | NA | NA | 1 | NA | NA | NA |
| Ammonium Sulfate | 7,687 | 47 | 12,475 | 176 | 1,209 | 156 | 9,490 | 223 | 13,051 | 768 | 255 | NA |
| Ammonium Sulfate Solution | 75 | NA | 325 | 5 | NA | NA | 3 | 2 | 93 | 4 | NA | NA |
| Ammonium Sulfate-nitrate | 49 | NA | 360 | NA | NA | NA | NA | NA | 391 | 2 | NA | NA |
| Ammonium Sulfate-urea | NA | NA | NA | NA | NA | NA | 25 | NA | NA | NA | NA | NA |
| Ammonium Thiosulfate | 3 | NA | 584 | NA | 32 | NA | 423 | 2 | 2,194 | NA | NA | 1 |
| Anhydrous Ammonia | 30 | NA | 2,311 | 7,746 | 30 | NA | 2,666 | 172 | 2,855 | NA | 568 | 159 |
| Aqua Ammonia | NA | NA | 298 | 25 | NA | NA | NA | NA | NA | NA | 101 | NA |

## Table C-6. (Continued)

| Description | Delaware | | Maryland | | New Jersey | | New York | | Pennsylvania | | West Virginia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Calcium Ammonium Nitrate | NA | NA | 5 | NA | 8 | NA | 14 | 50 | NA | NA | NA | NA |
| Calcium Cyanamide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Nitrate | 17 | NA | 352 | 89 | 601 | 261 | 1,346 | 101 | 427 | 268 | 23 | NA |
| Calcium Nitrate-urea | 2 | NA | NA | NA | NA | NA | 25 | NA | NA | NA | NA | NA |
| Ferrous Ammonium Sulfate | 1 | NA | 33 | NA | 14 | NA | 28 | NA | NA | NA | 2 | NA |
| Magnesium Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Nitric Acid | NA | NA | 2 | NA | NA | NA | 6 | NA | NA | NA | NA | 2 |
| Nitrogen Solution 28% | 1,569 | NA | 536 | 2 | 23,963 | 827 | 612 | 119 | 11,335 | 609 | 813 | NA |
| Nitrogen Solution 30% | 37,586 | 1 | 80,379 | 12,904 | 1,205 | 22 | 13,438 | 149 | 70,479 | 1,029 | 3,260 | NA |
| Nitrogen Solution 32% | 1,128 | NA | 206 | NA | NA | 2 | 24,339 | 6 | 6,726 | NA | NA | NA |
| Nitrogen Solution <28% | 11,197 | 14 | 15,016 | 454 | 3,844 | 23 | 1,267 | 70 | 10,228 | 87 | 13 | NA |
| Nitrogen Solution >32% | NA | NA | NA | NA | NA | NA | 165 | NA | 35 | 10 | NA | NA |
| Sodium Nitrate | 11 | NA | 91 | 4 | 150 | 60 | 56 | 11 | 2 | 7 | 16 | 1 |
| Sulfur Coated Urea | NA | 4 | NA | 14 | 6 | 10 | 198 | 100 | 97 | NA | NA | NA |
| Urea | 448 | 125 | 8,216 | 764 | 3,640 | 817 | 28,253 | 543 | 49,294 | 467 | 2,650 | 7 |
| Urea Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Urea-formaldehyde | NA | 10 | 174 | 170 | 2,657 | 597 | 341 | 233 | 7,006 | 942 | 70 | 19 |
| Zinc Ammonium Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Manganese Ammonium Sulfate | NA | NA | NA | NA | NA | NA | NA | 3 | NA | NA | NA | NA |
| Other | 297 | 23 | 1,745 | 589 | 928 | 840 | 1,302 | 412 | 2,984 | 1,299 | 9 | 22 |

**Table C-6. (Continued)**

| Description | Delaware | | Maryland | | New Jersey | | New York | | Pennsylvania | | West Virginia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| TOTAL | 61,886 | 264 | 126,083 | 23,359 | 40,361 | 3,793 | 90,184 | 2,346 | 185,472 | 5,634 | 8,505 | 240 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | | | | |
| Ammonium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate | NA | NA | 594 | 297 | NA | NA | 20 | NA | NA | NA | NA | NA |
| Ammonium Phosphate Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate Sulfate | 74 | NA | NA | NA | NA | NA | 48 | NA | NA | NA | NA | NA |
| Ammonium Polyphosphate | NA | NA | NA | NA | NA | NA | 194 | NA | 252 | NA | NA | NA |
| Basic Lime Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Basic Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bone Meal, Raw | NA | NA | NA | NA | NA | 13 | NA | 1 | 44 | 1 | NA | NA |
| Bone Meal, Steamed | NA | 5 | NA | 1 | 1 | 2 | 1 | 142 | 4 | NA | NA | NA |
| Bone, Precipitated | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Colloidal Phosphate (Soft Phosphate) | NA | NA | NA | NA | NA | NA | NA | NA | 45 | NA | NA | NA |
| Diammonium Phosphate | 1,860 | 64 | 17,407 | 1,217 | 1,342 | 120 | 7,398 | 165 | 12,038 | 5 | 3,881 | 116 |
| Limestone, Phosphatic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Liquid Ammonium Polyphosphate | 3,348 | NA | 3,995 | 80 | 1,119 | NA | 8,994 | 529 | 5,065 | 189 | 197 | 9 |
| Magnesium Phosphate | NA | NA | NA | NA | NA | NA | NA | 40 | NA | 1 | NA | NA |

## Table C-6. (Continued)

| Description | Delaware | | Maryland | | New Jersey | | New York | | Pennsylvania | | West Virginia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Monoammonium Phosphate | 690 | 79 | 6,678 | 453 | 163 | 1 | 18,643 | 796 | 12,313 | 24 | 3 | 5 |
| Nitric Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Phosphate Rock | NA | NA | 2 | NA | NA | NA | 1 | 3 | NA | NA | NA | NA |
| Phosphoric Acid | 1,322 | NA | 386 | 34 | NA | NA | NA | NA | 577 | NA | NA | NA |
| Precipitated Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Superphosphate, Enriched | 5 | NA | NA | NA | NA | NA | 23 | NA | NA | 14 | NA | NA |
| Superphosphate, Normal | 51 | 2 | 3 | 8 | 4 | 1,010 | NA | 27 | 91 | 4 | 1 | NA |
| Superphosphate, Triple | 23 | 64 | 7,370 | 852 | 166 | 115 | 1,120 | 82 | 5,828 | 50 | 1,441 | NA |
| Superphosphoric Acid | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 111 | 2 | 386 | 1,296 | 572 | 84 | NA | 130 | 649 | 200 | NA | 35 |
| TOTAL | 7,484 | 215 | 36,821 | 4,238 | 3,367 | 1,345 | 36,440 | 1,915 | 36,905 | 488 | 5,522 | 166 |
| **POTASH FERTILIZERS** | | | | | | | | | | | | |
| Lime-potash Mixtures | NA | NA | NA | NA | NA | NA | 5,565 | 3 | NA | NA | NA | NA |
| Manure Salts | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Muriate of Potash 60% (Pot. Chloride) | 12,005 | 37 | 30,368 | 2,663 | 2,237 | 563 | 42,640 | 527 | 25,241 | 134 | 4,325 | NA |
| Muriate of Potash 62% | 415 | 12 | 1,686 | 608 | 9 | 38 | 1,747 | 348 | 8,294 | 51 | 29 | 6 |
| Potash Suspensions | NA | NA | NA | NA | NA | NA | 90 | 213 | 2,449 | NA | NA | NA |
| Potassium Carbonate | NA | NA | 250 | NA | 48 | NA | (246) | NA | 25 | NA | NA | NA |
| Potassium Nitrate | 3 | NA | 1,393 | 2 | 138 | 3 | 84 | 12 | 8,482 | 9 | NA | NA |
| Potassium Sulfate | 1 | 8 | 287 | 16 | 85 | 125 | 329 | 41 | 1,532 | 190 | 130 | 1 |

## Table C-6. (Continued)

| Description | Delaware | | Maryland | | New Jersey | | New York | | Pennsylvania | | West Virginia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Potassium-magnesium Sulfate | 137 | NA | 1,041 | 6 | 106 | 62 | 1,931 | 28 | 451 | 27 | NA | 6 |
| Potassium-metaphosphate | NA | NA | NA | NA | 173 | NA | NA | NA | NA | NA | NA | NA |
| Potassium-sodium Nitrate | NA | NA | NA | NA | 32 | NA | 109 | NA | NA | NA | NA | NA |
| Other | 1,538 | 42 | 554 | 160 | 2,557 | 247 | 8,187 | 168 | 548 | 172 | 7 | 62 |
| TOTAL | 14,099 | 99 | 35,579 | 3,455 | 5,385 | 1,038 | 60,437 | 1,339 | 47,022 | 582 | 4,491 | 75 |
| **ORGANIC FERTILIZERS** | | | | | | | | | | | | |
| Blood, Dried | NA | 3 | NA | NA | NA | 2 | NA | 6 | 9 | NA | NA | NA |
| Castor Pomace | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cocoa Shell Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Compost | NA | 170 | NA | NA | NA | 7,841 | NA | 1,413 | NA | 481 | 1,990 | 3,300 |
| Cottonseed Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Fish Scrap | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Guano | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manure | NA | 386 | NA | 4,731 | NA | 4,041 | NA | 1,084 | 16 | 1,190 | NA | 1,612 |
| Peat | NA | NA | NA | 73 | 7 | 13 | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Activated | NA | NA | NA | NA | NA | 279 | 3,743 | 1,285 | 652 | 659 | NA | NA |
| Sewage Sludge, Digested | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Heat Dried | NA | 127 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Other | 29 | 4 | NA | NA | 24 | 3,980 | 1 | NA | NA | NA | NA | NA |
| Soybean Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tankage, Animal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-6. (Continued)

| Description | Delaware | | Maryland | | New Jersey | | New York | | Pennsylvania | | West Virginia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Tankage, Process | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | NA | 353 | NA | 1,099 | NA | 3 | 374 | 995 | 5,013 | NA | NA | NA |
| TOTAL | 29 | 1,043 | NA | 5,903 | 31 | 16,160 | 4,118 | 4,784 | 5,689 | 2,330 | 1,990 | 4,912 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | | | | |
| Aluminum Sulfate | 22 | NA | NA | 1 | 1 | NA | 3 | 5 | 5 | NA | NA | NA |
| Borax | 27 | NA | 153 | NA | 24 | 16 | 231 | 212 | 113 | NA | 24 | NA |
| Calcium Chelate | 1 | NA | NA | NA | NA | 6 | NA | 74 | 1 | NA | NA | NA |
| Calcium Chloride | NA | NA | NA | NA | 8 | NA | 2 | NA | 384 | NA | NA | NA |
| Calcium Sulfate (Hydrous) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cobalt Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Chelate | NA | NA | NA | NA | NA | NA | 2 | NA | NA | NA | NA | NA |
| Copper Compound | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Oxide, Black | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Sulfate | NA | NA | 2 | NA | 1 | NA | 14 | 42 | 381 | NA | NA | NA |
| Epsom Salt (Magnesium Sulfate) | NA | NA | 1 | NA | 7 | 26 | 9 | 2 | 13 | NA | NA | NA |
| Ferric Oxide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ferric Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | 51 | NA | NA | NA |
| Ferrous Sulfate | NA | 1 | NA | NA | NA | NA | 4 | 2 | 12 | 2 | NA | NA |
| Gypsum (Calcium Sulfate) | 47 | NA | 328 | NA | 558 | 88 | 1 | 103 | 408 | 301 | NA | NA |
| Iron Chelate | NA | NA | NA | 19 | 2 | 34 | 40 | 55 | 29 | 3 | NA | 4 |
| Iron Compound | NA | NA | 1 | 9 | NA | 6 | 16 | 29 | NA | NA | NA | NA |
| Lime Sulfur Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Magnesia (Magnesium Oxide) | NA | NA | 3 | NA | NA | NA | 26 | 106 | 180 | 23 | 2 | NA |

## Table C-6. (Continued)

| Description | Delaware | | Maryland | | New Jersey | | New York | | Pennsylvania | | West Virginia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Magnesium Chelate | NA | NA | NA | NA | NA | NA | 11 | NA | NA | NA | NA | NA |
| Manganese Agstone | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Chelate | NA | NA | 17 | NA | NA | NA | 5 | NA | 1 | NA | NA | NA |
| Manganese Oxide | 7 | NA | 3 | NA | NA | NA | 1 | NA | NA | NA | NA | NA |
| Manganese Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Sulfate | 63 | NA | 26 | NA | 5 | 1 | 90 | NA | 6 | NA | NA | NA |
| Manganous Oxide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potting Soil | NA | 14 | NA | NA | NA | 360 | NA | NA | NA | NA | NA | NA |
| Sodium Molybdate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Additive | NA | NA | NA | NA | NA | 2 | NA | NA | NA | NA | NA | NA |
| Soil Amendment | NA | 3 | NA | NA | NA | 2 | NA | 67 | NA | NA | NA | NA |
| Soil Conditioner | NA | NA | NA | NA | 4,920 | 2,215 | NA | NA | NA | NA | NA | NA |
| Sulfur | NA | 5 | 42 | 1 | 13 | 10 | 171 | 193 | 645 | 1 | 7 | 2 |
| Sulfuric Acid | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Chelate | 5 | NA | 30 | NA | NA | NA | 55 | NA | 4 | NA | NA | NA |
| Zinc Oxide | NA | NA | NA | NA | NA | NA | 6 | 325 | 36 | NA | NA | NA |
| Zinc Oxysulfate | NA | NA | 15 | NA | NA | NA | 7 | 41 | 8 | NA | NA | NA |
| Zinc Sulfate | 37 | NA | 61 | NA | 1 | 11 | 156 | 9 | 23 | NA | NA | NA |
| Zinc Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 240 | 5 | 49 | 22 | 30 | 34 | 272 | 28 | 413 | 18 | 1 | 1 |
| TOTAL | 449 | 29 | 730 | 50 | 5,570 | 2,811 | 1,122 | 1,293 | 2,713 | 347 | 34 | 7 |
| **LIMING MATERIALS** | | | | | | | | | | | | |
| Calcitic Lime (75% Neutral) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Hydroxide (Hydrate) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-6. (Continued)

| Description | Delaware | | Maryland | | New Jersey | | New York | | Pennsylvania | | West Virginia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Calcium Oxide (Burnt) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic & Calcitic Blend (Pelletized) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic Lime (75% Neutral) | NA | NA | NA | NA | 10 | NA | NA | NA | NA | NA | NA | NA |
| Lime Suspensions | NA | NA | 228 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Non-lime Filler (Water, Sand, Etc.) | NA | NA | NA | NA | NA | NA | 92 | NA | NA | NA | NA | NA |
| Standard Calcite | NA | NA | 7,947 | NA | NA | NA | 933 | 7 | 24 | NA | 478 | 80 |
| Standard Dolomite | NA | NA | NA | NA | NA | NA | 11 | 23 | NA | NA | NA | NA |
| Other | 40 | 130 | 6,074 | NA | 89 | 286 | 2,753 | NA | 500 | NA | NA | NA |
| TOTAL | 40 | 130 | 14,249 | NA | 99 | 286 | 3,790 | 30 | 524 | NA | 478 | 80 |
| ALL FERTILIZERS | | | | | | | | | | | | |
| TOTAL | 121,175 | 5,271 | 330,382 | 109,242 | 206,895 | 124,661 | 342,631 | 73,735 | 487,229 | 82,103 | 39,117 | 8,885 |

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

**Table C-7 Fertilizer Consumption by Use, South Atlantic States, 1996 (tons)**

| Description | Florida | | Georgia | North Carolina[1] | | South Carolina | | Virginia | |
|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonarm |
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | |
| N-P-K | 802,855 | 270,510 | 989,848 | 687,330 | 18,704 | 267,331 | 31,980 | 268,843 | 73,625 |
| N-P | 29,646 | 20,039 | 55,376 | 69,238 | 1,148 | 14,900 | 951 | 60,991 | 5,656 |
| N-K | 348,543 | 30,579 | NA | 79,179 | 908 | 39,109 | 3,091 | 19,996 | 1,603 |
| P-K | 60,465 | 310 | NA | 19,407 | 44 | 60,412 | 101 | 4,744 | 5 |
| **TOTAL** | 1,241,508 | 321,437 | 1,045,224 | 855,153 | 20,805 | 381,751 | 36,124 | 354,574 | 80,888 |
| **NITROGEN FERTILIZERS** | | | | | | | | | |
| Ammonium Nitrate | 32,473 | 1,117 | 81,043 | 36,935 | 296 | 16,486 | 1,078 | 12,289 | 222 |
| Ammonium Nitrate Solution | 3,294 | NA | NA | NA | NA | 382 | NA | 38 | NA |
| Ammonium Nitrate-limestone Mixtures | 5 | NA | NA | 392 | NA | NA | NA | NA | NA |
| Ammonium Nitrate-sulfate | 4 | 2 | NA | 11,166 | 18 | 54 | NA | 844 | NA |
| Ammonium Polysulfide | NA | 1 | NA | 2,765 | NA | 581 | 25 | 98 | NA |
| Ammonium Sulfate | 25,597 | 4,105 | 8,088 | 34,540 | 210 | 2,708 | 582 | 24,800 | 37 |
| Ammonium Sulfate Solution | 209 | 1 | NA | 1 | NA | 31 | NA | 423 | 6 |
| Ammonium Sulfate-nitrate | 1,073 | NA | NA | 107 | NA | 4 | 3 | 73 | NA |
| Ammonium Sulfate-urea | NA | NA | NA | NA | NA | 455 | 1 | 9 | 4 |
| Ammonium Thiosulfate | 564 | 279 | NA | 253 | NA | 65 | NA | 253 | NA |
| Anhydrous Ammonia | 3,561 | 1,974 | 8,734 | 5,155 | NA | 2,215 | NA | 703 | 79 |
| Aqua Ammonia | 27 | NA | NA | 308 | NA | NA | NA | 265 | NA |
| Calcium Ammonium Nitrate | 24 | NA | NA | 85 | NA | 212 | NA | 33 | NA |
| Calcium Cyanamide | NA | NA | NA | 1 | NA | 2 | NA | NA | NA |
| Calcium Nitrate | 10,740 | 174 | NA | 6,805 | 1 | 1,292 | 50 | 811 | 12 |
| Calcium Nitrate-urea | 10 | NA | NA | 1,046 | NA | 439 | NA | NA | NA |
| Ferrous Ammonium Sulfate | 32 | 1 | NA | 122 | NA | NA | NA | 88 | NA |

## Table C-7. (Continued)

| Description | Florida | | Georgia | North Carolina[1] | | South Carolina | | Virginia | |
|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonarm |
| Magnesium Nitrate | 3 | NA | NA | NA | NA | NA | NA | NA | NA |
| Nitric Acid | NA | NA | NA | 1 | NA | 1 | 15 | 962 | 12 |
| Nitrogen Solution 28% | 15,967 | 2,646 | NA | 1,016 | 1 | 2,440 | 25 | 686 | 46 |
| Nitrogen Solution 30% | 249 | 41 | 332,803 | 281,692 | 1,410 | 66,162 | NA | 82,872 | NA |
| Nitrogen Solution 32% | 12,175 | 817 | NA | 21,855 | 1,924 | 1,105 | 40 | 898 | 1 |
| Nitrogen Solution <28% | 25,344 | 1,655 | NA | 85,596 | 73 | 73,857 | 103 | 45,055 | 19 |
| Nitrogen Solution >32% | 358 | NA | NA | 70 | NA | 1,177 | NA | 353 | NA |
| Sodium Nitrate | 885 | 28 | NA | 13,966 | 11 | 2,197 | 21 | 1,619 | 21 |
| Sulfur Coated Urea | 50 | 1 | NA | NA | 3 | 138 | 8 | 46 | NA |
| Urea | 10,010 | 6,705 | 23,762 | 14,837 | 42 | 3,049 | 1,255 | 21,987 | 1,064 |
| Urea Solution | 159 | NA | NA | NA | NA | 115 | 28 | NA | NA |
| Urea-formaldehyde | 3,833 | 3,812 | NA | 1,409 | 6 | 2,733 | 287 | 722 | 45 |
| Zinc Ammonium Sulfate Solution | NA | NA | NA | 85 | NA | 105 | NA | 129 | NA |
| Zinc Manganese Ammonium Sulfate | 1 | 3 | NA | 7 | NA | NA | NA | 63 | NA |
| Other | 21,459 | 4,299 | 27,930 | 4,365 | 82 | 7,651 | 316 | 1,207 | 208 |
| **TOTAL** | 168,105 | 27,661 | 482,360 | 524,580 | 4,077 | 185,656 | 3,835 | 197,327 | 1,774 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | |
| Ammonium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate | 1 | 1 | NA | NA | NA | NA | NA | 2 | NA |
| Ammonium Phosphate Nitrate | 1 | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate Sulfate | NA | NA | NA | NA | NA | 16 | NA | 8 | NA |
| Ammonium Polyphosphate | 6 | NA | NA | NA | NA | NA | NA | NA | NA |
| Basic Lime Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Basic Slag | 2,869 | NA | NA | 119 | NA | NA | NA | NA | NA |
| Bone Meal, Raw | NA | NA | NA | 24 | NA | 1 | 15 | NA | NA |

## Table C-7. (Continued)

| Description | Florida | | Georgia | North Carolina[1] | | South Carolina | | Virginia | |
|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonarm |
| Bone Meal, Steamed | 4 | 33 | NA | 2 | NA | NA | NA | 94 | 44 |
| Bone, Precipitated | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Metaphosphate | 13 | NA | NA | 14 | NA | NA | NA | 88 | NA |
| Colloidal Phosphate (Soft Phosphate) | 391 | 2 | NA | 34 | NA | NA | 1 | 47 | 3 |
| Diammonium Phosphate | 2,817 | 10,858 | 13,123 | 33,191 | 1,069 | 2,179 | 578 | 48,160 | 381 |
| Limestone, Phosphatic | 45 | NA | NA | NA | NA | NA | NA | NA | NA |
| Liquid Ammonium Polyphosphate | 7,902 | 153 | 42,253 | 22,532 | 2 | 9,755 | 127 | 6,190 | 471 |
| Magnesium Phosphate | 16 | 9 | NA | 12 | NA | 5 | NA | NA | NA |
| Monoammonium Phosphate | 45 | 39 | NA | 2,225 | NA | 27 | 1 | 1,916 | 1 |
| Nitric Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Phosphate Rock | NA | NA | NA | NA | NA | NA | NA | 24 | NA |
| Phosphoric Acid | 2,940 | 5 | NA | 156 | NA | 1 | NA | 100 | NA |
| Precipitated Phosphate | NA | NA | NA | 23 | NA | NA | NA | NA | NA |
| Superphosphate, Enriched | 25 | NA | NA | 16 | NA | 23 | 3 | 19 | NA |
| Superphosphate, Normal | 1,673 | 64 | NA | 133 | NA | 561 | NA | 199 | 12 |
| Superphosphate, Triple | 2,513 | 1,747 | 5,171 | 10,757 | 15 | 1,587 | 726 | 6,041 | 23 |
| Superphosphoric Acid | 2,219 | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 4,974 | 736 | 11,371 | 22 | NA | 11 | 71 | 68 | 315 |
| **TOTAL** | 28,455 | 13,647 | 71,918 | 69,261 | 1,087 | 14,167 | 1,522 | 62,955 | 1,250 |
| **POTASH FERTILIZERS** | | | | | | | | | |
| Lime-potash Mixtures | NA | 30 | NA | 96 | NA | 1 | NA | 93 | NA |
| Manure Salts | 1 | NA | NA | 464 | 13 | NA | 1 | 21 | 3 |
| Muriate of Potash 60% (Pot. Chloride) | 10,218 | 352 | 29,836 | 73,330 | 3,258 | 11,366 | 253 | 63,401 | 4 |
| Muriate of Potash 62% | 530 | 208 | NA | 5,086 | 6 | 2,771 | 143 | 4,067 | 103 |
| Potash Suspensions | 179 | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-7. (Continued)

| Description | Florida | | Georgia | North Carolina[1] | | South Carolina | | Virginia | |
|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonarm |
| Potassium Carbonate | NA | 2 | NA | 276 | NA | 4 | NA | NA | NA |
| Potassium Nitrate | 3,765 | 377 | NA | 16,073 | 10 | 5,295 | 66 | 14 | 13 |
| Potassium Sulfate | 9,062 | 251 | NA | 4,799 | 4 | 2,577 | 49 | 871 | 2 |
| Potassium-magnesium Sulfate | 2,466 | 936 | 6,325 | 5,759 | 6 | 893 | 28 | 577 | 14 |
| Potassium-metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium-sodium Nitrate | 917 | 29 | NA | 15,253 | 16 | 325 | NA | 1,434 | NA |
| Other | 10,210 | 1,195 | 12,594 | 3,539 | 47 | 4,560 | 252 | 4,489 | 166 |
| **TOTAL** | 37,349 | 3,378 | 48,755 | 124,677 | 3,360 | 27,793 | 792 | 74,968 | 306 |
| **ORGANIC FERTILIZERS** | | | | | | | | | |
| Blood, Dried | NA | 5 | NA | 111 | 9 | NA | NA | 66 | NA |
| Castor Pomace | NA | NA | NA | 8 | NA | NA | NA | NA | NA |
| Cocoa Shell Meal | NA | NA | NA | 11 | NA | NA | NA | NA | NA |
| Compost | NA | 3 | NA | 12 | NA | NA | 1,586 | NA | 19,263 |
| Cottonseed Meal | 1 | NA | NA | 39 | NA | NA | NA | NA | NA |
| Fish Scrap | NA | NA | NA | 12 | 6 | NA | NA | NA | NA |
| Guano | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manure | 1,167 | 2,843 | NA | 6,288 | 966 | 74 | 3,499 | 621 | 7,057 |
| Peat | NA | NA | NA | 1,958 | NA | NA | NA | 50 | 12 |
| Sewage Sludge, Activated | 3,076 | 7,606 | NA | NA | 12 | NA | 56 | NA | NA |
| Sewage Sludge, Digested | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Heat Dried | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Other | NA | NA | NA | 6 | NA | NA | NA | NA | 253 |
| Soybean Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tankage, Animal | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tankage, Process | NA | NA | NA | 83 | NA | NA | NA | NA | NA |
| Other | 244 | 751 | 29,314 | 93,204 | 531 | 55 | 1,343 | 119 | 12,107 |

## Table C-7. (Continued)

| Description | Florida | | Georgia | North Carolina[1] | | South Carolina | | Virginia | |
|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonarm |
| **TOTAL** | 4,487 | 11,208 | 29,314 | 101,733 | 1,524 | 129 | 6,483 | 856 | 38,692 |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | |
| Aluminum Sulfate | 4 | NA | NA | 3 | NA | NA | NA | NA | 9 |
| Borax | 25 | 60 | NA | 978 | NA | 71 | 4 | 467 | NA |
| Calcium Chelate | 211 | 11 | NA | 3 | NA | NA | NA | 2 | NA |
| Calcium Chloride | 8 | NA | NA | 2 | NA | 4 | 2 | 24 | NA |
| Calcium Sulfate (Hydrous) | 13 | NA | NA | NA | NA | NA | NA | NA | NA |
| Cobalt Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Chelate | NA | NA | NA | 34 | NA | NA | NA | NA | NA |
| Copper Compound | 4 | NA | NA | NA | NA | 3 | NA | NA | NA |
| Copper Oxide, Black | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Sulfate | 168 | 7 | NA | 35 | NA | 4 | NA | 3 | NA |
| Epsom Salt (Magnesium Sulfate) | 626 | 233 | NA | 2 | NA | 8 | NA | 4 | 1 |
| Ferric Oxide | NA | 1 | NA | NA | NA | NA | NA | NA | NA |
| Ferric Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ferrous Sulfate | 951 | 771 | NA | NA | NA | NA | NA | NA | NA |
| Gypsum (Calcium Sulfate) | 21,375 | 982 | 79,514 | 30,114 | NA | 9,168 | 338 | 92,136 | 67 |
| Iron Chelate | 148 | 405 | NA | 44 | NA | NA | NA | NA | 7 |
| Iron Compound | 6 | 166 | NA | NA | NA | 17 | 22 | NA | 5 |
| Lime Sulfur Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Magnesia (Magnesium Oxide) | 159 | NA | NA | 32 | NA | 47 | NA | 13 | NA |
| Magnesium Chelate | 19 | 1 | NA | NA | NA | NA | NA | 3 | NA |
| Manganese Agstone | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Chelate | 37 | 1 | NA | 80 | NA | NA | NA | 1 | NA |
| Manganese Oxide | 13 | NA | NA | NA | NA | (1) | NA | 3 | NA |
| Manganese Slag | NA | 72 | NA | NA | NA | 88 | NA | NA | NA |

**Table C-7. (Continued)**

| Description | Florida | | Georgia | North Carolina[1] | | South Carolina | | Virginia | |
|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonarm |
| Manganese Sulfate | 2,801 | 437 | NA | 119 | NA | 8 | NA | 1 | NA |
| Manganous Oxide | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potting Soil | NA | NA | NA | NA | NA | NA | NA | NA | 28,521 |
| Sodium Molybdate | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Additive | 1 | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Amendment | NA | NA | NA | NA | NA | NA | NA | NA | 5,036 |
| Soil Conditioner | 10 | 346 | NA | 1 | NA | NA | NA | NA | 58 |
| Sulfur | 717 | 89 | NA | 409 | 2 | 199 | 27 | 583 | 1 |
| Sulfuric Acid | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Chelate | 15 | NA | NA | 27 | NA | NA | NA | 41 | NA |
| Zinc Oxide | 84 | 34 | NA | NA | NA | 3 | NA | NA | NA |
| Zinc Oxysulfate | NA | NA | NA | 11 | NA | 8 | NA | 3 | NA |
| Zinc Sulfate | 2 | NA | NA | 3 | NA | 1 | NA | 27 | NA |
| Zinc Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | 47,338 | 12,956 | 39,388 | 9,268 | 68 | 4,298 | 149 | 492 | 26 |
| **TOTAL** | 74,735 | 16,573 | 118,902 | 41,164 | 71 | 13,926 | 542 | 93,813 | 33,731 |

## Table C-7. (Continued)

| Description | Florida | | Georgia | North Carolina[1] | | South Carolina | | Virginia | |
|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonarm |
| **LIMING MATERIALS** | | | | | | | | | |
| Calcitic Lime (75% Neutral) | 24,064 | 1,060 | NA | NA | NA | NA | NA | NA | NA |
| Calcium Hydroxide (Hydrate) | 191 | 40 | NA | NA | NA | NA | NA | NA | NA |
| Calcium Oxide (Burnt) | 186 | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic & Calcitic Blend (Pelletized) | 342 | 433 | NA | NA | NA | NA | NA | 46 | 70 |
| Dolomitic Lime (75% Neutral) | 98,197 | 13,469 | NA | NA | NA | NA | NA | 197 | NA |
| Lime Suspensions | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Non-lime Filler (Water, Sand, Etc.) | NA | 7 | NA | NA | NA | NA | NA | NA | NA |
| Standard Calcite | 18,641 | 3,647 | NA | 222,411 | NA | NA | NA | 3,917 | NA |
| Standard Dolomite | 33,848 | 2,370 | NA | NA | NA | NA | NA | NA | NA |
| Other | 19,835 | 28 | NA | NA | NA | NA | NA | 15,804 | 156 |
| **TOTAL** | 195,305 | 21,054 | NA | 222,411 | NA | NA | NA | 19,964 | 232 |
| **ALL FERTILIZERS** | | | | | | | | | |
| **TOTAL** | 1,730,243 | 393,012 | 1,741,097 | 1,816,998 | 28,386 | 605,744 | 43,284 | 745,966 | 129,208 |

[1] North Carolina has other use codes which were not included in this table.

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

# Table C-8. Fertilizer Consumption by Use, Mountain States, 1996 (tons)

| Description | Arizona | | Colorado | | Idaho | | Montana | New Mexico | | Nevada | | Utah | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | | | | | | | |
| N-P-K | NA | NA | 21,532 | 1,687 | NA | NA | 4,383 | 6,270 | 381 | 1,848 | 3,831 | 1,013 | 12,552 | 3,565 | 2,911 |
| N-P | 58,528 | 969 | 74,704 | NA | 213,955 | NA | 166,831 | 36,393 | 200 | 4,887 | 2,025 | 14,196 | 2,356 | 52,801 | 437 |
| N-K | 1,810 | 43 | 891 | NA | NA | NA | 238 | 460 | NA | 12 | 158 | 13 | 139 | 729 | 3 |
| P-K | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 17 | NA | NA | NA | 5 |
| TOTAL | 60,338 | 1,012 | 97,126 | 1,687 | 213,955 | NA | 171,452 | 43,123 | 581 | 6,747 | 6,031 | 15,221 | 15,047 | 57,096 | 3,356 |
| **NITROGEN FERTILIZERS** | | | | | | | | | | | | | | | |
| Ammonium Nitrate | 2,157 | 259 | 53,971 | NA | 126,896 | NA | 56,557 | 1,827 | NA | 1,141 | 558 | 35,825 | 608 | 28,342 | 12 |
| Ammonium Nitrate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | 24 | 26 | NA | NA | NA | NA |
| Ammonium Nitrate-limestone Mixtures | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Nitrate-sulfate | NA | NA | NA | NA | 6,508 | NA | NA | 48 | NA | NA | NA | NA | NA | 1,036 | NA |
| Ammonium Polysulfide | 7,155 | NA | NA | NA | 900 | NA | NA | 965 | 24 | 301 | NA | 792 | NA | NA | NA |
| Ammonium Sulfate | 5,780 | 3,215 | 3,830 | NA | 82,425 | NA | 18,146 | 7,050 | 4 | 3,448 | 226 | 10,386 | 1,146 | 3,096 | 92 |
| Ammonium Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | 16 | NA | NA | NA | NA | 6 | NA | NA |
| Ammonium Sulfate-nitrate | NA | NA | NA | NA | NA | NA | NA | 1,707 | NA | NA | NA | NA | NA | 1 | NA |
| Ammonium Sulfate-urea | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Thiosulfate | NA | NA | 7,853 | NA | 13,972 | NA | 1,660 | 2,346 | 1 | 326 | NA | 477 | 3 | 1,788 | NA |
| Anhydrous Ammonia | 17,944 | 933 | 50,381 | NA | 44,552 | NA | 75,716 | 13,603 | 147 | 559 | NA | 1,799 | NA | 84,839 | NA |
| Aqua Ammonia | 1,344 | 64 | 200 | NA | 6,672 | NA | 426 | 6 | NA | NA | NA | NA | NA | 158 | NA |

## Table C-8. (Continued)

| Description | Arizona | | Colorado | | Idaho | | Montana | New Mexico | | Nevada | | Utah | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Calcium Ammonium Nitrate | NA | NA | 176 | NA | NA | NA | NA | 377 | NA | 326 | NA | NA | 5 | 98 | NA |
| Calcium Cyanamide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Nitrate | 1,175 | 134 | 626 | NA | NA | NA | NA | 1,136 | NA | NA | 18 | NA | NA | 545 | NA |
| Calcium Nitrate-urea | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 87 | NA |
| Ferrous Ammonium Sulfate | NA | NA | NA | NA | NA | NA | NA | 43 | NA | NA | NA | NA | NA | NA | NA |
| Magnesium Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Nitric Acid | NA | NA | 188 | NA | NA | NA | NA | 20 | NA | NA | NA | NA | 4 | NA | NA |
| Nitrogen Solution 28% | NA | NA | 6,053 | NA | NA | NA | 15,076 | 4,529 | NA | NA | NA | 32 | NA | 578 | NA |
| Nitrogen Solution 30% | NA | NA | 252 | NA | NA | NA | NA | 106 | NA | NA | NA | NA | NA | 65 | NA |
| Nitrogen Solution 32% | 137,907 | 1,054 | 63,869 | NA | 136,491 | NA | 7,895 | 30,953 | 97 | 4,022 | 83 | 10,665 | 1 | 50,020 | 77 |
| Nitrogen Solution <28% | 41,286 | 122 | 9,458 | NA | 2,002 | NA | NA | 401 | NA | 311 | 65 | 221 | 23 | 108 | 2 |
| Nitrogen Solution >32% | NA | NA | NA | NA | NA | NA | NA | 23 | NA | NA | NA | NA | NA | NA | NA |
| Sodium Nitrate | NA | NA | NA | NA | NA | NA | NA | 20 | NA | 7 | NA | 67 | 1 | NA | NA |
| Sulfur Coated Urea | NA | NA | 11 | NA | NA | NA | NA | 237 | NA | NA | NA | 46 | 132 | NA | NA |
| Urea | 27,030 | 413 | 27,931 | NA | 123,923 | NA | 168,648 | 13,029 | 77 | 387 | 132 | 4,085 | 878 | 10,772 | 283 |
| Urea Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | 63 | NA | NA | NA | NA | NA |
| Urea-formaldehyde | NA | NA | 2 | NA | NA | NA | NA | NA | NA | 10 | 1 | 18 | 57 | NA | NA |
| Zinc Ammonium Sulfate Solution | NA | NA | 4 | NA | NA | NA | NA | NA | NA | NA | NA | 4 | NA | 64 | NA |
| Zinc Manganese Ammonium Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-8. (Continued)

| Description | Arizona | | Colorado | | Idaho | | Montana | New Mexico | | Nevada | | Utah | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Other | NA | NA | 6,678 | NA | NA | NA | NA | 1,802 | NA | 3,057 | 4,578 | 294 | 832 | 376 | NA |
| TOTAL | 241,778 | 6,193 | 231,483 | NA | 544,340 | NA | 344,124 | 80,245 | 350 | 13,982 | 5,687 | 64,711 | 3,696 | 181,973 | 465 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | | | | | | | |
| Ammonium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate | 35 | 2 | NA | NA | 201 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Phosphate Sulfate | 8,999 | 499 | 78 | NA | 39,813 | NA | 17,674 | 542 | NA | 1,241 | 708 | 2,426 | 1 | 4,612 | NA |
| Ammonium Polyphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Basic Lime Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Basic Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bone Meal, Raw | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1 | NA | NA | NA | NA |
| Bone Meal, Steamed | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 17 | NA | NA | NA | NA |
| Bone, Precipitated | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 284 | NA |
| Calcium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Colloidal Phosphate (Soft Phosphate) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Diammonium Phosphate | 1,735 | 2 | 3,998 | NA | 49,045 | NA | 47,927 | 3,120 | NA | 58 | NA | 1,363 | NA | 22,378 | NA |
| Limestone, Phosphatic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Liquid Ammonium Polyphosphate | 18,959 | 195 | 11,328 | NA | 10,277 | NA | 3,211 | 17,212 | NA | 555 | 88 | 1,508 | NA | 1,572 | NA |
| Magnesium Phosphate | NA | NA | NA | NA | NA | NA | NA | 25 | NA | NA | NA | NA | NA | NA | NA |

## Table C-8. (Continued)

| Description | Arizona | | Colorado | | Idaho | | Montana | New Mexico | | Nevada | | Utah | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Monoammonium Phosphate | 28,801 | 272 | 59,301 | NA | 114,618 | NA | 98,019 | 11,328 | 198 | 2,939 | 157 | 8,657 | 1,862 | 24,131 | 431 |
| Nitric Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Phosphate Rock | NA | NA | 232 | NA | NA | NA | NA | NA | NA | NA | NA | 721 | 464 | NA | NA |
| Phosphoric Acid | 3,737 | NA | 451 | NA | 5,626 | NA | NA | NA | NA | 24 | NA | 32 | NA | 64 | NA |
| Precipitated Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1,187 | NA |
| Superphosphate, Enriched | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 56 | NA | NA | NA |
| Superphosphate, Normal | NA | NA | NA | NA | 3,785 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Superphosphate, Triple | 682 | 49 | 946 | NA | 3,759 | NA | 1,059 | 1,082 | NA | 350 | 65 | 10,522 | 2 | 1,385 | 30 |
| Superphosphoric Acid | NA | NA | NA | NA | 13,069 | NA | NA | 635 | NA | NA | NA | NA | NA | 4,619 | NA |
| Other | NA | NA | 2,013 | NA | 88 | NA | NA | 98 | NA | 70 | 100 | 41 | 173 | NA | NA |
| TOTAL | 62,947 | 1,018 | 78,345 | NA | 240,282 | NA | 167,891 | 34,043 | 198 | 5,238 | 1,135 | 25,326 | 2,502 | 60,231 | 461 |
| **POTASH FERTILIZERS** | | | | | | | | | | | | | | | |
| Lime-potash Mixtures | NA | NA | NA | NA | 237 | NA | NA | 307 | NA | NA | NA | NA | NA | NA | NA |
| Manure Salts | NA | NA | NA | NA | NA | NA | NA | 1,530 | NA | NA | NA | NA | NA | NA | NA |
| Muriate of Potash 60% (Pot. Chloride) | 3,157 | 619 | 3,418 | NA | 44,162 | NA | 31,808 | 14,671 | NA | 227 | NA | 3,568 | 1 | 2,736 | 87 |
| Muriate of Potash 62% | NA | NA | 5,221 | NA | 494 | NA | NA | 13 | NA | NA | NA | 211 | NA | 70 | NA |
| Potash Suspensions | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium Carbonate | NA | NA | NA | NA | NA | NA | NA | 442 | NA | NA | NA | NA | NA | NA | NA |
| Potassium Nitrate | 1,810 | 43 | 871 | NA | NA | NA | NA | NA | NA | 3 | 12 | NA | NA | NA | NA |
| Potassium Sulfate | 351 | 57 | 685 | NA | 2,138 | NA | NA | 464 | NA | 35 | 14 | 874 | 45 | 44 | NA |

## Table C-8. (Continued)

| Description | Arizona | | Colorado | | Idaho | | Montana | New Mexico | | Nevada | | Utah | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Potassium-magnesium Sulfate | 94 | 1 | 322 | NA | NA | NA | NA | 5,241 | NA | NA | NA | NA | NA | 156 | NA |
| Potassium-metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium-sodium Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1 | NA | NA |
| Other | NA | NA | 1,396 | NA | 17,395 | NA | NA | 66 | NA | 270 | 19 | 205 | 7 | 1 | NA |
| TOTAL | 5,412 | 720 | 11,913 | NA | 64,426 | NA | 31,808 | 22,732 | NA | 535 | 46 | 4,859 | 54 | 3,008 | 87 |
| **ORGANIC FERTILIZERS** | | | | | | | | | | | | | | | |
| Blood, Dried | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Castor Pomace | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cocoa Shell Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Compost | NA | NA | 2,381 | NA | NA | NA | 4,284 | NA | NA | NA | NA | NA | NA | 2,128 | NA |
| Cottonseed Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Fish Scrap | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Guano | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manure | NA | NA | 5,712 | 1,687 | NA | NA | 99 | NA | NA | NA | 217 | NA | 673 | 265 | NA |
| Peat | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 395 | NA |
| Sewage Sludge, Activated | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 97 | NA | NA |
| Sewage Sludge, Digested | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Heat Dried | NA | NA | 12,506 | NA | NA | NA | NA | NA | NA | NA | 4 | NA | NA | NA | NA |
| Sewage Sludge, Other | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soybean Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tankage, Animal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 202 | NA |
| Tankage, Process | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

# Table C-8.  (Continued)

| Description | Arizona | | Colorado | | Idaho | | Montana | New Mexico | | Nevada | | Utah | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Other | NA | NA | 1,046 | NA | NA | NA | NA | NA | NA | 2 | 5 | 2 | NA | NA | NA |
| TOTAL | NA | NA | 21,646 | 1,687 | NA | NA | 4,383 | NA | NA | 2 | 226 | 2 | 770 | 2,990 | NA |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | | | | | | | |
| Aluminum Sulfate | NA | NA | NA | NA | NA | NA | 6 | NA | NA | NA | NA | NA | NA | NA | NA |
| Borax | NA | NA | 25 | NA | NA | NA | NA | NA | NA | 15 | NA | 21 | NA | 10 | NA |
| Calcium Chelate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1 | NA | NA | NA |
| Calcium Chloride | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Sulfate (Hydrous) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cobalt Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Chelate | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1 | NA | NA | NA | NA | NA |
| Copper Compound | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Oxide, Black | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Sulfate | NA | NA | 18 | NA | 343 | NA | NA | NA | NA | NA | NA | 1 | NA | 5 | NA |
| Epsom Salt (Magnesium Sulfate) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 82 | NA |
| Ferric Oxide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ferric Sulfate | 310 | 182 | NA | NA | NA | NA | NA | NA | NA | 22 | NA | 2 | NA | NA | NA |
| Ferrous Sulfate | NA | NA | 971 | NA | NA | NA | NA | NA | NA | 1 | 46 | NA | 3 | 396 | 4 |
| Gypsum (Calcium Sulfate) | 24,519 | 1,524 | 1,493 | NA | 3,703 | NA | 261 | NA | NA | 5,657 | 174 | 133 | 105 | NA | NA |
| Iron Chelate | NA | NA | 18 | NA | 310 | NA | NA | NA | NA | 1 | NA | 17 | 20 | NA | NA |
| Iron Compound | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 5 | 20 | 2 | NA | NA |
| Lime Sulfur Solution | 716 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Magnesia (Magnesium Oxide) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-8. (Continued)

| Description | Arizona | | Colorado | | Idaho | | Montana | New Mexico | | Nevada | | Utah | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Magnesium Chelate | NA | NA | NA | NA | 415 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Agstone | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Chelate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1 | NA | NA | NA |
| Manganese Oxide | NA | NA | 4 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Sulfate | NA | NA | 19 | NA | NA | NA | NA | NA | NA | 2 | NA | 15 | NA | 37 | NA |
| Manganous Oxide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potting Soil | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 44 | NA | NA | NA |
| Sodium Molybdate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Additive | NA | NA | 2 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Amendment | NA | NA | 339 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Conditioner | NA | NA | 10,398 | 419 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sulfur | 2,075 | 93 | 2,786 | NA | 17,672 | NA | 788 | 8 | NA | 656 | 196 | 406 | 288 | 1,287 | NA |
| Sulfuric Acid | 13,351 | 463 | 1,177 | NA | NA | NA | NA | NA | NA | 24 | NA | NA | NA | NA | NA |
| Zinc Chelate | NA | NA | 121 | NA | 4,859 | NA | NA | NA | NA | 2 | NA | 5 | NA | 1 | NA |
| Zinc Oxide | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 132 | NA | 111 | NA |
| Zinc Oxysulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Sulfate | NA | NA | 818 | NA | 31 | NA | NA | NA | NA | 25 | 1 | 96 | NA | 555 | NA |
| Zinc Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 17 | NA |
| Other | 1,879 | 149 | 72 | NA | 4,799 | NA | 1,865 | 6,689 | 93 | 16 | 66 | 269 | 16 | 32 | NA |
| TOTAL | 42,851 | 2,411 | 18,263 | 419 | 32,134 | NA | 2,920 | 6,697 | 93 | 6,423 | 488 | 1,165 | 434 | 2,534 | 4 |
| **LIMING MATERIALS** | | | | | | | | | | | | | | | |
| Calcitic Lime (75% Neutral) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-8. (Continued)

| Description | Arizona | | Colorado | | Idaho | | Montana | New Mexico | | Nevada | | Utah | | Wyoming | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Calcium Hydroxide (Hydrate) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Oxide (Burnt) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic & Calcitic Blend (Pelletized) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic Lime (75% Neutral) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1 | NA |
| Lime Suspensions | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Non-lime Filler (Water, Sand, Etc.) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Standard Calcite | NA | NA | 516 | NA | NA | NA | 48 | NA | NA | NA | NA | NA | NA | NA | NA |
| Standard Dolomite | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | NA | NA | NA | NA | 37 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| TOTAL | NA | NA | 516 | NA | 37 | NA | 48 | NA | NA | NA | NA | NA | NA | 1 | NA |
| ALL FRTILIZERS | | | | | | | | | | | | | | | |
| TOTAL | 352,987 | 10,342 | 362,185 | 2,106 | 881,219 | NA | 551,412 | 154,604 | 1,024 | 28,130 | 12,408 | 97,331 | 19,868 | 252,150 | 3,942 |

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

## Table C-9. Fertilizer Consumption by Use, Pacific States (and Puerto Rico), 1996 (tons)

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| **MULTIPLE NUTRIENT FERTILIZERS** | | | | | | | | | | |
| N-P-K | 2,379 | 931,934 | 316,847 | 45,031 | 17,966 | 2,387 | 22,331 | 44,974 | 66,668 | 139 |
| N-P | 585 | 206,474 | NA | 6,297 | 101,918 | 5 | 136,658 | 7,544 | 30 | NA |
| N-K | NA | 24,219 | NA | NA | 5,395 | 158 | 4,551 | 1,085 | 1,572 | NA |
| P-K | NA | 60 | NA | NA | 315 | NA | 520 | 492 | 9 | 4 |
| TOTAL | 2,964 | 1,162,687 | 316,847 | 51,328 | 125,594 | 2,550 | 164,060 | 54,095 | 68,279 | 143 |
| **NITROGEN FERTILIZERS** | | | | | | | | | | |
| Ammonium Nitrate | 15 | 92,968 | NA | NA | 32,335 | NA | 51,332 | 734 | 132 | NA |
| Ammonium Nitrate Solution | NA | 67,364 | NA | NA | 2,700 | NA | NA | NA | NA | NA |
| Ammonium Nitrate-limestone Mixtures | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Nitrate-sulfate | NA | NA | NA | NA | 26 | NA | 1,171 | 1,293 | NA | NA |
| Ammonium Polysulfide | NA | 9,125 | NA | NA | 3,489 | NA | 12,433 | NA | NA | NA |
| Ammonium Sulfate | 123 | 205,878 | NA | 15,285 | 86,534 | 96 | 57,966 | 396 | 1,613 | NA |
| Ammonium Sulfate Solution | NA | NA | NA | NA | 314 | NA | NA | 4 | NA | NA |
| Ammonium Sulfate-nitrate | NA | NA | NA | NA | 847 | NA | 99 | 59 | NA | NA |

## Table C-9. (Continued)

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Ammonium Sulfate-urea | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ammonium Thiosulfate | NA | 8,977 | NA | NA | 11,596 | NA | 39,528 | NA | NA | NA |
| Anhydrous Ammonia | NA | 154,673 | NA | NA | 32,545 | NA | 78,047 | 95 | NA | NA |
| Aqua Ammonia | NA | 204,931 | NA | NA | 9,179 | NA | 134,951 | NA | NA | NA |
| Calcium Ammonium Nitrate | NA | 173,949 | NA | NA | 649 | NA | 2,076 | NA | NA | NA |
| Calcium Cyanamide | NA | NA | NA | NA | NA | NA | 248 | NA | NA | NA |
| Calcium Nitrate | NA | 95,323 | NA | NA | 3,889 | NA | 13,474 | 2 | NA | NA |
| Calcium Nitrate-urea | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ferrous Ammonium Sulfate | NA | NA | NA | NA | NA | NA | 500 | 1,305 | NA | NA |
| Magnesium Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Nitric Acid | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Nitrogen Solution 28% | NA | 7,168 | NA | NA | 4,678 | NA | 5,873 | 723 | NA | NA |
| Nitrogen Solution 30% | NA | NA | NA | NA | NA | NA | 16 | NA | NA | NA |
| Nitrogen Solution 32% | NA | 586,101 | NA | 18,236 | 70,144 | NA | 137,638 | 37 | NA | NA |
| Nitrogen Solution <28% | NA | 975 | NA | NA | 403 | NA | 13,104 | 3,437 | NA | NA |

## Table C-9. (Continued)

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Nitrogen Solution >32% | NA | NA | NA | NA | NA | NA | NA | 967 | NA | NA |
| Sodium Nitrate | NA | 1,694 | NA | NA | NA | NA | 24 | NA | NA | NA |
| Sulfur Coated Urea | NA | 1,741 | NA | NA | 248 | NA | NA | NA | 8 | NA |
| Urea | 5,125 | 86,788 | NA | 2,480 | 111,569 | NA | 68,121 | 1 | 2,108 | NA |
| Urea Solution | NA | 8,437 | NA | NA | NA | NA | NA | NA | NA | NA |
| Urea-formaldehyde | NA | NA | NA | NA | 3,730 | 130 | 374 | 25 | 1 | NA |
| Zinc Ammonium Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Zinc Manganese Ammonium Sulfate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | NA | NA | NA | NA | 9,362 | 122 | 22,181 | 1,777 | NA | 1 |
| TOTAL | 5,263 | 1,706,091 | NA | 36,000 | 384,237 | 348 | 639,157 | 10,854 | 3,863 | 1 |
| **PHOSPHATE FERTILIZERS** | | | | | | | | | | |
| Ammonium Metaphosphate | NA | NA | NA | NA | NA | NA | 8,284 | NA | NA | NA |
| Ammonium Phosphate | NA | NA | NA | 3,215 | 116 | NA | 353 | NA | NA | NA |
| Ammonium Phosphate Nitrate | NA | NA | NA | NA | 1 | NA | 2,511 | NA | NA | NA |
| Ammonium Phosphate Sulfate | NA | 35,053 | NA | NA | 34,228 | 5 | 29,578 | 82 | NA | NA |
| Ammonium Polyphosphate | NA | NA | NA | NA | NA | NA | 3,706 | NA | NA | NA |

## Table C-9. (Continued)

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Basic Lime Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Basic Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Bone Meal, Raw | NA | NA | NA | NA | NA | NA | 82 | NA | NA | NA |
| Bone Meal, Steamed | NA | NA | NA | NA | NA | NA | 374 | NA | NA | NA |
| Bone, Precipitated | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Colloidal Phosphate (Soft Phosphate) | NA | NA | NA | NA | NA | NA | 6 | NA | NA | NA |
| Diammonium Phosphate | 585 | 18,104 | NA | NA | 7,963 | NA | 10,413 | 1 | 30 | NA |
| Limestone, Phosphatic | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Liquid Ammonium Polyphosphate | NA | 74,203 | NA | 3,081 | 8,361 | NA | 39,510 | NA | NA | NA |
| Magnesium Phosphate | NA | NA | NA | NA | NA | NA | NA | 3 | NA | NA |
| Monoammonium Phosphate | NA | 78,651 | NA | NA | 44,192 | NA | 39,186 | 3,690 | 1 | NA |
| Nitric Phosphate | NA | NA | NA | NA | NA | NA | 2,394 | NA | NA | NA |
| Phosphate Rock | NA | NA | NA | 11 | 2,804 | NA | 65 | NA | NA | NA |
| Phosphoric Acid | NA | 10,668 | NA | NA | 1,440 | NA | 3,047 | NA | NA | NA |
| Precipitated Phosphate | NA | NA | NA | NA | NA | NA | NA | NA | 6 | NA |

**Table C-9. (Continued)**

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Superphosphate, Enriched | NA | NA | NA | NA | 194 | NA | 7 | 356 | NA | NA |
| Superphosphate, Normal | 4 | 468 | NA | 155 | NA | NA | 5 | NA | NA | NA |
| Superphosphate, Triple | 4 | 4,363 | NA | 172 | 2,336 | NA | 5,250 | NA | 255 | NA |
| Superphosphoric Acid | NA | 1,533 | NA | NA | 10,582 | NA | 462 | NA | NA | NA |
| Other | NA | 31 | NA | NA | 59 | NA | 2,345 | 433 | NA | NA |
| TOTAL | 593 | 223,074 | NA | 6,635 | 112,274 | 5 | 147,578 | 4,565 | 291 | NA |
| **POTASH FERTILIZERS** | | | | | | | | | | |
| Lime-potash Mixtures | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manure Salts | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Muriate of Potash 6NA% (Pot. Chloride) | 30 | 52,170 | NA | 494 | 32,666 | NA | 64,228 | 22 | 68 | NA |
| Muriate of Potash 62% | NA | NA | NA | NA | 10,917 | NA | 73 | NA | NA | NA |
| Potash Suspensions | NA | NA | NA | NA | 2,647 | NA | 4,444 | NA | NA | NA |
| Potassium Carbonate | NA | NA | NA | NA | 21 | NA | 4 | NA | NA | NA |
| Potassium Nitrate | NA | 23,208 | NA | NA | 244 | NA | 76 | NA | 179 | NA |
| Potassium Sulfate | 2 | 41,748 | NA | 845 | 3,883 | NA | 8,913 | 1,012 | 326 | NA |
| Potassium-magnesium Sulfate | NA | 12,705 | NA | NA | 7,666 | NA | 9,766 | 164 | NA | NA |

## Table C-9. (Continued)

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Potassium-metaphosphate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Potassium-sodium Nitrate | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | NA | 319 | NA | 16,328 | 533 | NA | 9,974 | 271 | NA | NA |
| TOTAL | 32 | 130,149 | NA | 17,667 | 58,576 | NA | 97,478 | 1,469 | 573 | NA |
| **ORGANIC FERTILIZERS** | | | | | | | | | | |
| Blood, Dried | NA | 1,612 | NA | NA | NA | NA | 158 | NA | NA | NA |
| Castor Pomace | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Cocoa Shell Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Compost | NA | NA | NA | NA | NA | NA | 948 | NA | NA | NA |
| Cottonseed Meal | NA | NA | NA | NA | NA | NA | 72 | NA | NA | NA |
| Fish Scrap | NA | NA | NA | NA | NA | NA | 377 | NA | NA | NA |
| Guano | NA | NA | NA | NA | NA | NA | 6 | NA | NA | NA |
| Manure | NA | NA | NA | NA | NA | NA | 17,470 | NA | NA | NA |
| Peat | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Activated | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Digested | NA | NA | NA | NA | NA | NA | 2 | NA | NA | NA |
| Sewage Sludge, Heat Dried | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sewage Sludge, Other | NA | 77,169 | NA | NA | NA | NA | NA | NA | NA | NA |
| Soybean Meal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-9. (Continued)

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Tankage, Animal | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Tankage, Process | NA | NA | NA | NA | NA | NA | 371 | NA | NA | NA |
| Other | NA | NA | NA | NA | NA | NA | 11,544 | NA | 11 | NA |
| TOTAL | NA | 78,781 | NA | NA | NA | NA | 30,947 | NA | 11 | NA |
| **SECONDARY AND MICRONUTRIENT FERTILIZERS** | | | | | | | | | | |
| Aluminum Sulfate | NA | NA | NA | NA | 2 | NA | 136 | NA | NA | NA |
| Borax | NA | NA | NA | NA | 788 | NA | 3,491 | NA | NA | NA |
| Calcium Chelate | NA | NA | NA | 3,751 | NA | NA | NA | NA | NA | NA |
| Calcium Chloride | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Calcium Sulfate (Hydrous) | NA | NA | NA | NA | NA | NA | 179 | NA | NA | NA |
| Cobalt Sulfate | NA | NA | NA | NA | NA | NA | 2 | NA | NA | NA |
| Copper Chelate | NA | NA | NA | NA | NA | NA | 25 | NA | NA | NA |
| Copper Compound | NA | 342 | NA | NA | 240 | NA | NA | NA | NA | NA |
| Copper Oxide, Black | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Copper Sulfate | NA | NA | NA | NA | NA | NA | 89 | NA | NA | NA |
| Epsom Salt (Magnesium Sulfate) | NA | NA | NA | NA | 14 | NA | 1,250 | NA | 219 | NA |
| Ferric Oxide | NA | NA | NA | NA | NA | NA | 1 | NA | NA | NA |
| Ferric Sulfate | NA | NA | NA | NA | NA | NA | 4,073 | NA | NA | NA |
| Ferrous Sulfate | NA | NA | NA | NA | NA | NA | 1,159 | NA | NA | NA |

## Table C-9.  (Continued)

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Gypsum (Calcium Sulfate) | NA | 1,170,333 | NA | NA | 12,275 | 460 | 22,513 | NA | NA | NA |
| Iron Chelate | NA | NA | NA | NA | 7 | NA | 155 | NA | NA | NA |
| Iron Compound | NA | 4,736 | NA | NA | 2,277 | 7 | NA | NA | NA | NA |
| Lime Sulfur Solution | NA | NA | NA | NA | NA | NA | 3 | NA | NA | NA |
| Magnesia (Magnesium Oxide) | NA | NA | NA | 240 | NA | NA | NA | NA | 7 | NA |
| Magnesium Chelate | NA | NA | NA | NA | NA | NA | 35 | NA | NA | NA |
| Manganese Agstone | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Chelate | NA | NA | NA | NA | NA | NA | 105 | NA | NA | NA |
| Manganese Oxide | NA | NA | NA | NA | 59 | NA | 12 | NA | NA | NA |
| Manganese Slag | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese Sulfate | NA | NA | NA | NA | NA | NA | 293 | NA | NA | NA |
| Manganous Oxide | NA | NA | NA | 2 | NA | NA | NA | NA | NA | NA |
| Potting Soil | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sodium Molybdate | NA | NA | NA | NA | NA | NA | 23 | NA | NA | NA |
| Soil Additive | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Soil Amendment | NA | NA | NA | NA | 301 | 15 | NA | NA | NA | NA |
| Soil Conditioner | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Sulfur | NA | 57,043 | NA | 137 | 2,439 | 1 | 7,155 | NA | NA | NA |

**Table C-9. (Continued)**

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Sulfuric Acid | NA | 117,877 | NA | NA | 223 | NA | NA | NA | NA | NA |
| Zinc Chelate | NA | NA | NA | NA | NA | NA | 790 | NA | NA | NA |
| Zinc Oxide | NA | NA | NA | NA | 1,066 | NA | 417 | NA | NA | NA |
| Zinc Oxysulfate | NA | NA | NA | NA | NA | NA | 35 | NA | NA | NA |
| Zinc Sulfate | NA | NA | NA | 15 | NA | NA | 3,499 | NA | NA | NA |
| Zinc Sulfate Solution | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Other | NA | 242,945 | 3,520 | NA | 473 | 24 | 8,886 | 76,536 | 81 | NA |
| TOTAL | NA | 1,593,276 | 3,520 | 4,144 | 20,163 | 507 | 54,325 | 76,536 | 307 | NA |
| **LIMING MATERIALS** | | | | | | | | | | |
| Calcitic Lime (75% Neutral) | NA | NA | NA | 8,696 | NA | NA | NA | NA | NA | NA |
| Calcium Hydroxide (Hydrate) | NA | NA | NA | NA | 164 | 7 | 1,793 | NA | NA | NA |
| Calcium Oxide (Burnt) | NA | NA | NA | 96 | NA | NA | NA | NA | NA | NA |
| Dolomitic & Calcitic Blend (Pelletized) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Dolomitic Lime (75% Neutral) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Lime Suspensions | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Non-lime Filler (Water, Sand, Etc.) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Standard Calcite | 180 | NA | NA | NA | 147,021 | 898 | 12,832 | NA | NA | NA |

## Table C-9. (Continued)

| Description | Alaska | California | | Hawaii | Oregon | | Washington | | Puerto Rico | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Farm | Farm | Nonfarm | Farm | Farm | Nonfarm | Farm | Nonfarm | Farm | Nonfarm |
| Standard Dolomite | NA | NA | NA | NA | 15,334 | 5,139 | 13,959 | NA | NA | NA |
| Other | NA | 621,915 | NA | NA | 23,615 | 547 | 54,705 | NA | NA | NA |
| TOTAL | 180 | 621,915 | NA | 8,792 | 186,134 | 6,590 | 83,289 | NA | NA | NA |
| ALL FERTILIZERS | | | | | | | | | | |
| TOTAL | 8,447 | 5,209,585 | 320,367 | 118,269 | 791,874 | 9,995 | 1,061,442 | 143,746 | 73,115 | 144 |

NA = it is unclear from the database whether there was no non-farm use recorded or on-farm use was zero.

# APPENDIX D
# AAPFCO UNIFORM FERTILIZER BILL

# APPENDIX E

# INTERNATIONAL AND NATIONAL LIMITS FOR POLLUTANTS IN BIOSOLIDS

## Appendix E. International and National Limits for Pollutants in Biosolids

These tables were abstracted from *A Global Atlas of Wastewater Sludge and Biosolids Use and Disposal*, Peter Matthews (ed.), International Association on Water Quality, Scientific and Technical Report No. 4, London England, 1996.

**Table E-1. International Contaminant Concentration Limits for Biosolid Application to Land**

| Australia (New South Wales) | | | | |
|---|---|---|---|---|
| | Contaminant Acceptance Thresholds Thresholds (mg/kg) | | Max. Allowable Soil Conc (mg/kg dw) | |
| Contaminant | Grade A* | Grade C* | Ag land* | Non-ag land* |
| Arsenic | 20 | 20 | 20 | 20 |
| Cadmium | 3 | 20 | 1 | 5 |
| Chromium | 100 | 500 | 100 | 250 |
| Copper | 150 | 420 | 100 | 375 |
| Lead | 1 | 15 | 15 | 150 |
| Mercury | 60 | 270 | 1 | 4 |
| Nickel | 60 | 270 | 60 | 125 |
| Selenium | 5 | 50 | 5 | 8 |
| Zinc | 200 | 2500 | 200 | 700 |
| | | | | |
| DDT/DDD/DDE | 0.50 | 1.00 | 0.50 | 0.50 |
| Aldrin | 0.02 | 0.50 | 0.02 | 0.02 |
| Dieldrin | 0.02 | 0.50 | 0.02 | 0.02 |
| Chlordane | 0.02 | 0.50 | 0.02 | 0.02 |
| Heptachlor | 0.02 | 0.50 | 0.02 | 0.02 |
| HCB | 0.02 | 0.50 | 0.02 | 0.02 |
| Lindane | 0.02 | 0.50 | 0.02 | 0.02 |
| BHC | 0.02 | 0.50 | 0.02 | 0.02 |
| PCBs | 0.30 | 1.00 | 0.30 | 0.30 |

* Grade A has unrestricted use, Grade C is the lowest grade that can be used in agriculture

## Table E-1. (Continued)

| Austria (Lower A., 1994) | | |
|---|---|---|
| **Inorganic** | **Max. Allowable Contaminants in Sludge (mg/kg dw)** | |
| | **Class II - Lower A*** | **Tyrol*** |
| **Arsenic** | | 20 |
| **Cadmium** | 2 | 10 |
| **Chromium** | 50 | 500 |
| **Copper** | 200 | 500 |
| **Cobalt** | 10 | 2000 |
| **Lead** | 100 | 500 |
| **Mercury** | 2 | 10 |
| **Molybdenum** | -- | 100 |
| **Nickel** | 25 | 100 |
| **Zinc** | 1000 | 2000 |
| **Organic** | | |
| **PCB** | 0.2 | 0.2 |
| **PCDD/F** | 0.0001 | 0.0001 |
| **AOX** | 500 | 500 |
| * Most conservative class and States were chosen for this example. Tyrol was chosen because it is the only state with limits for arsenic | | |

| Belgium | | |
|---|---|---|
| **Contaminant** | **Limits for Sludge Deposits on Soils (mg/kg DM)**** | **Max levels for Sludge Deposits on Soils (mg/kg DM)** |
| **Cadmium** | 1 | 12 |
| **Chromium** | 100 | 500 |
| **Copper** | 50 | 750 |
| **Lead** | 50 | 600 |
| **Mercury** | 1 | 10 |
| **Nickel** | 30 | 100 |
| **Zinc** | 150 | 2500 |
| ** Depends on soil type, most conservative (sandy) chosen for this table | | |

## Table E-1. (Continued)

| China (Tianjin) | | | |
|---|---|---|---|
| **Inorganic** | **Max permissible (mg/kg)*** | **Typical Sludge (mg/kg)**** | **Typical Soil (mg/kg)** |
| **Aluminum** | | 432 | na |
| **Arsenic** | 75 | 18.75 | 15.16 |
| **Boron** | 150 | na | |
| **Cadmium** | 5 | 5.1 | 0.17 |
| **Chromium(III)** | 600 | 528 | 73.12 |
| **Copper** | 250 | 514 | 27.5 |
| **Lead** | 300 | | 16.7 |
| **Mercury** | 5 | 8.6 | 0.047 |
| **Nickel** | 100 | | 27.62 |
| **Zinc** | 500 | 1294 | 61.8 |
| **Organic** | | | |
| **Mineral Oil** | 3000 | | |

* more conservative value used for soil with pH < 6.5 for all elements except Nickel
** max value of range shown

| Taiwan | | |
|---|---|---|
| **Contaminant** | **Guidelines for Contaminated Soils (mg/kg)***** | **Mean Background in Rural Soil (mg/kg)** |
| **Arsenic** | 14 | 4.54 |
| **Cadmium** | 2.5 | 1.74 |
| **Chromium** | 101 | 43.2 |
| **Copper** | 89 | 20.3 |
| **Lead** | 58 | 32.6 |
| **Mercury** | 0.55 | 0.13 |
| **Nickel** | 63 | 43.2 |
| **Zinc** | 163 | 180 |

*** Proposed monitoring values

**Table E-1. (Continued)**

| Denmark | | | |
|---|---|---|---|
| **Contaminant** | **Limit Values (mg/kg DS)** | **Average Sludge Used in Agriculture (mg/kg)** | |
| **Cadmium** | 0.8 | 1.5 | |
| **Calcium** | | 40 | |
| **Chromium** | 100 | 30 | |
| **Copper** | 1000 | 280 | |
| **Lead** | 120 | 73 | |
| **Mercury** | 0.8 | 1.3 | |
| **Nickel** | 30 | 23 | |
| **Zinc** | 4000 | 810 | |
| | | | |
| **Nitrogen** | | 40 | |
| **Phosphorus** | | 25 | |
| **European Union** | | | |
| **Contaminant** | **Permitted Loads 86/275/EC (mg/kg)*** | **Soil Boundary Values 86/278/EC (mg/kg)** | **Sludge Boundary Values (mg/kg) 86/278/EC** |
| **Cadmium** | 0.15 | 1-3 | 20-40 |
| **Chromium** | 4 | 100-150 | 1000-1500 |
| **Copper** | 12 | 50-140 | 1000-1750 |
| **Lead** | 15 | 50-300 | 750-1200 |
| **Mercury** | 0.1 | 1-1.5 | 16-25 |
| **Nickel** | 3 | 30-75 | 300-400 |
| **Zinc** | 30 | 150-300 | 2500-4000 |

* mean value over a period of 10 years

## Table E-1. (Continued)

| France | | | |
|---|---|---|---|
| **Contaminant** | **Limits for Sludge Use (mg/kg dw)** | **Average Sludge (mg/kg dw)*** | **Average Soil (mg/kg dw)*** |
| **Cadmium** | 2 | 4.5 | 0.3-0.5 |
| **Chromium** | 150 | 116 | < 30 |
| **Copper** | 100 | 409 | < 30 |
| **Lead** | 100 | 28.8 | < 30 |
| **Mercury** | 1 | 1.05 | < 1 |
| **Nickel** | 50 | 74.7 | < 50 |
| **Selenium** | 10 | 5.2 | < 0.3 |
| **Zinc** | 300 | 1479 | < 80 |
| * City of Besancon | | | |

| Italy | | | |
|---|---|---|---|
| **Contaminant** | **Limit Values for Sludge Used in Agriculture (mg/kg DM)** | | |
| **Cadmium** | 20 | | |
| **Copper** | 1000 | | |
| **Lead** | 750 | | |
| **Mercury** | 10 | | |
| **Nickel** | 300 | | |
| **Zinc** | 2500 | | |
| **Salmonella** | < 1000 | (MPN/g SS) | |

**Table E-1. (Continued)**

| Japan | |
|---|---|
| Contaminant | Industrial Wastes* Max allowable in extracted solution (mg/liter) |
| 1,1,1-Trichloroethane | 3 |
| 1,1,2-Trichloroethane | 0.06 |
| 1,2-Dichloroethane | 0.04 |
| 1,2-Dichloroethylene | 0.4 |
| 1,2-Dichloropropene | 0.02 |
| Alkyl Mercury Cpds | ND |
| Arsenic and Cpds | 0.3 |
| Benzene | 0.1 |
| Cadmium and Cpds | 0.3 |
| Carbon Tetrachloride | 0.02 |
| Chrome (VI) | 1.5 |
| Cyanide cpds | 1 |
| Dichloromethane | 0.2 |
| Lead and Cpds | 0.3 |
| Mercury and Cpds | 0.005 |
| Organic Phosphorus | 1 |
| PCB | 0.003 |
| Selenium and Cpds | 0.3 |
| Simazine | 0.03 |
| Tetrachloroethylene | 0.1 |
| Thiobendcarb | 0.2 |
| Thiuram | 0.06 |
| Triichloroethylene | 0.3 |

* Note that these values apply to industrial wastes

## Table E-1. (Continued)

| Netherlands | | |
|---|---|---|
| **Contaminant** | **Limits for Sewage Sludge on Land (mg/kg DM)** | |
| Arsenic | 15 | |
| Cadmium | 1.25 | |
| Chromium | 75 | |
| Copper | 75 | |
| Lead | 100 | |
| Mercury | 0.75 | |
| Nickel | 30 | |
| Zinc | 300 | |
| **Norway** | | |
| **Contaminant** | **Max content on soil when sludge is used in agriculture (mg/kg DS)** | **Max content in soil before sludge is used in agriculture (mg/kg DS)** |
| Cadmium | 4 | 1 |
| Chromium | 125 | 100 |
| Copper | 1000 | 50 |
| Lead | 100 | 50 |
| Mercury | 5 | 1 |
| Nickel | 80 | 30 |
| Zinc | 1500 | 150 |

## Table E-1. (Continued)

| Slovakia | | |
|---|---|---|
| **Contaminant** | **Max Permissible Conc in Raw Material (mg/kg)** | **Max Permissible Conc in Compost (mg/kg)*** |
| **Arsenic** | 50 | 10 |
| **Cadmium** | 13 | 2 |
| **Chromium** | 1000 | 100 |
| **Copper** | 1200 | 100 |
| **Lead** | 500 | 100 |
| **Mercury** | 10 | 1 |
| **Molybdenum** | 25 | 5 |
| **Nickel** | 200 | 50 |
| **Zinc** | 3000 | 300 |
| * Compost class I | | |
| **South Africa** | | |
| **Contaminant** | **Max Permissible in Soil (mg/kg)** | **Sludge Limts for Agricultural Use (mg/kg)** |
| **Arsenic** | 2 | 15 |
| **Boron** | 10 | 80 |
| **Cadmium** | 2 | |
| **Chromium** | 80 | 1750 |
| **Cobalt** | 20 | 100 |
| **Copper** | 100 | |
| **Fluoride** | 50 | 400 |
| **Lead** | 56 | 400 |
| **Mercury** | 0.5 | |
| **Molybdenum** | 2.3 | 25 |
| **Nickel** | 15 | |
| **Selenium** | 2 | 15 |
| **Zinc** | 185 | |

## Table E-1. (Continued)

| Sweden | | |
|---|---|---|
| **Contaminant** | **Max Permissible Concentrations in Sewage Sludge on Ag Land (mg/kg)*** | **No Use of Sludge on Ag Land if Soil Exceeds Value (mg/kg DS)** |
| **Cadmium** | 2 | 0.4 |
| **Chromium** | 100 | 30 |
| **Copper** | 600 | 40 |
| **Lead** | 100 | 40 |
| **Mercury** | 2.5 | 0.3 |
| **Nickel** | 50 | 30 |
| **Zinc** | 800 | 75 |
| * Limits as of January 1, 1998 | | |

| Switzerland | | |
|---|---|---|
| **Contaminant** | **Limits for Sludge Used in Agriculture (mg/kg DS)** | |
| **Cadmium** | 5 | |
| **Chromium** | 500 | |
| **Cobalt** | 60 | |
| **Copper** | 600 | |
| **Lead** | 500 | |
| **Mercury** | 5 | |
| **Molybdenum** | 20 | |
| **Nickel** | 80 | |
| **Zinc** | 2000 | |
| | | |
| **AOX** | 500 | |

## Table E-1. (Continued)

| United Kingdom | | | |
|---|---|---|---|
| | Max Permissible Concentration | | |
| Contaminant | In Soil After Application of Sludge (mg/kg DS)* | Typical Value for Sludge (mg/kg) | Typical Value for Soil (mg/kg) |
| **Arsenic** | 50 | 3 | 10 |
| **Cadmium** | 3 | | |
| **Chromium** | 400 | 50 | 15 |
| **Copper** | 80 | | |
| **Fluorine** | 500 | 100 | 60 |
| **Lead** | 300 | | |
| **Mercury** | 1 | | |
| **Molybdenum** | 4 | 1 | 15 |
| **Nickel** | 50 | | |
| **Selenium** | 3 | 0.3 | 0.2 |
| **Zinc** | 200 | | |
| * Values for soil $5.0 < pH < 5.5$ | | | |

## Table E-2. State Contaminant Concentration Limits for Biosolid Application to Land

| Maximum Allowable Concentrations, Micronutrient Concentrations for Land Application (mg/kg dw) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Contaminant** | **NH** | **VT** | **MA** | **NY** | **RI** | **ME** | **CN** |
| **Arsenic** | 75 | 75 | 75 | 75 | 75 | 75 | 5 |
| **Cadmium** | 85 | 25 | 25 | 25 | 25 | 10 | 34 |
| **Chromium** | 3000 | 1000 | 1000 | 1000 | 3000 | 1000 | 1200 |
| **Copper** | 4300 | 1000 | 1000 | 1000 | 4300 | 1000 | 1500 |
| **Lead** | 840 | 1000 | 1000 | 1000 | 840 | 700 | 300 |
| **Mercury** | 57 | 10 | 10 | 10 | 57 | 10 | 17 |
| **Molybdenum** | 75 | 75 | 10 | 75 | 75 | 75 | 15 |
| **Nickel** | 420 | 200 | 200 | 200 | 420 | 200 | 420 |
| **Selenium** | 100 | 100 | 100 | 100 | 100 | 100 | 36 |
| **Zinc** | 7500 | 2500 | 2500 | 2500 | 7500 | 2000 | 2800 |
| **Chromium (VI)** | | | | | | | 150 |
| **Barium** | | | | | | | 4700 |
| **Micronutrient Concentrations for Product Distribution and Marketing, Max Allowable (mg/kg dw)** | | | | | | | |
| **Contaminant** | **NH** | **VT** | **MA** | **NY** | **RI** | **ME** | **CN** |
| **Arsenic** | 41 | 41 | 41 | 41 | 41 | 41 | 5 |
| **Cadmium** | 39 | 25 | 14 | 10 | 39 | 10 | 34 |
| **Chromium** | 1200 | 1000 | 1000 | 100 | 1200 | 1000 | 1200 |
| **Copper** | 1500 | 1000 | 1000 | 1000 | 1500 | 1000 | 1500 |
| **Lead** | 300 | 1000 | 300 | 250 | 300 | 700 | 300 |
| **Mercury** | 17 | 10 | 10 | 10 | 17 | 10 | 17 |
| **Molybdenum** | 18 | 18 | 10 | 18 | 75 | 18 | 18 |
| **Nickel** | 420 | 200 | 200 | 200 | 420 | 200 | 420 |
| **Selenium** | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| **Zinc** | 2800 | 2500 | 2500 | 2500 | 2800 | 2000 | 2800 |
| **Chromium (VI)** | | | | | | | 150 |
| **Barium** | | | | | | | 4700 |

## Table E-2. (Continued)

| Pennsylvania | | | |
| --- | --- | --- | --- |
| Contaminant | Biosolids Analysis Philadelphia (mg/kg) | Max Allowable For Land Application (mg/kg) | National Biosolids Survey (mg/kg) |
| Arsenic | 15 | 50 | 9.93 |
| Cadmium | 6 | 56 | 6.95 |
| Chromium | 178 | 2000 | 119 |
| Copper | 668 | 2866 | 741 |
| Lead | 191 | 560 | 134 |
| Mercury | 3 | 38 | 5.2 |
| Molybdenum | 12 | 75 | 9.2 |
| Nickel | 52 | 420 | 42 |
| Selenium | 6 | 66 | 5 |
| Zinc | 1372 | 5000 | 1201 |

# APPENDIX F
# NPK, MICRONUTRIENT, LIME AND GYPSUM FERTILIZER APPLICATION RATES FROM USDA/NASS DATABASES U.S. AGRICULTURAL EXTENSION SERVICE INTERVIEWS AND INTERNET PUBLICATIONS

**Table F-1. Average and Maximum N, P, and K Application Rates for High Acreage Crops[a]**

| | | Average and Maximum N, P ($P_2O_5$), and K ($K_2O$) Application Rates for High-Acreage Crops, lb/A | | |
|---|---|---|---|---|
| **Field Crops** | | **N average; (max)** | **$P_2O_5$ average; (max)** | **$K_2O$ average; (max)** |
| Corn | | 133 (170) | 57 (87) | 79 (116) |
| Cotton | | 100 (175) | 48 (83) | 73 (106) |
| Potatoes | | 195 (285) | 173 (198) | 139 (204) |
| Soybeans | | 24 (40) | 49 (56) | 85 (102) |
| Tobacco | | 88 (108) | 93 (116) | 203 (284) |
| Wheat | winter (60%)[b] | 61 (115) | 30 (53) | 29 (40) |
| | durum (6%) | 60 (NA)[c] | 23 (NA) | 21 (NA) |
| | spring (34%) | 67 (91) | 31 (37) | 21 (28) |
| Wheat, aggregate[d] | | 63 (NC)[e] | 30 (NC) | 26 (NC) |
| **Vegetables** | | | | |
| Broccoli | | 206 (247) | 109 (159) | 62 (131) |
| Carrots | | 182 (234) | 166 (200) | 110 (340) |
| Head lettuce | | 262 (357) | 190 (252) | 77 (124) |
| Onion | | 186 (269) | 137 (217) | 139 (266) |
| Green peas | | 30 (42) | 55 (108) | 73 (110) |
| Snap beans | fresh (29%) | 85 (101) | 88 (104) | 115 (132) |
| | processed (71%) | 64 (154) | 64 (128) | 68 (101) |
| Snap beans, aggregate | | 70 (NC) | 71 (NC) | 82 (NC) |
| Corn | fresh (25%) | 125 (274) | 81 (129) | 137 (216) |
| | processed (75%) | 135 (227) | 63 (134) | 85 (98) |
| Corn, aggregate | | 133 (NC) | 68 (NC) | 98 (NC) |
| Tomatoes | fresh (24%) | 264 (311) | 174 (201) | 408 (534) |
| | processed (76%) | 163 (164) | 103 (110) | 49 (289) |
| Tomatoes, aggregate | | 187 (NC) | 120 (NC) | 135 (NC) |
| **Fruit** | | | | |
| Watermelon | | 120 (414) | 94 (163) | 119 (182) |
| Oranges | | 164 (179) | 43 (46) | 177 (182) |
| Grapefruit | | 128 (132) | 56 (81) | 146 (147) |

**Table F-1. (Continued)**

| Field Crops | Average and Maximum N, P ($P_2O_5$), and K ($K_2O$) Application Rates for High-Acreage Crops, lb/A | | |
|---|---|---|---|
| | N average; (max) | $P_2O_5$ average; (max) | $K_2O$ average; (max) |
| Apples | 62 (75) | 34 (60) | 54 (75) |
| Grapes | 67 (117) | 55 (89) | 107 (151) |
| Peaches | 84 (109) | 38 (50) | 76 (124) |

a) Source: USDA/NASS databases; USDA/NASS/ERS, 1997 for field crops; USDA/NASS/ERS, 1997 for vegetables; USDA/NASS/ERS, 1996 for fruits
b) Percent of total acreage planted in that variant of crop
c) NA = data not available from USDA/NASS
d) Acreage-weighted application rate for total crop
e) NC = not calculated as such a value is not needed

## Table F-2. Fertilizer Application Rates

| Micronutrient | Application Rate per Crop Year | State | Crop | Application Method | Comment | Citation |
|---|---|---|---|---|---|---|
| Zinc | 5 lbs/A | GA | Onions | nl[a] | | Internet[b] |
| | 5 lbs/A | GA | Peppers | nl | | Internet |
| | 5 lbs/A | GA | Eggplant | nl | | Internet |
| | 5-10 lbs/A | MN | Fruit/Vegetables | Broadcast | | Internet[c] |
| | 1-2 lbs/A | MN | Fruit/Vegetables (corn, edible beans) | Row Applied Starter | | Internet |
| | 1-2 lbs/A | NE | Dry Beans | Row | | Internet[d] |
| | 5-10 lbs/A | NE | Dry Beans | Broadcast | | Internet |
| | 5-10 lbs/A | NE | Soybeans | nl | | Internet |
| | 3-5 lbs/A | AL | Sorghum | nl | | Internet[e] |
| | 3-4 lbs/A | OR | Pole Beans | Banded | | OSU Extension Bulletin/Herschell Pendell |
| | 10 lbs/A | OR | Pole Beans | Broadcast | | OSU Extension Bulletin/Herschell Pendell |
| | 15 lbs/A | OR | Apples, prunes, cherries, pears | Foliar Spray | | OSU Extension Bulletin/Herschell Pendell |
| | 3-4 lbs/A | OR | Onions, potatoes | Banded | | OSU Extension Bulletin/Herschell Pendell |
| | 10 lbs/A | OR | Onions, potatoes | Broadcast | | OSU Extension Bulletin/Herschell Pendell |
| | 5-10 lbs/A | WA | nl | nl | "normal" rate | WSU-Bob Stevens |
| | 20 lbs/A | WA | nl | nl | "if really deficient" | WSU-Bob Stevens |
| | 10-20 lbs/A | WA, OR | Dryland potatoes | nl | Central OR and WA | WSU-Bob Stevens |

**Table F-2. (Continued)**

| Micronutrient | Application Rate per Crop Year | State | Crop | Application Method | Comment | Citation |
|---|---|---|---|---|---|---|
| | 10 lbs/A | CA | nl | nl | Peat, muck, high organic, but not continuously | Bill Liebhardt-UC Davis |
| | 1-5 lbs/A | CA | nl | nl | Over the long range | Bill Liebhardt-UC Davis |
| | 2-10 lbs/A | | nl | nl | | CoZinCo |
| | 3.6-13 lbs/ A | Ontario, Canada | nl | nl | 4-14 kg/ha | Internet[f] |
| | 20 lbs/A | CA | Almonds, grapes, trees, cherries | Foliar | If deficient | CALTECH- Bob Dixon |
| | 18 lbs/A | WA | nl | nl | | WA-Dept. of Ecology |
| | 1.9 lbs/A | WA | nl | nl | Sample H4756[g] | WA-Dept. of Ecology |
| | 0.5-2 lbs/A | WA | nl | nl | Sample H4772 | WA-Dept. of Ecology |
| Sulfur | 40-60 lbs/A | GA | Onions (seed bed) | nl | | Internet[b] |
| | 35-55 lbs/A | GA | Onions (mature crop) | nl | | Internet |
| | ≥10 lbs/A | GA | Peppers | nl | | Internet |
| | ≥10 lbs/A | GA | Eggplant | nl | | Internet |
| | 10-15 lbs/A | MN | nl | Row/side Application | | Internet[c] |
| | 20-30 lbs/A | MN | nl | Broadcast | | Internet |

## Table F-2. (Continued)

| Micronutrient | Application Rate per Crop Year | State | Crop | Application Method | Comment | Citation |
|---|---|---|---|---|---|---|
| | 25 lbs/A | MN | Alfalfa, barley, corn, oats, wheat, rye | nl | | Internet[c] |
| | 5-10 lbs/A | NE | Corn | Row Application | | Internet[d] |
| | 10-20 lbs/A | NE | nl | Broadcast | | Internet |
| | 30-40 lbs/A | NE | Irrigated alfalfa | nl | | Internet |
| | 10-20 lbs/A | AL | Oats | nl | | Internet[e] |
| | 10 lbs/A | AL | Cotton; most crops | nl | | Internet |
| | 40 lbs/A | WA | Alfalfa, potatoes, corn | nl | | WSU-Bob Stevens |
| | 10-25 lbs/A | CA | nl | nl | Sandy soils | CALTECH-Bob Dixon |
| | 20-40 lbs/A | WA | nl | nl | Sample H4766 Gypsum | CALTECH-Bob Dixon |
| | 5.6-9.8 lbs/A | WA | nl | nl | Sample H2532 | CALTECH-Bob Dixon |
| | 5-39 lbs/A | WA | nl | nl | Sample H2547 thiosol | CALTECH-Bob Dixon |
| | 8-40 lbs/A | WA | nl | nl | Sample H1231 nitrosol | CALTECH-Bob Dixon |
| | 170-800 lbs/A | MN | nl | nl | Sandy soil pH 7-4.5 | Internet[c] |
| | 500-2500 lbs/A | MN | nl | nl | Loam soil pH 7-4.5 | Internet |
| | 1000 lbs/A | WA | nl | nl | Once | WSU-Bob Stevens |

## Table F-2. (Continued)

| Micronutrient | Application Rate per Crop Year | State | Crop | Application Method | Comment | Citation |
|---|---|---|---|---|---|---|
| | 1500 lbs/A | WA | nl | nl | Over several years | WSU-Bob Stevens |
| | 4 tons gypsum/A (1-2 ton sulfur/application) | | nl | nl | | WSU-Bob Stevens |
| | 200/300-1000/2000 lbs/A | | nl | nl | CA-sandy soils | CALTECH-Bob Dixon |
| Boron | 1 lb/A | MO | Cotton | Side-dress | | Internet[h] |
| | 2 lb/A | MO | nl | nl | After liming | Internet |
| | 1 lb/A | MO | Alfalfa | nl | | Internet |
| | 1 lb/A | GA | Onions | nl | | Internet[b] |
| | 1 lb/A | GA | Peppers | nl | | Internet |
| | 1 lb/A | GA | Eggplant | nl | | Internet |
| | 1-4 lbs/A | MN | Fruits/ Vegetables | nl | | Internet[c] |
| | 1-1.5 lbs/A | MN | Corn | nl | | Internet |
| | 0.1-0.3 lbs/A | MN | Alfalfa | Foliar Spray | | Internet |
| | 1 lb/A | NE | Soybeans | nl | | Internet[d] |
| | 0.3 lbs/A | AL | Cotton | Foliar Spray | | Internet[e] |
| | 2-3 lbs/A | WA | nl | nl | | WSU-Bob Stevens |
| | < 1 lbs/A | CA | Almonds, grapes | Foliar spray | | CALTECH-Bob Dixon |

## Table F-2. (Continued)

| Micronutrient | Application Rate per Crop Year | State | Crop | Application Method | Comment | Citation |
|---|---|---|---|---|---|---|
| | 2-4 lbs/A | CA | nl | applied to soil | | CALTECH-Bob Dixon |
| | 3 lbs/A | WA | nl | nl | Sample H0753 | WSU-Dept. of Ecology |
| Gypsum | 100-1500 lbs/A | | nl | nl | pH - over a few years | WSU-Bob Stevens |
| | 8000 lbs/A | | nl | nl | Soil amendment- 2000-4000 lbs/A at a time | WSU-Bob Stevens |
| | 2000 lb/A minimum | CA | nl | nl | Soil structure | CALTECH-Bob Dixon |
| | 4000-8000 lbs/A average | CA | nl | nl | | CALTECH-Bob Dixon |
| Manganese (Mn) | 4-15 lbs/A | MN | Vegetables | nl | | Internet[c] |
| | 8 lbs/A | MN | Onions | nl | | Internet |
| | 0.2-15 lbs/A | MN | General | nl | | Internet |
| | 8.9-17.7 lbs/A | WA | nl | nl | Sample H4753 | WSU-Bob Stevens |
| | 0.3-1 lbs/A | WA | nl | nl | Sample H4772 | WSU-Bob Stevens |
| | 1.1 lbs/A | WA | nl | nl | Sample H4756 | WSU-Bob Stevens |
| | 25 lbs/A | GA | Onions | nl | | Internet[b] |
| | 25 lbs/A | GA | Peppers | nl | | Internet |
| | 25 lbs/A | GA | Eggplant | nl | | Internet |

**Table F-2.  (Continued)**

| Micronutrient | Application Rate per Crop Year | State | Crop | Application Method | Comment | Citation |
|---|---|---|---|---|---|---|
| | 10-20 lbs/A | MN | Fruit/Vegetables (corn) | Row-application | | Internet [c] |
| | 50-100 lbs/A | MN | Fruit/Vegetables (corn) | Broadcast | | Internet |
| | 6.3-63 lbs/A | WA | nl | nl | Sample H2530 | WSU-Bob Stevens |
| | 50-180 lbs/A | WA | nl | nl | Sample H4768 | WSU-Bob Stevens |
| | 226-453 lbs/A | WA | nl | nl | Sample H2550 | WSU-Bob Stevens |
| Iron | 0.1-0.15 lbs/A | MN | Fruit/Vegetables | Foliar Spray | | Internet[c] |
| | 10-30 lbs/A | NE | Corn | nl | | Internet[d] |
| Lime $CaCO_3$ | 2500 lbs/A | MO | nl | nl | Lime stabilized biosolids 900 lbs/A Ca | Internet[h] |
| | 2000 lbs/A | MO | nl | nl | Limestone | Internet |
| | 2000 lbs/A | GA | Peppers | nl | Lime | Internet[b] |
| | 4000-15000 lbs/A | MN | nl | nl | Lime | Internet[c] |
| | 2000 lbs/A | AL | nl | nl | Ornamentals | Internet[e] |
| | 4000-6000 lbs/A | OR | nl | nl | | OSU-Hershel Pendell |
| | 500-1000 lbs/A | | nl | nl | $CaCO_3$ equiv. Low | WSU-Bob Stevens |

**Table F-2. (Continued)**

| Micronutrient | Application Rate per Crop Year | State | Crop | Application Method | Comment | Citation |
|---|---|---|---|---|---|---|
| | 2000-4000 lbs/A | | nl | nl | $CaCO_3$ equiv. High | WSU-Bob Stevens |
| | 8000 lbs/A gypsum | | nl | nl | 1-2 ton/ applicaton | WSU-Bob Stevens |
| | 2000-16000 lbs/A | CA | nl | nl | Min.-Max. | CALTECH-Bob Dixon |
| | 6000-8000 lbs/A | CA | nl | nl | Average | CALTECH-Bob Dixon |
| | 2000 lbs/A gypsum | | nl | nl | Minimum | CALTECH-Bob Dixon |
| | 4000-8000 lbs/A gypsum | | nl | nl | Typical | CALTECH-Bob Dixon |
| | 1000 lbs/A | MN | Potatoes | | | Internet[c] |
| | 660-1320 lbs/A | | nl | nl | Sample H2529 dical lime | WSU-Dept. Of Ecology |
| | 3400-6800 lbs/A | | nl | nl | Once every 3 years; sample H4763 Kiln dust lime | WSU-Dept. Of Ecology |
| | 1133-2267 lbs/A | | nl | nl | per crop year | WSU-Dept. Of Ecology |
| | 2736-5776 lbs/A | | nl | nl | Once every 3 years; sample H4775; wood ash | WSU-Dept. Of Ecology |

**Table F-2. (Continued)**

| Micronutrient | Application Rate per Crop Year | State | Crop | Application Method | Comment | Citation |
|---|---|---|---|---|---|---|
| | 912-1925 lbs/A | | nl | nl | Per crop year | WSU-Dept. of Ecology |
| | 1920-3840 lbs/A | | nl | nl | Sample H4759; ground limestone | WSU-Dept. of Ecology |

a) nl = not listed
b) University of Georgia College of Agriculture & Environmental Sciences/Cooperative Extension
www.ces.uga.edu/pubcd/b1027-w.html#Lime and Fertilizer
c) University of Minnesota Extension Service
www.mes.umn.edu/Documents/D/C/DC6572.html
d) University of Nebraska-Lincoln/Institute of Agriculture and Natrural Resources/Cooperative Extension
www.ianr.un/.edu/PUBS/fieldcrops/g174.htm
e) Alabama A&M and Auburn Universities/Alabama Cooperative Extension System
www.acenet.auburn.edu/department/grain/ANR469.htm
f) University of Guelph Soil Testing Laboratory
ozone.crle.uoguelph.ca/manure
g) University of Washington Department of Ecology; Data from Sample H4756
h) University of Missouri-Columbia; Department of Agronomy
muextension.missouri.edu/xplor/agguides

# APPENDIX G
# YEARLY ADDITIONS OF METALS TO SOILS FROM FERTILIZERS, MICRONUTRIENTS AND SOIL AMENDMENTS

## LIST OF TABLES

## Table G-1a. Yearly Cd and Pb Additions to Soil (kg/ha) from $P_2O_5$ Fertilizers

| Source[a] | ID[b] | Percent $P_2O_5$ | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Pb addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 24837 | 53 | 1 | 2 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.001 |
| | 24836 | 53 | 69.5 | 2.5 | 0.012 | 0.025 | 0.037 | 0.000 | 0.001 | 0.001 |
| | 24355 | 53 | 140 | 1 | 0.025 | 0.051 | 0.074 | 0.000 | 0.000 | 0.001 |
| | 24728 | 53 | 130 | 1 | 0.023 | 0.048 | 0.069 | 0.000 | 0.000 | 0.001 |
| | 24278 | 53 | 150 | 0 | 0.027 | 0.055 | 0.080 | 0.000 | 0.000 | 0.000 |
| | 23058 | 53 | 154 | 0 | 0.027 | 0.056 | 0.082 | 0.000 | 0.000 | 0.000 |
| | 23189 | 53 | 140 | 0 | 0.025 | 0.051 | 0.074 | 0.000 | 0.000 | 0.000 |
| | 22811 | 53 | 133 | 2 | 0.024 | 0.049 | 0.071 | 0.000 | 0.001 | 0.001 |
| | 22816 | 53 | 130 | 1 | 0.023 | 0.048 | 0.069 | 0.000 | 0.000 | 0.001 |
| | 22818 | 53 | 140 | 2 | 0.025 | 0.051 | 0.074 | 0.000 | 0.001 | 0.001 |
| | 21786 | 53 | 151 | 0 | 0.027 | 0.055 | 0.080 | 0.000 | 0.000 | 0.000 |
| | 21741 | 53 | 140 | 0 | 0.025 | 0.051 | 0.074 | 0.000 | 0.000 | 0.000 |
| | 26286 | 53 | 139 | 1 | 0.025 | 0.051 | 0.074 | 0.000 | 0.000 | 0.001 |
| | 25864 | 53 | 150 | 0 | 0.027 | 0.055 | 0.080 | 0.000 | 0.000 | 0.000 |
| | 25731 | 53 | 135.5 | 0 | 0.024 | 0.050 | 0.072 | 0.000 | 0.000 | 0.000 |
| | 25699 | 53 | 41 | 0 | 0.007 | 0.015 | 0.022 | 0.000 | 0.000 | 0.000 |
| | 25167 | 53 | 140 | 1 | 0.025 | 0.051 | 0.074 | 0.000 | 0.000 | 0.001 |
| | 26736 | 53 | 162.5 | 0 | 0.029 | 0.059 | 0.086 | 0.000 | 0.000 | 0.000 |
| | 20704 | 53 | 0 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | 20968 | 53 | 149 | NR[c] | 0.026 | 0.055 | 0.079 | NC[d] | NC | NC |
| | 20969 | 53 | 145 | NR | 0.026 | 0.053 | 0.077 | NC | NC | NC |
| | 20970 | 53 | 150 | NR | 0.027 | 0.055 | 0.080 | NC | NC | NC |
| | 25108 | 45 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 23226 | 45 | 120 | 4 | 0.025 | 0.052 | 0.075 | 0.001 | 0.002 | 0.003 |
| Wash St | H4770 | 45 | 119 | 10.5 | 0.025 | 0.051 | 0.075 | 0.002 | 0.005 | 0.007 |
| Raven | TSP#1[e] | 45 | 5 | 11.1 | 0.001 | 0.002 | 0.003 | 0.002 | 0.005 | 0.007 |
| | TSP#2 | 45 | 6.2 | 13.2 | 0.001 | 0.003 | 0.004 | 0.003 | 0.006 | 0.008 |
| Charter | TSP-1 | 45 | 7.8 | 12 | 0.002 | 0.003 | 0.005 | 0.003 | 0.005 | 0.008 |
| | TSP-2 | 45 | 9.1 | 16 | 0.002 | 0.004 | 0.006 | 0.003 | 0.007 | 0.010 |
| | TSP-3 | 45 | 6.8 | 12 | 0.001 | 0.003 | 0.004 | 0.003 | 0.005 | 0.008 |

Note: Footnotes may be found at the end of this table

## Table G-1a. (Continued)

| | | | | | Yearly Cd addition in kg/ha at | | | Yearly Pb addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| Source[a] | ID[b] | Percent $P_2O_5$ | Cd mg/kg | Pb mg/kg | 94 kg/ha | 194 kg/ha | 282 kg/ha | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| Charter | TSP-4 | 45 | 8.7 | 16 | 0.002 | 0.004 | 0.005 | 0.003 | 0.007 | 0.010 |
| | TSP-5 | 45 | 8.1 | 15 | 0.002 | 0.003 | 0.005 | 0.003 | 0.006 | 0.009 |
| | TSP-6 | 45 | 47 | 4.5 | 0.010 | 0.020 | 0.029 | 0.001 | 0.002 | 0.003 |
| | TSP-7 | 45 | 7.5 | 12 | 0.002 | 0.003 | 0.005 | 0.003 | 0.005 | 0.008 |
| | TSP-8 | 45 | 6.8 | 16 | 0.001 | 0.003 | 0.004 | 0.003 | 0.007 | 0.010 |
| | TSP-9 | 45 | 39 | 4.5 | 0.008 | 0.017 | 0.024 | 0.001 | 0.002 | 0.003 |
| | TSP-10 | 45 | 7.8 | 12 | 0.002 | 0.003 | 0.005 | 0.003 | 0.005 | 0.008 |
| | TSP-11 | 45 | 8.1 | 4.5 | 0.002 | 0.003 | 0.005 | 0.001 | 0.002 | 0.003 |
| | TSP-12 | 45 | 7.8 | 16 | 0.002 | 0.003 | 0.005 | 0.003 | 0.007 | 0.010 |
| | TSP-13 | 45 | 8.1 | 12 | 0.002 | 0.003 | 0.005 | 0.003 | 0.005 | 0.008 |
| | TSP-14 | 45 | 8.1 | 12 | 0.002 | 0.003 | 0.005 | 0.003 | 0.005 | 0.008 |
| | TSP-15 | 45 | 11 | 12 | 0.002 | 0.005 | 0.007 | 0.003 | 0.005 | 0.008 |
| | TSP-16 | 45 | 8.8 | 12 | 0.002 | 0.004 | 0.006 | 0.003 | 0.005 | 0.008 |
| | TSP-17 | 45 | 7.2 | 12 | 0.002 | 0.003 | 0.005 | 0.003 | 0.005 | 0.008 |
| | TSP-18 | 45 | 30 | 12 | 0.006 | 0.013 | 0.019 | 0.003 | 0.005 | 0.008 |
| | TSP-19 | 45 | 40 | 12 | 0.008 | 0.017 | 0.025 | 0.003 | 0.005 | 0.008 |
| | TSP-20 | 45 | 8.5 | 12 | 0.002 | 0.004 | 0.005 | 0.003 | 0.005 | 0.008 |
| | TSP-21 | 45 | 36 | 4.5 | 0.008 | 0.016 | 0.023 | 0.001 | 0.002 | 0.003 |
| | TSP-22 | 45 | 7.7 | 15 | 0.002 | 0.003 | 0.005 | 0.003 | 0.006 | 0.009 |
| | TSP-23 | 45 | 8.1 | 16 | 0.002 | 0.003 | 0.005 | 0.003 | 0.007 | 0.010 |
| | TSP-24 | 45 | 26 | 4.5 | 0.005 | 0.011 | 0.016 | 0.001 | 0.002 | 0.003 |
| M&O | TSP | 45 | 180 | 18 | 0.038[f] | 0.078 | **0.113**[g] | 0.004 | 0.008 | 0.011 |
| CDFA | 25972 | 20 | 32 | 200 | 0.015 | 0.031 | 0.045 | 0.094 | 0.194 | 0.282 |
| | 25658 | 20 | 7 | 2 | 0.003 | 0.007 | 0.010 | 0.001 | 0.002 | 0.003 |
| | 24682 | 20 | 3 | 14 | 0.001 | 0.003 | 0.004 | 0.007 | 0.014 | 0.020 |
| | 22899 | 15 | 1 | 1 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.002 |
| | 20705 | 15 | 2 | 5 | 0.001 | 0.003 | 0.004 | 0.003 | 0.006 | 0.009 |
| | 21244 | 23 | 0 | 4.7 | 0.000 | 0.000 | 0.000 | 0.002 | 0.004 | 0.006 |
| | 20986 | 33.5 | 0 | 9.5 | 0.000 | 0.000 | 0.000 | 0.003 | 0.006 | 0.008 |
| | 20987 | 33.5 | 0 | 2.2 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 |
| Wash St | H2549 | 68 | 0.15 | 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| Average | | 45.3 | 57.9 | 10.1 | 0.011 | 0.022 | 0.033 | 0.003 | 0.007 | 0.009 |

a) Sources:
   CDFA: California Department of Food and Agriculture (1997)
   Wash St: Washington State Department of Ecology (1997)
   Raven: Raven and Loeppert (1997)
   Charter: Charter et al. (1993)
   M&O: Mortvedt and Osborn (1982)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) TSP = Triple superphosphate
f) Shading indicates highest yearly addition values of this metal from phosphate products
g) Bold indicates a yearly addition that exceeds the Canadian Fertilizers Act limits for this metal

## Table G-1b. Yearly As and Cr Additions to Soil (kg/ha) from $P_2O_5$ Fertilizers

| Source[a] | ID Number[b] | Percent $P_2O_5$ | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Cr addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 24837 | 53 | 7 | NR[c] | 0.001 | 0.003 | 0.004 | NC[d] | NC | NC |
| | 24836 | 53 | 12 | NR | 0.002 | 0.004 | 0.006 | NC | NC | NC |
| | 24355 | 53 | 14.5 | NR | 0.003 | 0.005 | 0.008 | NC | NC | NC |
| | 24728 | 53 | 13.5 | NR | 0.002 | 0.005 | 0.007 | NC | NC | NC |
| | 24278 | 53 | 12.3 | NR | 0.002 | 0.005 | 0.007 | NC | NC | NC |
| | 23058 | 53 | 17 | NR | 0.003 | 0.006 | 0.009 | NC | NC | NC |
| | 23189 | 53 | 14.5 | NR | 0.003 | 0.005 | 0.008 | NC | NC | NC |
| | 22811 | 53 | 16 | NR | 0.003 | 0.006 | 0.009 | NC | NC | NC |
| | 22816 | 53 | 17 | NR | 0.003 | 0.006 | 0.009 | NC | NC | NC |
| | 22818 | 53 | 17 | NR | 0.003 | 0.006 | 0.009 | NC | NC | NC |
| | 21786 | 53 | 8 | NR | 0.001 | 0.003 | 0.004 | NC | NC | NC |
| | 21741 | 53 | 15.5 | NR | 0.003 | 0.006 | 0.008 | NC | NC | NC |
| | 26286 | 53 | 16 | NR | 0.003 | 0.006 | 0.009 | NC | NC | NC |
| | 25864 | 53 | 9 | NR | 0.002 | 0.003 | 0.005 | NC | NC | NC |
| | 25731 | 53 | 20.5 | NR | 0.004 | 0.008 | 0.011 | NC | NC | NC |
| | 25699 | 53 | 3.5 | NR | 0.001 | 0.001 | 0.002 | NC | NC | NC |
| | 25167 | 53 | 19 | NR | 0.003 | 0.007 | 0.010 | NC | NC | NC |
| | 26736 | 53 | 15.5 | NR | 0.003 | 0.006 | 0.008 | NC | NC | NC |
| | 20704 | 53 | 5.5 | NR | 0.001 | 0.002 | 0.003 | NC | NC | NC |
| | 20968 | 53 | 13 | NR | 0.002 | 0.005 | 0.007 | NC | NC | NC |
| | 20969 | 53 | 16.5 | NR | 0.003 | 0.006 | 0.009 | NC | NC | NC |
| | 20970 | 53 | 15 | NR | 0.003 | 0.005 | 0.008 | NC | NC | NC |
| | 25108 | 45 | 0.5 | NR | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| | 23226 | 45 | 14 | NR | 0.003 | 0.006 | 0.009 | NC | NC | NC |
| Wash St | H4770 | 45 | 15.5 | 516 | 0.003 | 0.007 | 0.010 | 0.108 | 0.222 | 0.323 |
| Raven | TSP#1[e] | 45 | 16.2 | 88.9 | 0.003 | 0.007 | 0.010 | 0.019 | 0.038 | 0.056 |
| | TSP#2 | 45 | 15.3 | NR | 0.003 | 0.007 | 0.010 | NC | NC | NC |
| Hamamo | TSP#1 | 46 | 12.3 | NR | 0.003 | 0.005 | 0.008 | NC | NC | NC |
| | TSP#5 | 46 | 13 | NR | 0.003 | 0.005 | 0.008 | NC | NC | NC |
| | SP#2 | 21 | 7.5 | NR | 0.003 | 0.007 | 0.01 | NC | NC | NC |
| | SP#4 | 21 | 13 | NR | 0.003 | 0.012 | 0.017 | NC | NC | NC |
| Charter | TSP-1 | 45 | 11.1 | 63 | 0.002 | 0.005 | 0.007 | 0.013 | 0.027 | 0.039 |
| | TSP-2 | 45 | 12.9 | 85 | 0.003 | 0.006 | 0.008 | 0.018 | 0.037 | 0.053 |
| | TSP-3 | 45 | 14.7 | 69 | 0.003 | 0.006 | 0.009 | 0.014 | 0.030 | 0.043 |

Note: Footnotes may be found at the end of this table

## Table G-1b. (Continued)

| Source[a] | ID | Percent $P_2O_5$ | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Cr addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Charter | TSP-4 | 45 | 9.7 | 68 | 0.002 | 0.004 | 0.006 | 0.014 | 0.029 | 0.043 |
| | TSP-5 | 45 | 9.8 | 77 | 0.002 | 0.004 | 0.006 | 0.016 | 0.033 | 0.048 |
| | TSP-6 | 45 | 2.7 | 309 | 0.001 | 0.001 | 0.002 | 0.065 | 0.133 | 0.194 |
| | TSP-7 | 45 | 13.8 | 70 | 0.003 | 0.006 | 0.009 | 0.015 | 0.030 | 0.044 |
| | TSP-8 | 45 | 13.4 | 70 | 0.003 | 0.006 | 0.008 | 0.015 | 0.030 | 0.044 |
| | TSP-9 | 45 | 8.8 | 548 | 0.002 | 0.004 | 0.006 | 0.114 | 0.236 | 0.343 |
| | TSP-10 | 45 | 10.1 | 76 | 0.002 | 0.004 | 0.006 | 0.016 | 0.033 | 0.048 |
| | TSP-11 | 45 | 9.4 | 74 | 0.002 | 0.004 | 0.006 | 0.015 | 0.032 | 0.046 |
| | TSP-12 | 45 | 13.2 | 73 | 0.003 | 0.006 | 0.008 | 0.015 | 0.031 | 0.046 |
| | TSP-13 | 45 | 13.7 | 70 | 0.003 | 0.006 | 0.009 | 0.015 | 0.030 | 0.044 |
| | TSP-14 | 45 | 9.7 | 76 | 0.002 | 0.004 | 0.006 | 0.016 | 0.033 | 0.048 |
| | TSP-15 | 45 | 18.5 | 72 | 0.004 | 0.008 | 0.012 | 0.015 | 0.031 | 0.045 |
| | TSP-16 | 45 | 9.2 | 68 | 0.002 | 0.004 | 0.006 | 0.014 | 0.029 | 0.043 |
| | TSP-17 | 45 | 15.8 | 70 | 0.003 | 0.007 | 0.010 | 0.015 | 0.030 | 0.044 |
| | TSP-18 | 45 | 4.8 | 223 | 0.001 | 0.002 | 0.003 | 0.047 | 0.096 | 0.140 |
| | TSP-19 | 45 | 2.4 | 373 | 0.001 | 0.001 | 0.002 | 0.078 | 0.161 | 0.234 |
| | TSP-20 | 45 | 10.1 | 81 | 0.002 | 0.004 | 0.006 | 0.017 | 0.035 | 0.051 |
| | TSP-21 | 45 | 3.1 | 272 | 0.001 | 0.001 | 0.002 | 0.057 | 0.117 | 0.170 |
| | TSP-22 | 45 | 10 | 65 | 0.002 | 0.004 | 0.006 | 0.014 | 0.028 | 0.041 |
| | TSP-23 | 45 | 12.4 | 68 | 0.003 | 0.005 | 0.008 | 0.014 | 0.029 | 0.043 |
| | TSP-24 | 45 | 7.1 | 159 | 0.001 | 0.003 | 0.004 | 0.033 | 0.069 | 0.100 |
| CDFA | 25972 | 20 | 13 | NR | 0.006[f] | 0.013 | 0.018 | NC | NC | NC |
| | 25658 | 20 | 1 | NR | 0.000 | 0.001 | 0.001 | NC | NC | NC |
| | 24682 | 20 | 12 | NR | 0.006 | 0.012 | 0.017 | NC | NC | NC |
| | 22899 | 15 | 0.5 | NR | 0.000 | 0.001 | 0.001 | NC | NC | NC |
| | 20705 | 15 | 2.6 | NR | 0.002 | 0.003 | 0.005 | NC | NC | NC |
| | 21244 | 23 | 0 | NR | 0 | 0 | 0 | NC | NC | NC |
| | 20986 | 33.5 | 0 | NR | 0 | 0 | 0 | NC | NC | NC |
| | 20987 | 33.5 | 0 | NR | 0 | 0 | 0 | NC | NC | NC |
| Wash St | H2549 | 68 | 7.8 | 896 | 0.001 | 0.002 | 0.003 | 0.124 | 0.256 | 0.372 |
| Average | | 45.3 | 11.0 | 173.33 | 0.002 | 0.005 | 0.007 | 0.034 | 0.070 | 0.102 |

a) Sources:
   California Department of Food and Agriculture (1997)
   Washington Department of Ecology (1997)
   Raven and Loeppert (1997)
   Hamamo: Hamamo et al. (1995)
   Charter et al. (1993) and Charter et al. (1995) for As
   Mortvedt and Osborn (1982)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) TSP = Triple superphosphate
f) Shading indicates highest yearly addition values of this contaminant from phosphate products

## Table G-1c. Yearly Hg and Ni Additions to Soil (kg/ha) from $P_2O_5$ Fertilizers

| Source[a] | ID[b] | Percent $P_2O_5$ | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | Yearly Hg addition in kg/ha at 173 lb $P_2O_5$/A 194 kg/ha | Yearly Hg addition in kg/ha at 252 lb $P_2O_5$/A 282 kg/ha | Yearly Ni addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | Yearly Ni addition in kg/ha at 173 lb $P_2O_5$/A 194 kg/ha | Yearly Ni addition in kg/ha at 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 23226 | 45 | NR[c] | 132 | NC[d] | NC | NC | 0.028 | 0.057 | 0.083 |
| Wash St | H4770 | 45 | 0.003 | 151 | 0.000 | 0.000 | 0.000 | 0.032[e] | 0.065[e] | 0.095[e] |
| Raven | TSP#1[f] | 45 | 0.2 | 25.2 | 0.000[e] | 0.000[e] | 0.000[e] | 0.005 | 0.011 | 0.016 |
| | TSP#2 | 45 | 0.2 | 15.6 | 0.000 | 0.000 | 0.000 | 0.003 | 0.007 | 0.010 |
| Charter | TSP-1 | 45 | NR | 15 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | TSP-2 | 45 | NR | 19 | NC | NC | NC | 0.004 | 0.008 | 0.012 |
| | TSP-3 | 45 | NR | 17 | NC | NC | NC | 0.004 | 0.007 | 0.011 |
| | TSP-4 | 45 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | TSP-5 | 45 | NR | 19 | NC | NC | NC | 0.004 | 0.008 | 0.012 |
| | TSP-6 | 45 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | TSP-7 | 45 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | TSP-8 | 45 | NR | 18 | NC | NC | NC | 0.004 | 0.008 | 0.011 |
| | TSP-9 | 45 | NR | 40 | NC | NC | NC | 0.008 | 0.017 | 0.025 |
| | TSP-10 | 45 | NR | 17 | NC | NC | NC | 0.004 | 0.007 | 0.011 |
| | TSP-11 | 45 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | TSP-12 | 45 | NR | 17 | NC | NC | NC | 0.004 | 0.007 | 0.011 |
| | TSP-13 | 45 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | TSP-14 | 45 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | TSP-15 | 45 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | TSP-16 | 45 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | TSP-17 | 45 | NR | 18 | NC | NC | NC | 0.004 | 0.008 | 0.011 |
| | TSP-18 | 45 | NR | 17 | NC | NC | NC | 0.004 | 0.007 | 0.011 |
| | TSP-19 | 45 | NR | 15 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | TSP-20 | 45 | NR | 17 | NC | NC | NC | 0.004 | 0.007 | 0.011 |
| | TSP-21 | 45 | NR | 18 | NC | NC | NC | 0.004 | 0.008 | 0.011 |
| | TSP-22 | 45 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | TSP-23 | 45 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | TSP-24 | 45 | NR | 15 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| M&O | TSP | 45 | NR | 135 | NC | NC | NC | 0.028 | 0.058 | 0.085 |
| CDFA | 21244 | 23 | NR | 10 | NC | NC | NC | 0.004 | 0.008 | 0.012 |
| | 20986 | 33.5 | NR | 11.6 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | 20987 | 33.5 | NR | 9.8 | NC | NC | NC | 0.003 | 0.006 | 0.008 |
| Wash St | H2549 | 68 | 0.003 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Average | | 44.3 | 0.10 | 27.5 | 0.000 | 0.000 | 0.000 | 0.006 | 0.012 | 0.018 |

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
Charter: Charter et al. (1993)
M&O: Mortvedt and Osborn (1982)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Shading indicates highest yearly addition values of this metal from phosphate products
f) TSP = Triple superphosphate

## Table G-1d. Yearly V and Cu Additions to Soil (kg/ha) from $P_2O_5$ Fertilizers

| Source[a] | ID[b] | Percent $P_2O_5$ | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Cu addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 24837 | 53 | NR[c] | 3 | NC[d] | NC | NC | 0.001 | 0.001 | 0.002 |
| | 24836 | 53 | NR | 2 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | 24355 | 53 | NR | 58.5 | NC | NC | NC | 0.010 | 0.021 | 0.031 |
| | 24728 | 53 | NR | 100 | NC | NC | NC | 0.018 | 0.037 | 0.053 |
| | 24278 | 53 | NR | 52 | NC | NC | NC | 0.009 | 0.019 | 0.028 |
| | 23058 | 53 | NR | 51.5 | NC | NC | NC | 0.009 | 0.019 | 0.027 |
| | 23189 | 53 | NR | 48 | NC | NC | NC | 0.009 | 0.018 | 0.026 |
| | 22811 | 53 | NR | 57 | NC | NC | NC | 0.010 | 0.021 | 0.030 |
| | 22816 | 53 | NR | 55 | NC | NC | NC | 0.010 | 0.020 | 0.029 |
| | 22818 | 53 | NR | 60 | NC | NC | NC | 0.011 | 0.022 | 0.032 |
| | 21786 | 53 | NR | 27 | NC | NC | NC | 0.005 | 0.010 | 0.014 |
| | 21741 | 53 | NR | 55 | NC | NC | NC | 0.010 | 0.020 | 0.029 |
| | 26286 | 53 | NR | 55 | NC | NC | NC | 0.010 | 0.020 | 0.029 |
| | 25864 | 53 | NR | 11 | NC | NC | NC | 0.002 | 0.004 | 0.006 |
| | 25731 | 53 | NR | 59 | NC | NC | NC | 0.010 | 0.022 | 0.031 |
| | 25699 | 53 | NR | 3 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | 25167 | 53 | NR | 55 | NC | NC | NC | 0.010 | 0.020 | 0.029 |
| | 26736 | 53 | NR | 42.5 | NC | NC | NC | 0.008 | 0.016 | 0.023 |
| | 20704 | 53 | NR | 2 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | 20968 | 53 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 20969 | 53 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 20970 | 53 | NR | NR | NC | NC | NC | NC | NC | NC |
| CDFA | 25108 | 45 | NR | 6.5 | NC | NC | NC | 0.001 | 0.003 | 0.004 |
| | 23226 | 45 | NR | 57 | NC | NC | NC | 0.012 | 0.025 | 0.036 |
| Wash St | H4770 | 45 | 721 | 40.2 | 0.151[e] | 0.311[e] | 0.452[e] | 0.008 | 0.017 | 0.025 |
| Raven | TSP#1[f] | 45 | 189 | 3.2 | 0.039 | 0.081 | 0.118 | 0.001 | 0.001 | 0.002 |
| | TSP#2 | 45 | 154 | 3.5 | 0.032 | 0.066 | 0.097 | 0.001 | 0.002 | 0.002 |
| Hamamo | TSP#1 | 46 | 162 | NR | 0.033 | 0.068 | 0.099 | NC | NC | NC |
| | TSP#5 | 46 | 203 | NR | 0.041 | 0.086 | 0.124 | NC | NC | NC |
| | SP#2 | 21 | 48.7 | NR | 0.022 | 0.045 | 0.065 | NC | NC | NC |
| | SP#4 | 21 | 194 | NR | 0.087 | 0.179 | 0.261 | NC | NC | NC |
| Charter | TSP-1 | 45 | NR | 3.7 | NC | NC | NC | 0.001 | 0.002 | 0.002 |
| | TSP-2 | 45 | NR | 3.2 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | TSP-3 | 45 | NR | 2.1 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | TSP-4 | 45 | NR | 5.8 | NC | NC | NC | 0.001 | 0.003 | 0.004 |

Note: Footnotes may be found at the end of this table

## Table G-1d. (Continued)

| Source[a] | ID[b] | Percent $P_2O_5$ | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Cu addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Charter | TSP-5 | 45 | NR | 2.1 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | TSP-6 | 45 | NR | 3.7 | NC | NC | NC | 0.001 | 0.002 | 0.002 |
| | TSP-7 | 45 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | TSP-8 | 45 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | TSP-9 | 45 | NR | 13 | NC | NC | NC | 0.003 | 0.006 | 0.008 |
| | TSP-10 | 45 | NR | 2.6 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | TSP-11 | 45 | NR | 2.6 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | TSP-12 | 45 | NR | 2.6 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | TSP-13 | 45 | NR | 2.6 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | TSP-14 | 45 | NR | 2.1 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | TSP-15 | 45 | NR | 3.2 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | TSP-16 | 45 | NR | 5.8 | NC | NC | NC | 0.001 | 0.003 | 0.004 |
| | TSP-17 | 45 | NR | 3.7 | NC | NC | NC | 0.001 | 0.002 | 0.002 |
| | TSP-18 | 45 | NR | 3.7 | NC | NC | NC | 0.001 | 0.002 | 0.002 |
| | TSP-19 | 45 | NR | 3.2 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | TSP-20 | 45 | NR | 2.6 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | TSP-21 | 45 | NR | 2.6 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | TSP-22 | 45 | NR | 2.1 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | TSP-23 | 45 | NR | 4.2 | NC | NC | NC | 0.001 | 0.002 | 0.003 |
| | TSP-24 | 45 | NR | 3.7 | NC | NC | NC | 0.001 | 0.002 | 0.002 |
| M&O | TSP | 45 | NR | 55 | NC | NC | NC | 0.011 | 0.024 | 0.034 |
| CDFA | 25972 | 20 | NR | 690 | NC | NC | NC | 0.324 | 0.669 | 0.973 |
| | 25658 | 20 | NR | 1170 | NC | NC | NC | 0.550[e] | 1.135[e] | 1.650[e] |
| | 24682 | 20 | NR | 33 | NC | NC | NC | 0.016 | 0.032 | 0.047 |
| | 22899 | 15 | NR | 1 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | 20705 | 15 | NR | 7 | NC | NC | NC | 0.004 | 0.009 | 0.013 |
| | 21244 | 23 | NR | 53.5 | NC | NC | NC | 0.022 | 0.045 | 0.066 |
| | 20986 | 33.5 | NR | 31.5 | NC | NC | NC | 0.009 | 0.018 | 0.027 |
| | 20987 | 33.5 | NR | 250 | NC | NC | NC | 0.070 | 0.145 | 0.210 |
| Wash St | H2549 | 68 | 57.2 | 0.2 | 0.008 | 0.016 | 0.024 | 0.000 | 0.000 | 0.000 |
| Average | | 45.3 | 280.3 | 56.6 | 0.052 | 0.107 | 0.155 | 0.020 | 0.042 | 0.061 |

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
Hamamo: Hamamo et al. (1995)
Charter: Charter et al. (1993);
M&O: Mortvedt and Osborn (1982)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Shading indicates highest yearly addition values of this metal from phosphate products
f) TSP = Triple superphosphate

## Table G-1e. Yearly Zn Additions to Soil (kg/ha) from $P_2O_5$ Fertilizers

| Source[a] | ID[b] | Percent $P_2O_5$ in product | Zn mg/kg | Yearly Zn addition in kg/ha at 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|
| Wash St | H4770 | 45 | 1260 | 0.263 | 0.543 | 0.790 |
| Raven | TSP#1[c] | 45 | 61.3 | 0.013 | 0.026 | 0.038 |
| | TSP#2 | 45 | NR[d] | NC[e] | NC | NC |
| Charter | TSP-1 | 45 | 77 | 0.016 | 0.033 | 0.048 |
| | TSP-2 | 45 | 108 | 0.023 | 0.047 | 0.068 |
| | TSP-3 | 45 | 75 | 0.016 | 0.032 | 0.047 |
| | TSP-4 | 45 | 80 | 0.017 | 0.034 | 0.050 |
| | TSP-5 | 45 | 85 | 0.018 | 0.037 | 0.053 |
| | TSP-6 | 45 | 346 | 0.072 | 0.149 | 0.217 |
| | TSP-7 | 45 | 82 | 0.017 | 0.035 | 0.051 |
| | TSP-8 | 45 | 77 | 0.016 | 0.033 | 0.048 |
| | TSP-9 | 45 | 696 | 0.145 | 0.300 | 0.436 |
| | TSP-10 | 45 | 82 | 0.017 | 0.035 | 0.051 |
| | TSP-11 | 45 | 95 | 0.020 | 0.041 | 0.060 |
| | TSP-12 | 45 | 96 | 0.020 | 0.041 | 0.060 |
| | TSP-13 | 45 | 100 | 0.021 | 0.043 | 0.063 |
| | TSP-14 | 45 | 98 | 0.020 | 0.042 | 0.061 |
| | TSP-15 | 45 | 105 | 0.022 | 0.045 | 0.066 |
| | TSP-16 | 45 | 92 | 0.019 | 0.040 | 0.058 |
| | TSP-17 | 45 | 93 | 0.019 | 0.040 | 0.058 |
| | TSP-18 | 45 | 242 | 0.051 | 0.104 | 0.152 |
| | TSP-19 | 45 | 313 | 0.065 | 0.135 | 0.196 |
| | TSP-20 | 45 | 191 | 0.040 | 0.082 | 0.120 |
| | TSP-21 | 45 | 276 | 0.058 | 0.119 | 0.173 |
| | TSP-22 | 45 | 100 | 0.021 | 0.043 | 0.063 |
| | TSP-23 | 45 | 92 | 0.019 | 0.040 | 0.058 |
| | TSP-24 | 45 | 221 | 0.046 | 0.095 | 0.138 |
| M&O | TSP | 45 | 1550 | 0.324[f] | 0.668 | 0.971 |
| Wash St | H2549 | 68 | 31.3 | 0.004 | 0.009 | 0.013 |
| Average | | 45.8 | 240.2 | 0.050 | 0.103 | 0.150 |

a) Sources:
Washington State Department of Ecology (1997)
Raven and Loeppert (1997)
Charter et al. (1993)
Mortvedt and Osborn (1982)
b) Sample identification used by author
c) TSP = Triple superphosphate
d) NR = not reported
e) NC = not calculated
f) Shading indicates highest yearly addition values of this metal from phosphate products

**Table G-2a. Yearly Cd and Pb Additions to Soil (kg/ha) from NPK Fertilizers Applied for $P_2O_5$ Content**

| | | | | | | | Yearly Cd Addition in kg/ha soil at: | | | Yearly Pb Addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Percent | | | Cd | Pb | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| Source[a] | ID[b] | N | P | K | mg/kg | mg/kg | 94 kg/ha | 194 kg/ha | 282 kg/ha | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| Charter | MAP-1[b] | 11 | 52 | 0 | 6.4 | 4.5 | 0.001 | 0.002 | 0.003 | 0.001 | 0.002 | 0.002 |
| | MAP-2 | 11 | 52 | 0 | 6.7 | 4.5 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-3 | 11 | 52 | 0 | 7.3 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-4 | 11 | 52 | 0 | 7.4 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-5 | 11 | 52 | 0 | 7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-6 | 11 | 52 | 0 | 7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-7 | 11 | 52 | 0 | 6.7 | 4.5 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-8 | 11 | 52 | 0 | 7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-9 | 11 | 52 | 0 | 6.7 | 4.5 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-10 | 11 | 52 | 0 | 6.7 | 4.5 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-11 | 11 | 52 | 0 | 7.1 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-12 | 11 | 52 | 0 | 7.7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-13 | 11 | 52 | 0 | 8.3 | 4.5 | 0.002 | 0.003 | 0.005 | 0.001 | 0.002 | 0.002 |
| | MAP-14 | 11 | 52 | 0 | 7.4 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-15 | 11 | 52 | 0 | 7 | 12 | 0.001 | 0.003 | 0.004 | 0.002 | 0.004 | 0.007 |
| | MAP-16 | 11 | 52 | 0 | 6.7 | 4.5 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-17 | 11 | 52 | 0 | 7.7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-18 | 11 | 52 | 0 | 7.3 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-19 | 11 | 52 | 0 | 7.3 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-20 | 11 | 52 | 0 | 6.7 | 4.5 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-21 | 11 | 52 | 0 | 6.7 | 4.5 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-22 | 11 | 52 | 0 | 7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | MAP-23 | 11 | 52 | 0 | 7.7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.002 |
| | DAP-1[d] | 18 | 46 | 0 | 5.4 | 12 | 0.001 | 0.002 | 0.003 | 0.002 | 0.005 | 0.007 |
| | DAP-2 | 18 | 46 | 0 | 6.7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-3 | 18 | 46 | 0 | 6.7 | 12 | 0.001 | 0.003 | 0.004 | 0.002 | 0.005 | 0.007 |
| | DAP-4 | 18 | 46 | 0 | 8.9 | 4.5 | 0.002 | 0.004 | 0.005 | 0.001 | 0.002 | 0.003 |
| | DAP-5 | 18 | 46 | 0 | 94 | 4.5 | 0.019 | 0.040 | 0.058 | 0.001 | 0.002 | 0.003 |
| | DAP-6 | 18 | 46 | 0 | 6.4 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-7 | 18 | 46 | 0 | 6.4 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-8 | 18 | 46 | 0 | 6 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-9 | 18 | 46 | 0 | 7.3 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-10 | 18 | 46 | 0 | 6 | 12 | 0.001 | 0.003 | 0.004 | 0.002 | 0.005 | 0.007 |
| | DAP-11 | 18 | 46 | 0 | 8.6 | 4.5 | 0.002 | 0.004 | 0.005 | 0.001 | 0.002 | 0.003 |
| | DAP-12 | 18 | 46 | 0 | 6 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-13 | 18 | 46 | 0 | 5.7 | 4.5 | 0.001 | 0.002 | 0.003 | 0.001 | 0.002 | 0.003 |
| | DAP-14 | 18 | 46 | 0 | 5.7 | 4.5 | 0.001 | 0.002 | 0.003 | 0.001 | 0.002 | 0.003 |
| | DAP-15 | 18 | 46 | 0 | 7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |

Note: Footnotes may be found at the end of this table

## Table G-2a. (Continued)

| Source[a] | ID[b] | Percent N | Percent P | Percent K | Cd mg/kg | Pb mg/kg | Yearly Cd Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Pb Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Charter | DAP-16 | 18 | 46 | 0 | 6.3 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-17 | 18 | 46 | 0 | 6.7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-18 | 18 | 46 | 0 | 8.6 | 4.5 | 0.002 | 0.004 | 0.005 | 0.001 | 0.002 | 0.003 |
| | DAP-19 | 18 | 46 | 0 | 7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-20 | 18 | 46 | 0 | 6.7 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-21 | 18 | 46 | 0 | 6.4 | 12 | 0.001 | 0.003 | 0.004 | 0.002 | 0.005 | 0.007 |
| | DAP-22 | 18 | 46 | 0 | 7.3 | 12 | 0.001 | 0.003 | 0.004 | 0.002 | 0.005 | 0.007 |
| | DAP-23 | 18 | 46 | 0 | 7 | 12 | 0.001 | 0.003 | 0.004 | 0.002 | 0.005 | 0.007 |
| | DAP-24 | 18 | 46 | 0 | 6 | 4.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | DAP-25 | 18 | 46 | 0 | 6.4 | 12 | 0.001 | 0.003 | 0.004 | 0.002 | 0.005 | 0.007 |
| Wash St | H4754 | 11 | 52 | 0 | 0.15 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | H4755 | 18 | 46 | 0 | 6.9 | 2.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.001 | 0.002 |
| | H4762 | 16 | 15 | 15 | 0.75 | 5 | 0.000 | 0.001 | 0.001 | 0.003 | 0.006 | 0.009 |
| | H2526 | 11 | 37 | 0 | 0.6 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| | H2574 | 11 | 30 | 0 | 1.6 | 1 | 0.001 | 0.001 | 0.002 | 0.000 | 0.001 | 0.001 |
| | H2532 | 16 | 20 | 0 | 145 | 4.4 | 0.068 | **0.141**[e] | **0.204**[e] | 0.002 | 0.004 | 0.006 |
| | H2546 | 10 | 34 | 0 | 25 | 1 | 0.007 | 0.014 | 0.021 | 0.000 | 0.001 | 0.001 |
| Raven | MAP-1 | 11 | 52 | 0 | 0.15 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | MAP-2 | 11 | 52 | 0 | 4 | 2.9 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.002 |
| | DAP-1 | 18 | 46 | 0 | 4.6 | 3.7 | 0.001 | 0.002 | 0.003 | 0.001 | 0.002 | 0.002 |
| | DAP-2 | 18 | 46 | 0 | 35.5 | 2.1 | 0.007 | 0.015 | 0.022 | 0.000 | 0.001 | 0.001 |
| IMC | 8813182 | 18 | 46 | 0 | 5 | 0.88 | 0.001 | 0.002 | 0.003 | 0.000 | 0.000 | 0.001 |
| | 8813183 | 11 | 52 | 0 | 5.4 | 1 | 0.001 | 0.002 | 0.003 | 0.000 | 0.000 | 0.001 |
| | 8813184 | 11 | 52 | 0 | 5.6 | 2.9 | 0.001 | 0.002 | 0.003 | 0.001 | 0.001 | 0.002 |
| M&O | DAP(A) | 18 | 46 | 0 | 48 | 13 | 0.010 | 0.020 | 0.029 | 0.003 | 0.005 | 0.008 |
| | DAP(B) | 18 | 46 | 0 | 73 | 13 | 0.015 | 0.031 | 0.045 | 0.003 | 0.005 | 0.008 |
| | DAP(C) | 18 | 46 | 0 | 131 | 15 | 0.027 | 0.055 | 0.080 | 0.003 | 0.006 | 0.009 |
| | DAP(D) | 18 | 46 | 0 | 188 | 15 | 0.038 | 0.079 | **0.115** | 0.003 | 0.006 | 0.009 |
| MMO | DAP1 | 21 | 53 | 0 | 2 | 4 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 |
| | DAP2 | 18 | 46 | 0 | 74 | 8 | 0.015 | 0.031 | 0.045 | 0.002 | 0.003 | 0.005 |
| | DAP3 | 18 | 46 | 0 | 153 | 6 | 0.031 | 0.065 | **0.094** | 0.001 | 0.003 | 0.004 |

Note: Footnotes may be found at the end of this table

## Table G-2a. (Continued)

| | | | | | | | Yearly Cd Addition in kg/ha soil at: | | | Yearly Pb Addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Percent | | | Cd | Pb | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| Source[a] | ID[b] | N | P | K | mg/kg | mg/kg | 94 kg/ha | 194 kg/ha | 282 kg/ha | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| CDFA | 24295 | 10 | 34 | 0 | 28 | 0 | 0.008 | 0.016 | 0.023 | 0.000 | 0.000 | 0.000 |
| | 23730 | 4 | 21 | 25 | 105 | 2340 | 0.047 | **0.097** | **0.141** | 1.047 | 2.162 | **3.142** |
| | 23845 | 5 | 24 | 24 | 110 | 1700 | 0.043 | **0.089** | **0.129** | 0.666 | 1.374 | 1.998 |
| | 23647 | 4 | 5 | 3 | 0 | 2 | 0.000 | 0.000 | 0.000 | 0.004 | 0.008 | 0.011 |
| | 23622 | 11 | 52 | 0 | 162.5 | 4 | 0.029 | 0.061 | 0.088 | 0.001 | 0.001 | 0.002 |
| | 23202 | 11 | 52 | 0 | 0 | 1.7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| | 22278 | 11 | 52 | 0 | 135.5 | 0 | 0.024 | 0.051 | 0.073 | 0.000 | 0.000 | 0.000 |
| | 22396 | 11 | 52 | 0 | 166 | 4 | 0.030 | 0.062 | **0.090** | 0.001 | 0.001 | 0.002 |
| | 22245 | 19 | 24 | 18 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 21842 | 14.4 | 23.4 | 0 | 81.5 | 4650 | 0.033 | 0.068 | **0.098** | 1.868 | **3.855** | **5.604** |
| | 21884 | 14.2 | 13 | 30 | 37 | 23 | 0.027 | 0.055 | 0.080 | 0.017 | 0.034 | 0.050 |
| | 21936 | 6 | 20 | 20 | 60 | 266 | 0.028 | 0.058 | 0.085 | 0.125 | 0.258 | 0.375 |
| | 21946 | 16 | 16 | 16 | 32.5 | 0 | 0.019 | 0.039 | 0.057 | 0.000 | 0.000 | 0.000 |
| | 21949 | 15 | 15 | 15 | 9 | 2 | 0.006 | 0.012 | 0.017 | 0.001 | 0.003 | 0.004 |
| | 22023 | 8.5 | 40 | 0 | 200 | 5425 | 0.047 | **0.097** | **0.141** | 1.275 | **2.631** | **3.825** |
| | 22026 | 20 | 20 | 20 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 22244 | 4 | 12 | 8 | 42 | 2.5 | 0.033 | 0.068 | **0.099** | 0.002 | 0.004 | 0.006 |
| | 25338 | 18 | 12 | 12 | 95 | 3600 | **0.074**[f] | **0.154** | **0.223** | **2.820** | **5.820** | **8.460** |
| | 26520 | 12 | 61 | 0 | 0 | 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| | 26361 | 6 | 12 | 6 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 26412 | 18 | 46 | 0 | 5 | 2 | 0.001 | 0.002 | 0.003 | 0.000 | 0.001 | 0.001 |
| | 25861 | 18 | 46 | 0 | 5 | 2.5 | 0.001 | 0.002 | 0.003 | 0.001 | 0.001 | 0.002 |
| Average | | 14.1 | 42.9 | 2.33 | 28.6 | 202.3 | 0.008 | 0.017 | 0.025 | 0.087 | 0.179 | 0.261 |

a) Sources:
   Charter: Charter et al. (1993)
   Wash St: Washington State Department of Ecology 1997)
   Raven: Raven and Loeppert (1997)
   IMC: International Mineral Company (1997)
   M&O: Mortvedt and Osborn (1982)
   MMO: Mortvedt, Mays and Osborne (1981)
   CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author
c) MAP = monoammonium phosphate
d) DAP = diammonium phosphate
e) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal
f) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)

**Table G-2b. Yearly As and Cr Additions to Soil (kg/ha) from NPK Fertilizers Applied for $P_2O_5$ Content**

| Source[a] | ID[b] | Percent | | | As mg/kg | Cr mg/kg | Yearly As Addition in kg/ha soil at: | | | Yearly Cr Addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| | | N | P | K | | | 94 kg/ha | 194 kg/ha | 282 kg/ha | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| Charter | MAP-1[c] | 11 | 52 | 0 | 12.1 | 54 | 0.002 | 0.005 | 0.007 | 0.010 | 0.020 | 0.029 |
| | MAP-2 | 11 | 52 | 0 | 14.1 | 55 | 0.003 | 0.005 | 0.008 | 0.010 | 0.021 | 0.030 |
| | MAP-3 | 11 | 52 | 0 | 17.1 | 56 | 0.003 | 0.006 | 0.009 | 0.010 | 0.021 | 0.030 |
| | MAP-4 | 11 | 52 | 0 | 9.5 | 55 | 0.002 | 0.004 | 0.005 | 0.010 | 0.021 | 0.030 |
| | MAP-5 | 11 | 52 | 0 | 12.4 | 59 | 0.002 | 0.005 | 0.007 | 0.011 | 0.022 | 0.032 |
| | MAP-6 | 11 | 52 | 0 | 12.4 | 55 | 0.002 | 0.005 | 0.007 | 0.010 | 0.021 | 0.030 |
| | MAP-7 | 11 | 52 | 0 | 16 | 57 | 0.003 | 0.006 | 0.009 | 0.010 | 0.021 | 0.031 |
| | MAP-8 | 11 | 52 | 0 | 8.1 | 59 | 0.001 | 0.003 | 0.004 | 0.011 | 0.022 | 0.032 |
| | MAP-9 | 11 | 52 | 0 | 14.9 | 73 | 0.003 | 0.006 | 0.008 | 0.013 | 0.027 | 0.040 |
| | MAP-10 | 11 | 52 | 0 | 14.8 | 58 | 0.003 | 0.006 | 0.008 | 0.010 | 0.022 | 0.031 |
| | MAP-11 | 11 | 52 | 0 | 16.1 | 54 | 0.003 | 0.006 | 0.009 | 0.010 | 0.020 | 0.029 |
| | MAP-12 | 11 | 52 | 0 | 9.9 | 55 | 0.002 | 0.004 | 0.005 | 0.010 | 0.021 | 0.030 |
| | MAP-13 | 11 | 52 | 0 | 11.2 | 57 | 0.002 | 0.004 | 0.006 | 0.010 | 0.021 | 0.031 |
| | MAP-14 | 11 | 52 | 0 | 10.8 | 55 | 0.002 | 0.004 | 0.006 | 0.010 | 0.021 | 0.030 |
| | MAP-15 | 11 | 52 | 0 | 8.9 | 62 | 0.002 | 0.003 | 0.005 | 0.011 | 0.023 | 0.034 |
| | MAP-16 | 11 | 52 | 0 | 14.3 | 56 | 0.003 | 0.005 | 0.008 | 0.010 | 0.021 | 0.030 |
| | MAP-17 | 11 | 52 | 0 | 10.7 | 56 | 0.002 | 0.004 | 0.006 | 0.010 | 0.021 | 0.030 |
| | MAP-18 | 11 | 52 | 0 | 10.9 | 56 | 0.002 | 0.004 | 0.006 | 0.010 | 0.021 | 0.030 |
| | MAP-19 | 11 | 52 | 0 | 17.8 | 57 | 0.003 | 0.007 | 0.010 | 0.010 | 0.021 | 0.031 |
| | MAP-20 | 11 | 52 | 0 | 12.9 | 51 | 0.002 | 0.005 | 0.007 | 0.009 | 0.019 | 0.028 |
| | MAP-21 | 11 | 52 | 0 | 15.5 | 54 | 0.003 | 0.006 | 0.008 | 0.010 | 0.020 | 0.029 |
| | MAP-22 | 11 | 52 | 0 | 11.4 | 58 | 0.002 | 0.004 | 0.006 | 0.010 | 0.022 | 0.031 |
| | MAP-23 | 11 | 52 | 0 | 11.2 | 56 | 0.002 | 0.004 | 0.006 | 0.010 | 0.021 | 0.030 |

Note: Footnotes may be found at the end of this table

## Table G-2b. (Continued)

| Source[a] | ID[b] | Percent | | | As mg/kg | Cr mg/kg | Yearly As Addition in kg/ha soil at: | | | Yearly Cr Addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| | | N | P | K | | | 94 kg/ha | 194 kg/ha | 282 kg/ha | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| Charter | DAP-1[d] | 18 | 46 | 0 | 13.1 | 53 | 0.003 | 0.008 | 0.008 | 0.011 | 0.022 | 0.032 |
| | DAP-2 | 18 | 46 | 0 | 15.4 | 50 | 0.003 | 0.006 | 0.009 | 0.010 | 0.021 | 0.031 |
| | DAP-3 | 18 | 46 | 0 | 15.6 | 48 | 0.003 | 0.007 | 0.010 | 0.010 | 0.020 | 0.029 |
| | DAP-4 | 18 | 46 | 0 | 13.8 | 48 | 0.003 | 0.006 | 0.008 | 0.010 | 0.020 | 0.029 |
| | DAP-5 | 18 | 46 | 0 | 6.8 | 616 | 0.001 | 0.003 | 0.004 | 0.126 | 0.260 | 0.378 |
| | DAP-6 | 18 | 46 | 0 | 9.9 | 49 | 0.002 | 0.004 | 0.006 | 0.010 | 0.021 | 0.030 |
| | DAP-7 | 18 | 46 | 0 | 12.4 | 48 | 0.003 | 0.005 | 0.008 | 0.010 | 0.020 | 0.029 |
| | DAP-8 | 18 | 46 | 0 | 12.5 | 49 | 0.003 | 0.005 | 0.008 | 0.010 | 0.021 | 0.030 |
| | DAP-9 | 18 | 46 | 0 | 11.1 | 45 | 0.002 | 0.005 | 0.007 | 0.009 | 0.019 | 0.028 |
| | DAP-10 | 18 | 46 | 0 | 13.1 | 45 | 0.003 | 0.006 | 0.008 | 0.009 | 0.019 | 0.028 |
| | DAP-11 | 18 | 46 | 0 | 11.1 | 47 | 0.002 | 0.005 | 0.007 | 0.010 | 0.020 | 0.029 |
| | DAP-12 | 18 | 46 | 0 | 13.3 | 47 | 0.003 | 0.006 | 0.008 | 0.010 | 0.020 | 0.029 |
| | DAP-13 | 18 | 46 | 0 | 11.1 | 46 | 0.002 | 0.005 | 0.007 | 0.009 | 0.019 | 0.028 |
| | DAP-14 | 18 | 46 | 0 | 13.5 | 47 | 0.003 | 0.006 | 0.008 | 0.010 | 0.020 | 0.029 |
| | DAP-15 | 18 | 46 | 0 | 13 | 50 | 0.003 | 0.005 | 0.008 | 0.010 | 0.021 | 0.031 |
| | DAP-16 | 18 | 46 | 0 | 10.4 | 50 | 0.002 | 0.004 | 0.006 | 0.010 | 0.021 | 0.031 |
| | DAP-17 | 18 | 46 | 0 | 12.8 | 49 | 0.003 | 0.005 | 0.008 | 0.010 | 0.021 | 0.030 |
| | DAP-18 | 18 | 46 | 0 | 12.2 | 48 | 0.002 | 0.005 | 0.007 | 0.010 | 0.020 | 0.029 |
| | DAP-19 | 18 | 46 | 0 | 11.7 | 47 | 0.002 | 0.005 | 0.007 | 0.010 | 0.020 | 0.029 |
| | DAP-20 | 18 | 46 | 0 | 14.2 | 49 | 0.003 | 0.006 | 0.009 | 0.010 | 0.021 | 0.030 |
| | DAP-21 | 18 | 46 | 0 | 15/4 | 47 | 0.003 | 0.006 | 0.009 | 0.010 | 0.020 | 0.029 |
| | DAP-22 | 18 | 46 | 0 | 10.6 | 51 | 0.002 | 0.004 | 0.006 | 0.010 | 0.022 | 0.031 |
| | DAP-23 | 18 | 46 | 0 | 11.2 | 50 | 0.002 | 0.005 | 0.007 | 0.010 | 0.021 | 0.031 |
| | DAP-24 | 18 | 46 | 0 | 11.2 | 47 | 0.002 | 0.005 | 0.007 | 0.010 | 0.020 | 0.029 |
| | DAP-25 | 18 | 46 | 0 | 11.1 | 49 | 0.002 | 0.005 | 0.007 | 0.010 | 0.021 | 0.030 |

Note: Footnotes may be found at the end of this table

## Table G-2b. (Continued)

| Source[a] | ID[b] | Percent N | Percent P | Percent K | As mg/kg | Cr mg/kg | Yearly As Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Cr Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H4754 | 11 | 52 | 0 | 6.8 | 5.8 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | H4755 | 18 | 46 | 0 | 18 | 92 | 0.004 | 0.008 | 0.011 | 0.019 | 0.039 | 0.056 |
| | H4762 | 16 | 15 | 15 | 8 | 4.3 | 0.005 | 0.010 | 0.015 | 0.003 | 0.006 | 0.008 |
| | H2526 | 11 | 37 | 0 | 1.5 | 433 | 0.000 | 0.001 | 0.001 | 0.110 | 0.227 | 0.330 |
| | H2574 | 11 | 30 | 0 | 1.5 | 379 | 0.000 | 0.001 | 0.001 | 0.119 | 0.245 | 0.356 |
| | H2532 | 16 | 20 | 0 | 4.2 | 214 | 0.002 | 0.004 | 0.006 | 0.101 | 0.208 | 0.302 |
| | H2546 | 10 | 34 | 0 | 4.8 | 400 | 0.001 | 0.003 | 0.004 | 0.111 | 0.228 | 0.332 |
| Raven | MAP-1 | 11 | 52 | 0 | 10.9 | 16.9 | 0.002 | 0.004 | 0.006 | 0.003 | 0.006 | 0.009 |
| | MAP-2 | 11 | 52 | 0 | 13.7 | NR | 0.002 | 0.005 | 0.007 | NC | NC | NC |
| | DAP-1 | 18 | 46 | 0 | 9.9 | NR | 0.002 | 0.004 | 0.006 | NC | NC | NC |
| | DAP-2 | 18 | 46 | 0 | 16.2 | 196 | 0.003 | 0.007 | 0.010 | 0.040 | 0.083 | 0.120 |
| IMC | 8813182 | 18 | 46 | 0 | 0.05 | 64 | 0.000 | 0.000 | 0.000 | 0.013 | 0.027 | 0.039 |
| | 8813183 | 11 | 52 | 0 | 0.05 | 71 | 0.000 | 0.000 | 0.000 | 0.013 | 0.026 | 0.039 |
| | 8813184 | 11 | 52 | 0 | 0.05 | 75 | 0.000 | 0.000 | 0.000 | 0.014 | 0.028 | 0.041 |
| M&O | DAP(A) | 18 | 46 | 0 | NR[f] | NR | NC[g] | NC | NC | NC | NC | NC |
| | DAP(B) | 18 | 46 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | DAP(C) | 18 | 46 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | DAP(D) | 18 | 46 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| MMO | DAP1 | 21 | 53 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | DAP2 | 18 | 46 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | DAP3 | 18 | 46 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |

Note: Footnotes may be found at the end of this table

## Table G-2b. (Continued)

| Source[a] | ID[b] | Percent N | Percent P | Percent K | As mg/kg | Cr mg/kg | Yearly As Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Cr Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 24295 | 10 | 34 | 0 | 10 | NR | 0.003 | 0.006 | 0.008 | NC | NC | NC |
| | 23730 | 4 | 21 | 25 | 11.5 | NR | 0.005 | 0.011 | 0.015 | NC | NC | NC |
| | 23845 | 5 | 24 | 24 | 8.4 | NR | 0.003 | 0.007 | 0.010 | NC | NC | NC |
| | 23647 | 4 | 5 | 3 | 0.6 | NR | 0.001 | 0.002 | 0.003 | NC | NC | NC |
| | 23622 | 11 | 52 | 0 | 15.5 | NR | 0.003 | 0.006 | 0.008 | NC | NC | NC |
| | 23202 | 11 | 52 | 0 | 3.5 | NR | 0.001 | 0.001 | 0.002 | NC | NC | NC |
| | 22278 | 11 | 52 | 0 | 12.5 | NR | 0.002 | 0.005 | 0.007 | NC | NC | NC |
| | 22396 | 11 | 52 | 0 | 16 | NR | 0.003 | 0.006 | 0.009 | NC | NC | NC |
| | 22245 | 19 | 24 | 18 | 5.5 | NR | 0.002 | 0.004 | 0.006 | NC | NC | NC |
| | 21842 | 14.4 | 23.4 | 0 | 32.5 | NR | 0.013 | 0.027 | 0.039 | NC | NC | NC |
| | 21884 | 14.2 | 13 | 30 | 155 | NR | 0.112 | 0.231 | **0.336**[h] | NC | NC | NC |
| | 21936 | 6 | 20 | 20 | 45 | NR | 0.021 | 0.044 | 0.063 | NC | NC | NC |
| | 21946 | 16 | 16 | 16 | 2.5 | NR | 0.001 | 0.003 | 0.004 | NC | NC | NC |
| | 21949 | 15 | 15 | 15 | 6 | NR | 0.004 | 0.008 | 0.011 | NC | NC | NC |
| | 22023 | 8.5 | 40 | 0 | 23.5 | NR | 0.006 | 0.011 | 0.017 | NC | NC | NC |
| | 22026 | 20 | 20 | 20 | 4 | NR | 0.002 | 0.004 | 0.006 | NC | NC | NC |
| | 22244 | 4 | 12 | 8 | 3 | NR | 0.002 | 0.005 | 0.007 | NC | NC | NC |
| | 25338 | 18 | 12 | 12 | 11.2 | NR | 0.009 | 0.018 | 0.026 | NC | NC | NC |
| | 26520 | 12 | 61 | 0 | 0.65 | NR | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| | 26361 | 6 | 12 | 6 | 0.4 | NR | 0.000 | 0.001 | 0.001 | NC | NC | NC |
| | 26412 | 18 | 46 | 0 | 8 | NR | 0.002 | 0.003 | 0.005 | NC | NC | NC |
| | 25861 | 18 | 46 | 0 | 8.5 | NR | 0.002 | 0.004 | 0.005 | NC | NC | NC |
| Average | | 14.1 | 42.9 | 2.3 | 13.3 | 83.9 | 0.004 | 0.008 | 0.012 | 0.019 | 0.039 | 0.057 |

a) Sources:
Charter: Charter et al. (1993) and Charter et al. (1995) for As
Wash St: Washington State Department of Ecology (1997)
Rave: Raven and Loeppert (1997)
IMC: International Mineral Company (1997)
M&O: Mortvedt and Osborn (1982)
MMO: Mortvedt, Mays and Osborne (1981)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) MAP = monoammonium phosphate
d) DAP = diammonium phosphate
e) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)
f) NR = not reported
g) NC = not calculated
h) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this contaminant

## Table G-2c. Yearly Hg and Ni Additions to Soil (kg/ha) from NPK Fertilizers Applied for $P_2O_5$ Content

| Source[a] | ID[b] | Percent N | Percent P | Percent K | Hg mg/kg | Ni mg/kg | Yearly Hg Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Ni Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Charter | MAP-1[c] | 11 | 52 | 0 | NR[d] | 15 | NC[e] | NC | NC | 0.003 | 0.006 | 0.008 |
| | MAP-2 | 11 | 52 | 0 | NR | 17 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-3 | 11 | 52 | 0 | NR | 20 | NC | NC | NC | 0.004 | 0.007 | 0.011 |
| | MAP-4 | 11 | 52 | 0 | NR | 18 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | MAP-5 | 11 | 52 | 0 | NR | 17 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-6 | 11 | 52 | 0 | NR | 16 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-7 | 11 | 52 | 0 | NR | 16 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-8 | 11 | 52 | 0 | NR | 15 | NC | NC | NC | 0.003 | 0.006 | 0.008 |
| | MAP-9 | 11 | 52 | 0 | NR | 18 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | MAP-10 | 11 | 52 | 0 | NR | 17 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-11 | 11 | 52 | 0 | NR | 15 | NC | NC | NC | 0.003 | 0.006 | 0.008 |
| | MAP-12 | 11 | 52 | 0 | NR | 18 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | MAP-13 | 11 | 52 | 0 | NR | 17 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-14 | 11 | 52 | 0 | NR | 16 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-15 | 11 | 52 | 0 | NR | 19 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | MAP-16 | 11 | 52 | 0 | NR | 17 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-17 | 11 | 52 | 0 | NR | 16 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-18 | 11 | 52 | 0 | NR | 19 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | MAP-19 | 11 | 52 | 0 | NR | 20 | NC | NC | NC | 0.004 | 0.007 | 0.011 |
| | MAP-20 | 11 | 52 | 0 | NR | 15 | NC | NC | NC | 0.003 | 0.006 | 0.008 |
| | MAP-21 | 11 | 52 | 0 | NR | 19 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | MAP-22 | 11 | 52 | 0 | NR | 17 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | MAP-23 | 11 | 52 | 0 | NR | 17 | NC | NC | NC | 0.003 | 0.006 | 0.009 |

Note: Footnotes may be found at the end of this table

## Table G-2c. (Continued)

| Source[a] | ID[b] | Percent N | Percent P | Percent K | Hg mg/kg | Ni mg/kg | Yearly Hg Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | Yearly Hg Addition in kg/ha soil at: 173 lb $P_2O_5$/A 194 kg/ha | Yearly Hg Addition in kg/ha soil at: 252 lb $P_2O_5$/A 282 kg/ha | Yearly Ni Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | Yearly Ni Addition in kg/ha soil at: 173 lb $P_2O_5$/A 194 kg/ha | Yearly Ni Addition in kg/ha soil at: 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Charter | DAP-1[f] | 18 | 46 | 0 | NR | 13 | NC | NC | NC | 0.003 | 0.005 | 0.008 |
| | DAP-2 | 18 | 46 | 0 | NR | 11 | NC | NC | NC | 0.002 | 0.005 | 0.007 |
| | DAP-3 | 18 | 46 | 0 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-4 | 18 | 46 | 0 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | DAP-5 | 18 | 46 | 0 | NR | 127 | NC | NC | NC | 0.026 | 0.054 | 0.078 |
| | DAP-6 | 18 | 46 | 0 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-7 | 18 | 46 | 0 | NR | 12 | NC | NC | NC | 0.002 | 0.005 | 0.007 |
| | DAP-8 | 18 | 46 | 0 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-9 | 18 | 46 | 0 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-10 | 18 | 46 | 0 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-11 | 18 | 46 | 0 | NR | 15 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-12 | 18 | 46 | 0 | NR | 17 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | DAP-13 | 18 | 46 | 0 | NR | 15 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-14 | 18 | 46 | 0 | NR | 19 | NC | NC | NC | 0.004 | 0.008 | 0.012 |
| | DAP-15 | 18 | 46 | 0 | NR | 13 | NC | NC | NC | 0.003 | 0.005 | 0.008 |
| | DAP-16 | 18 | 46 | 0 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | DAP-17 | 18 | 46 | 0 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-18 | 18 | 46 | 0 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | DAP-19 | 18 | 46 | 0 | NR | 15 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-20 | 18 | 46 | 0 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-21 | 18 | 46 | 0 | NR | 13 | NC | NC | NC | 0.003 | 0.005 | 0.008 |
| | DAP-22 | 18 | 46 | 0 | NR | 14 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| | DAP-23 | 18 | 46 | 0 | NR | 13 | NC | NC | NC | 0.003 | 0.005 | 0.008 |
| | DAP-24 | 18 | 46 | 0 | NR | 17 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | DAP-25 | 18 | 46 | 0 | NR | 16 | NC | NC | NC | 0.003 | 0.007 | 0.010 |

Note: Footnotes may be found at the end of this table

## Table G-2c. (Continued)

| Source[a] | ID[b] | Percent | | | Hg mg/kg | Ni mg/kg | Yearly Hg Addition in kg/ha soil at: | | | Yearly Ni Addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| | | N | P | K | | | 94 kg/ha | 194 kg/ha | 282 kg/ha | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| Wash St | H4754 | 11 | 52 | 0 | 0.0025 | 19.2 | 0.000 | 0.000 | 0.000 | 0.003 | 0.007 | 0.010 |
| | H4755 | 18 | 46 | 0 | 0.025 | 19.1 | 0.000[g,h] | 0.000 | 0.000 | 0.004 | 0.008 | 0.012 |
| | H4762 | 16 | 15 | 15 | 0.0025 | 2.5 | 0.000 | 0.000 | 0.000 | 0.002 | 0.003 | 0.005 |
| | H2526 | 11 | 37 | 0 | 0.0025 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H2574 | 11 | 30 | 0 | 0.0025 | 13.9 | 0.000 | 0.000 | 0.000 | 0.004 | 0.009 | 0.013 |
| | H2532 | 16 | 20 | 0 | 0.024 | 195 | 0.000 | 0.000 | 0.000 | 0.092 | 0.189 | 0.275 |
| | H2546 | 10 | 34 | 0 | 0.0025 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Raven | MAP-1 | 11 | 52 | 0 | 0.2 | 7.4 | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 | 0.004 |
| | MAP-2 | 11 | 52 | 0 | 0.2 | 22.2 | 0.000 | 0.000 | 0.000 | 0.004 | 0.008 | 0.012 |
| | DAP-1 | 18 | 46 | 0 | 0.2 | 15.5 | 0.000 | 0.000 | 0.000 | 0.003 | 0.007 | 0.010 |
| | DAP-2 | 18 | 46 | 0 | 0.2 | 48.3 | 0.000 | 0.000 | 0.000 | 0.010 | 0.020 | 0.030 |
| IMC | 8813182 | 18 | 46 | 0 | 0.05 | 11 | 0.000 | 0.000 | 0.000 | 0.002 | 0.005 | 0.007 |
| | 8813183 | 11 | 52 | 0 | 0.05 | 12 | 0.000 | 0.000 | 0.000 | 0.002 | 0.004 | 0.007 |
| | 8813184 | 11 | 52 | 0 | 0.05 | 10 | 0.000 | 0.000 | 0.000 | 0.002 | 0.004 | 0.005 |
| M&O | DAP(A) | 18 | 46 | 0 | NR | 53 | NC | NC | NC | 0.011 | 0.022 | 0.032 |
| | DAP(B) | 18 | 46 | 0 | NR | 120 | NC | NC | NC | 0.025 | 0.051 | 0.074 |
| | DAP(C) | 18 | 46 | 0 | NR | 125 | NC | NC | NC | 0.026 | 0.053 | 0.077 |
| | DAP(D) | 18 | 46 | 0 | NR | 135 | NC | NC | NC | 0.028 | 0.057 | 0.083 |
| MMO | DAP1 | 21 | 53 | 0 | NR | 10 | NC | NC | NC | 0.002 | 0.004 | 0.005 |
| | DAP2 | 18 | 46 | 0 | NR | 156 | NC | NC | NC | 0.032 | 0.066 | 0.096 |
| | DAP3 | 18 | 46 | 0 | NR | 120 | NC | NC | NC | 0.025 | 0.051 | 0.074 |

Note: Footnotes may be found at the end of this table

## Table G-2c. (Continued)

| Source | ID[b] | Percent N | Percent P | Percent K | Hg mg/kg | Ni mg/kg | Yearly Hg Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Ni Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 24295 | 10 | 34 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 23730 | 4 | 21 | 25 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 23845 | 5 | 24 | 24 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 23647 | 4 | 5 | 3 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 23622 | 11 | 52 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 23202 | 11 | 52 | 0 | NR | 19 | NC | NC | NC | 0.003 | 0.007 | 0.010 |
| | 22278 | 11 | 52 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 22396 | 11 | 52 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 22245 | 19 | 24 | 18 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 21842 | 14.4 | 23.4 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 21884 | 14.2 | 13 | 30 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 21936 | 6 | 20 | 20 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 21946 | 16 | 16 | 16 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 21949 | 15 | 15 | 15 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 22023 | 8.5 | 40 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 22026 | 20 | 20 | 20 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 22244 | 4 | 12 | 8 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 25338 | 18 | 12 | 12 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 26520 | 12 | 61 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 26361 | 6 | 12 | 6 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 26412 | 18 | 46 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 25861 | 18 | 46 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| Average | | 14.1 | 42.9 | 2.3 | 0.07 | 28.36 | 0.000 | 0.000 | 0.000 | 0.006 | 0.013 | 0.019 |

a) Sources:
Charter: Charter et al. (1993)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
IMC: International Mineral Company (1997)
M&O: Mortvedt and Osborn (1982)
MMO: Mortvedt, Mays and Osborne (1981)
CDFA: California Department of Food and Agriculture (1997)

b) Sample identification used by author
c) MAP = monoammonium phosphate
d) NR = not reported
e) NC = not calculated
f) DAP = diammonium phosphate
g) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)
h) Values chosen for highest yearly addition based on actual detection of Hg in samples; Raven samples are listed as ND, < detection limit of 0.4 and listed here as half the detection limit

## Table G-2d. Yearly V and Cu Additions to Soil (kg/ha) from NPK Fertilizers Applied for $P_2O_5$ Content

| Source[a] | ID[b] | Percent | | | V | Cu | Yearly V Addition in kg/ha soil at: | | | Yearly Cu Addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| | | N | P | K | mg/kg | mg/kg | 94 kg/ha | 194 kg/ha | 282 kg/ha | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| Charter | MAP-1[c] | 11 | 52 | 0 | NR[d] | 0.75 | NC[e] | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-2 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-3 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-4 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-5 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-6 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-7 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-8 | 11 | 52 | 0 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | MAP-9 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-10 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-11 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-12 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-13 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-14 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-15 | 11 | 52 | 0 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | MAP-16 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-17 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-18 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-19 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-20 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-21 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-22 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | MAP-23 | 11 | 52 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |

Note: Footnotes may be found at the end of the table

## Table G-2d. (Continued)

| Source[a] | ID[b] | Percent N | Percent P | Percent K | V mg/kg | Cu mg/kg | Yearly V Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Cu Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Charter | DAP-1[f] | 18 | 46 | 0 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | DAP-2 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-3 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-4 | 18 | 46 | 0 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | DAP-5 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-6 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-7 | 18 | 46 | 0 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | DAP-8 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-9 | 18 | 46 | 0 | NR | 3.2 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | DAP-10 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-11 | 18 | 46 | 0 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | DAP-12 | 18 | 46 | 0 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | DAP-13 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-14 | 18 | 46 | 0 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | DAP-15 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-16 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-17 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-18 | 18 | 46 | 0 | NR | 2.1 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | DAP-19 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-20 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-21 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-22 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-23 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | DAP-24 | 18 | 46 | 0 | NR | 1.6 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | DAP-25 | 18 | 46 | 0 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.000 |

Note: Footnotes may be found at the end of this table

## Table G-2d. (Continued)

| Source[a] | ID[b] | Percent N | Percent P | Percent K | V mg/kg | Cu mg/kg | Yearly V Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Cu Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H4754 | 11 | 52 | 0 | 37.9 | 3.6 | 0.007 | 0.014 | 0.021 | 0.001 | 0.001 | 0.002 |
| | H4755 | 18 | 46 | 0 | 174 | 5.4 | 0.036 | 0.073 | 0.107 | 0.001 | 0.002 | 0.003 |
| | H4762 | 16 | 15 | 15 | 25.7 | 80.7 | 0.016 | 0.033 | 0.048 | 0.051 | 0.104 | 0.152 |
| | H2526 | 11 | 37 | 0 | 31.7 | 0.5 | 0.008 | 0.017 | 0.024 | 0.000 | 0.000 | 0.000 |
| | H2574 | 11 | 30 | 0 | 32 | 5.8 | 0.010 | 0.021 | 0.030 | 0.002 | 0.004 | 0.005 |
| | H2532 | 16 | 20 | 0 | 396 | 16 | 0.186[g] | 0.384 | 0.558 | 0.008 | 0.016 | 0.023 |
| | H2546 | 10 | 34 | 0 | 228 | 3.3 | 0.063 | 0.130 | 0.189 | 0.001 | 0.002 | 0.003 |
| Raven | MAP-1 | 11 | 52 | 0 | 146 | 13.2 | 0.026 | 0.054 | 0.079 | 0.002 | 0.005 | 0.007 |
| | MAP-2 | 11 | 52 | 0 | 205 | 1 | 0.037 | 0.076 | 0.111 | 0.000 | 0.000 | 0.001 |
| | DAP-1 | 18 | 46 | 0 | 177 | 1 | 0.036 | 0.075 | 0.109 | 0.000 | 0.000 | 0.001 |
| | DAP-2 | 18 | 46 | 0 | 237 | 41.8 | 0.048 | 0.100 | 0.145 | 0.009 | 0.018 | 0.026 |
| IMC | 8813182 | 18 | 46 | 0 | 180 | 0.45 | 0.037 | 0.076 | 0.110 | 0.000 | 0.000 | 0.000 |
| | 8813183 | 11 | 52 | 0 | 200 | 0.44 | 0.036 | 0.075 | 0.108 | 0.000 | 0.000 | 0.000 |
| | 8813184 | 11 | 52 | 0 | 250 | 1.3 | 0.045 | 0.093 | 0.136 | 0.000 | 0.000 | 0.001 |
| M&O | DAP(A) | 18 | 46 | 0 | NR | 5 | NC | NC | NC | 0.001 | 0.002 | 0.003 |
| | DAP(B) | 18 | 46 | 0 | NR | 8 | NC | NC | NC | 0.002 | 0.003 | 0.005 |
| | DAP(C) | 18 | 46 | 0 | NR | 35 | NC | NC | NC | 0.007 | 0.015 | 0.021 |
| | DAP(D) | 18 | 46 | 0 | NR | 98 | NC | NC | NC | 0.020 | 0.041 | 0.060 |
| MMO | DAP1 | 21 | 53 | 0 | NR | 1 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | DAP2 | 18 | 46 | 0 | NR | 8 | NC | NC | NC | 0.002 | 0.003 | 0.005 |
| | DAP3 | 18 | 46 | 0 | NR | 18 | NC | NC | NC | 0.004 | 0.008 | 0.011 |

Note: Footnotes may be found at the end of this table

## Table G-2d. (Continued)

| Source[a] | ID[b] | Percent N | Percent P | Percent K | V mg/kg | Cu mg/kg | Yearly V Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha | Yearly Cu Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 24295 | 10 | 34 | 0 | NR | 0 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | 23730 | 4 | 21 | 25 | NR | 245 | NC | NC | NC | 0.110 | 0.226 | 0.329 |
| | 23845 | 5 | 24 | 24 | NR | 190 | NC | NC | NC | 0.074 | 0.154 | 0.223 |
| | 23647 | 4 | 5 | 3 | NR | 52 | NC | NC | NC | 0.098 | 0.202 | 0.293 |
| | 23622 | 11 | 52 | 0 | NR | 65.5 | NC | NC | NC | 0.012 | 0.024 | 0.036 |
| | 23202 | 11 | 52 | 0 | NR | 11.5 | NC | NC | NC | 0.002 | 0.004 | 0.006 |
| | 22278 | 11 | 52 | 0 | NR | 53 | NC | NC | NC | 0.010 | 0.020 | 0.029 |
| | 22396 | 11 | 52 | 0 | NR | 62 | NC | NC | NC | 0.011 | 0.023 | 0.034 |
| | 22245 | 19 | 24 | 18 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 21842 | 14.4 | 23.4 | 0 | NR | 310 | NC | NC | NC | 0.125 | 0.257 | 0.374 |
| | 21884 | 14.2 | 13 | 30 | NR | 29.5 | NC | NC | NC | 0.021 | 0.044 | 0.064 |
| | 21936 | 6 | 20 | 20 | NR | 144 | NC | NC | NC | 0.068 | 0.140 | 0.203 |
| | 21946 | 16 | 16 | 16 | NR | 3 | NC | NC | NC | 0.002 | 0.004 | 0.005 |
| | 21949 | 15 | 15 | 15 | NR | 14 | NC | NC | NC | 0.009 | 0.018 | 0.026 |
| | 22023 | 8.5 | 40 | 0 | NR | 700 | NC | NC | NC | 0.165 | 0.340 | 0.494 |
| | 22026 | 20 | 20 | 20 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 22244 | 4 | 12 | 8 | NR | 4.5 | NC | NC | NC | 0.004 | 0.007 | 0.011 |
| | 25338 | 18 | 12 | 12 | NR | 450 | NC | NC | NC | 0.353 | 0.728 | 1.058 |
| | 26520 | 12 | 61 | 0 | NR | 2 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | 26361 | 6 | 12 | 6 | NR | 12 | NC | NC | NC | 0.009 | 0.019 | 0.028 |
| | 26412 | 18 | 46 | 0 | NR | 9 | NC | NC | NC | 0.002 | 0.004 | 0.006 |
| | 25861 | 18 | 46 | 0 | NR | 9.5 | NC | NC | NC | 0.002 | 0.004 | 0.006 |
| Average | | 14.1 | 42.9 | 2.3 | 165.7 | 31.0 | 0.042 | 0.087 | 0.127 | 0.013 | 0.028 | 0.040 |

a) Sources:
Charter: Charter et al. (1993)
Wash St: Washington State Department of Ecology (1997)
Raven: Raven and Loeppert (1997)
IMC: International Mineral Company (1997)
M&O: Mortvedt and Osborn (1982)
MMO: Mortvedt, Mays and Osborne (1981)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) MAP = monoammonium phosphate
d) NR = not reported
e) NC = not calculated
f) DAP = diammonium phosphate
g) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)

**Table G-2e. Yearly Zn Additions to Soil (kg/ha) from NPK Fertilizers Applied for $P_2O_5$ Content**

| Source[a] | ID[b] | Percent | | | Zn | Yearly Zn Addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| | | N | P | K | mg/kg | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| Charter | MAP-1[c] | 11 | 52 | 0 | 60 | 0.011 | 0.022 | 0.033 |
| | MAP-2 | 11 | 52 | 0 | 64 | 0.012 | 0.024 | 0.035 |
| | MAP-3 | 11 | 52 | 0 | 67 | 0.012 | 0.025 | 0.036 |
| | MAP-4 | 11 | 52 | 0 | 72 | 0.013 | 0.027 | 0.039 |
| | MAP-5 | 11 | 52 | 0 | 70 | 0.013 | 0.026 | 0.038 |
| | MAP-6 | 11 | 52 | 0 | 68 | 0.012 | 0.025 | 0.037 |
| | MAP-7 | 11 | 52 | 0 | 65 | 0.012 | 0.024 | 0.035 |
| | MAP-8 | 11 | 52 | 0 | 81 | 0.015 | 0.030 | 0.044 |
| | MAP-9 | 11 | 52 | 0 | 73 | 0.013 | 0.027 | 0.040 |
| | MAP-10 | 11 | 52 | 0 | 63 | 0.011 | 0.024 | 0.034 |
| | MAP-11 | 11 | 52 | 0 | 78 | 0.014 | 0.029 | 0.042 |
| | MAP-12 | 11 | 52 | 0 | 80 | 0.014 | 0.030 | 0.043 |
| | MAP-13 | 11 | 52 | 0 | 91 | 0.016 | 0.034 | 0.049 |
| | MAP-14 | 11 | 52 | 0 | 80 | 0.014 | 0.030 | 0.043 |
| | MAP-15 | 11 | 52 | 0 | 83 | 0.015 | 0.031 | 0.045 |
| | MAP-16 | 11 | 52 | 0 | 63 | 0.011 | 0.024 | 0.034 |
| | MAP-17 | 11 | 52 | 0 | 80 | 0.014 | 0.030 | 0.043 |
| | MAP-18 | 11 | 52 | 0 | 76 | 0.014 | 0.028 | 0.041 |
| | MAP-19 | 11 | 52 | 0 | 72 | 0.013 | 0.027 | 0.039 |
| | MAP-20 | 11 | 52 | 0 | 70 | 0.013 | 0.026 | 0.038 |
| | MAP-21 | 11 | 52 | 0 | 76 | 0.014 | 0.028 | 0.041 |
| | MAP-22 | 11 | 52 | 0 | 90 | 0.016 | 0.034 | 0.049 |
| | MAP-23 | 11 | 52 | 0 | 95 | 0.017 | 0.035 | 0.052 |

Note: Footnotes may be found at the end of this table

## Table G-2e. (Continued)

| Source[a] | ID[b] | Percent N | Percent P | Percent K | Zn mg/kg | Yearly Zn Addition in kg/ha soil at: 84 lb $P_2O_5$/A 94 kg/ha | 173 lb $P_2O_5$/A 194 kg/ha | 252 lb $P_2O_5$/A 282 kg/ha |
|---|---|---|---|---|---|---|---|---|
| Charter | DAP-1[d] | 18 | 46 | 0 | 85 | 0.017 | 0.036 | 0.052 |
| | DAP-2 | 18 | 46 | 0 | 86 | 0.018 | 0.036 | 0.053 |
| | DAP-3 | 18 | 46 | 0 | 87 | 0.018 | 0.037 | 0.053 |
| | DAP-4 | 18 | 46 | 0 | 80 | 0.016 | 0.034 | 0.049 |
| | DAP-5 | 18 | 46 | 0 | 2193 | 0.448 | 0.925 | 1.344 |
| | DAP-6 | 18 | 46 | 0 | 84 | 0.017 | 0.035 | 0.051 |
| | DAP-7 | 18 | 46 | 0 | 59 | 0.012 | 0.025 | 0.036 |
| | DAP-8 | 18 | 46 | 0 | 86 | 0.018 | 0.036 | 0.053 |
| | DAP-9 | 18 | 46 | 0 | 97 | 0.020 | 0.041 | 0.059 |
| | DAP-10 | 18 | 46 | 0 | 86 | 0.018 | 0.036 | 0.053 |
| | DAP-11 | 18 | 46 | 0 | 96 | 0.020 | 0.040 | 0.059 |
| | DAP-12 | 18 | 46 | 0 | 88 | 0.018 | 0.037 | 0.054 |
| | DAP-13 | 18 | 46 | 0 | 86 | 0.018 | 0.036 | 0.053 |
| | DAP-14 | 18 | 46 | 0 | 86 | 0.018 | 0.036 | 0.053 |
| | DAP-15 | 18 | 46 | 0 | 91 | 0.019 | 0.038 | 0.056 |
| | DAP-16 | 18 | 46 | 0 | 93 | 0.019 | 0.039 | 0.057 |
| | DAP-17 | 18 | 46 | 0 | 89 | 0.018 | 0.038 | 0.055 |
| | DAP-18 | 18 | 46 | 0 | 91 | 0.019 | 0.038 | 0.056 |
| | DAP-19 | 18 | 46 | 0 | 85 | 0.017 | 0.036 | 0.052 |
| | DAP-20 | 18 | 46 | 0 | 97 | 0.020 | 0.041 | 0.059 |
| | DAP-21 | 18 | 46 | 0 | 96 | 0.020 | 0.040 | 0.059 |
| | DAP-22 | 18 | 46 | 0 | 71 | 0.015 | 0.030 | 0.044 |
| | DAP-23 | 18 | 46 | 0 | 72 | 0.015 | 0.030 | 0.044 |
| | DAP-24 | 18 | 46 | 0 | 98 | 0.020 | 0.041 | 0.060 |
| | DAP-25 | 18 | 46 | 0 | 72 | 0.015 | 0.030 | 0.044 |

Note: Footnotes may be found at the end of this table

## Table G-2e. (Continued)

| Source[a] | ID[b] | Percent | | | Zn | Yearly Zn Addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| | | N | P | K | mg/kg | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| Wash St | H4754 | 11 | 52 | 0 | 54 | 0.010 | 0.020 | 0.029 |
| | H4755 | 18 | 46 | 0 | 81.6 | 0.017 | 0.034 | 0.050 |
| | H4762 | 16 | 15 | 15 | 81.6 | 0.051 | 0.106 | 0.153 |
| | H2562 | 11 | 37 | 0 | 25.3 | 0.006 | 0.013 | 0.019 |
| | H2574 | 11 | 30 | 0 | 301 | 0.094 | 0.195 | 0.283 |
| | H2532 | 16 | 20 | 0 | 1480 | 0.696[e] | 1.436 | 2.087 |
| | H2564 | 10 | 34 | 0 | 315 | 0.087 | 0.180 | 0.261 |
| Raven | MAP-1 | 11 | 52 | 0 | 10.3 | 0.002 | 0.004 | 0.006 |
| | MAP-2 | 11 | 52 | 0 | NR[f] | NC[g] | NC | NC |
| | DAP-1 | 18 | 46 | 0 | NR | NC | NC | NC |
| | DAP-2 | 18 | 46 | 0 | 386 | 0.079 | 0.163 | 0.237 |
| IMC | 8813182 | 18 | 46 | 0 | 57 | 0.012 | 0.024 | 0.035 |
| | 8813183 | 11 | 52 | 0 | 65 | 0.012 | 0.024 | 0.035 |
| | 8813184 | 11 | 52 | 0 | 58 | 0.010 | 0.022 | 0.031 |
| M&O | DAP(A) | 18 | 46 | 0 | 540 | 0.110 | 0.228 | 0.331 |
| | DAP(B) | 18 | 46 | 0 | 960 | 0.196 | 0.405 | 0.589 |
| | DAP(C) | 18 | 46 | 0 | 1315 | 0.269 | 0.555 | 0.806 |
| | DAP(D) | 18 | 46 | 0 | 1400 | 0.286 | 0.590 | 0.858 |
| MMO | DAP1 | 21 | 53 | 0 | 1 | 0.000 | 0.000 | 0.001 |
| | DAP2 | 18 | 46 | 0 | 1260 | 0.257 | 0.531 | 0.772 |
| | DAP3 | 18 | 46 | 0 | 1290 | 0.264 | 0.544 | 0.791 |

Note: Footnotes may be found at the end of this table

## Table G-2e. (Continued)

| Source[a] | ID[b] | Percent | | | Zn mg/kg | Yearly Zn Addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 84 lb $P_2O_5$/A | 173 lb $P_2O_5$/A | 252 lb $P_2O_5$/A |
| | | N | P | K | | 94 kg/ha | 194 kg/ha | 282 kg/ha |
| CDFA | 24295 | 10 | 34 | 0 | NR | NC | NC | NC |
| | 23730 | 4 | 21 | 25 | NR | NC | NC | NC |
| | 23845 | 5 | 24 | 24 | NR | NC | NC | NC |
| | 23647 | 4 | 5 | 3 | NR | NC | NC | NC |
| | 23622 | 11 | 52 | 0 | NR | NC | NC | NC |
| | 23202 | 11 | 52 | 0 | NR | NC | NC | NC |
| | 22278 | 11 | 52 | 0 | NR | NC | NC | NC |
| | 22396 | 11 | 52 | 0 | NR | NC | NC | NC |
| | 22245 | 19 | 24 | 18 | NR | NC | NC | NC |
| | 21842 | 14.4 | 23.4 | 0 | NR | NC | NC | NC |
| | 21884 | 14.2 | 13 | 30 | NR | NC | NC | NC |
| | 21936 | 6 | 20 | 20 | NR | NC | NC | NC |
| | 21946 | 16 | 16 | 16 | NR | NC | NC | NC |
| | 21949 | 15 | 15 | 15 | NR | NC | NC | NC |
| | 22023 | 8.5 | 40 | 0 | NR | NC | NC | NC |
| | 22026 | 20 | 20 | 20 | NR | NC | NC | NC |
| | 22244 | 4 | 12 | 8 | NR | NC | NC | NC |
| | 25338 | 18 | 12 | 12 | NR | NC | NC | NC |
| | 26520 | 12 | 61 | 0 | NR | NC | NC | NC |
| | 26361 | 6 | 12 | 6 | NR | NC | NC | NC |
| | 26412 | 18 | 46 | 0 | NR | NC | NC | NC |
| | 25861 | 18 | 46 | 0 | NR | NC | NC | NC |
| Average | | 14.1 | 42.9 | 2.3 | 233.6 | 0.054 | 0.112 | 0.163 |

a) Sources:
   Charter: Charter et al. (1995)
   Wash St: Washington State Department of Ecology (1997)
   Raven: Raven and Loeppert (1997)
   IMC: International Mineral Company (1997)
   M&O: Mortvedt and Osborn (1982)
   MMO: Mortvedt, Mays and Osborne (1981)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) MAP = monoammonium phosphate
d) DAP = diammonium phosphate
e) Shading indicates highest yearly addition values of this metal from NPK products (based on P content)
f) NR = not reported
g) NC = not calculated

## Table G-3a. Yearly Cd and Pb Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content

| Source[a] | ID Number[b] | Percent N | Percent P | Percent K | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly Cd addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly Cd addition in kg/ha at 414 lb N/A 464 kg/ha | Yearly Pb addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly Pb addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly Pb addition in kg/ha at 414 lb N/A 464 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PDA | B960243 | 19 | 19 | 19 | 3.5 | 2.2 | 0.003 | 0.004 | 0.009 | 0.002 | 0.003 | 0.005 |
| | B960244 | 12 | 24 | 24 | 4.3 | 4.6 | 0.005 | 0.008 | 0.017 | 0.005 | 0.009 | 0.018 |
| | B960249 | 7 | 35 | 12 | 4.6 | 3.9 | 0.009 | 0.015 | 0.030 | 0.008 | 0.013 | 0.026 |
| | B960282 | 9 | 44 | 9 | 2.3 | 3.5 | 0.004 | 0.006 | 0.012 | 0.005 | 0.009 | 0.018 |
| | B960325 | 10 | 21 | 15 | 2.7 | 11.1 | 0.004 | 0.006 | 0.013 | 0.015 | 0.026 | 0.052 |
| | B960333 | 8 | 32 | 16 | 3.9 | 5.3 | 0.007 | 0.011 | 0.023 | 0.009 | 0.015 | 0.031 |
| | B960389 | 19 | 19 | 19 | 1.6 | 1.4 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.003 |
| | B960412 | 7 | 26 | 26 | 2.6 | 2.8 | 0.005 | 0.009 | 0.017 | 0.006 | 0.009 | 0.019 |
| | B960418 | 19 | 19 | 19 | 2.2 | 3.8 | 0.002 | 0.003 | 0.005 | 0.003 | 0.005 | 0.009 |
| | B960441 | 9 | 34 | 10 | 3.3 | 3.6 | 0.005 | 0.008 | 0.017 | 0.006 | 0.009 | 0.019 |
| | B960442 | 9 | 3 | 10 | 3.6 | 3 | 0.006 | 0.009 | 0.019 | 0.005 | 0.008 | 0.015 |
| | B960453 | 10 | 20 | 20 | 4.3 | 3 | 0.006 | 0.010 | 0.020 | 0.004 | 0.007 | 0.014 |
| | B960475 | 9 | 40 | 5 | 14.3 | 422 | 0.022[c] | 0.037 | 0.074 | 0.652 | 1.083 | 2.176 |
| | B960510 | 9 | 43 | 10 | 5.2 | 1.7 | 0.008 | 0.013 | 0.027 | 0.003 | 0.004 | 0.009 |
| | B960580 | 10 | 10 | 10 | 1.8 | 3.6 | 0.003 | 0.004 | 0.008 | 0.005 | 0.008 | 0.017 |
| | B960584 | 10 | 20 | 20 | 2.6 | 2.5 | 0.004 | 0.006 | 0.012 | 0.003 | 0.006 | 0.012 |
| | B960599 | 15 | 15 | 15 | 2.1 | 2.1 | 0.002 | 0.003 | 0.006 | 0.002 | 0.003 | 0.006 |
| | B960611 | 19 | 19 | 19 | 24.35 | 1.1 | 0.018 | 0.030 | 0.059 | 0.001 | 0.001 | 0.003 |
| | B960639 | 6 | 2 | 0 | 5.7 | 6.9 | 0.013 | 0.022 | 0.044 | 0.016 | 0.027 | 0.053 |
| | B960708 | 7 | 27 | 11 | 6.4 | 153 | 0.013 | 0.021 | 0.042 | 0.304 | 0.505 | 1.014 |
| | B960711 | 8 | 24 | 8 | 9.5 | 14 | 0.017 | 0.027 | 0.055 | 0.024 | 0.040 | 0.081 |
| | B960713 | 10 | 20 | 10 | 2.4 | 6.7 | 0.003 | 0.006 | 0.011 | 0.009 | 0.015 | 0.031 |
| | B960715 | 15 | 15 | 15 | 2 | 1.8 | 0.002 | 0.003 | 0.006 | 0.002 | 0.003 | 0.006 |
| | B980726 | 19 | 19 | 19 | 4.1 | 3.7 | 0.003 | 0.005 | 0.010 | 0.003 | 0.004 | 0.009 |
| | B960820 | 26 | 9 | 9 | 2 | 2.3 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.004 |
| | B960896 | 10 | 20 | 20 | 3.3 | 3.6 | 0.005 | 0.008 | 0.015 | 0.005 | 0.008 | 0.017 |
| | B960900 | 10 | 20 | 20 | 3.1 | 3.3 | 0.004 | 0.007 | 0.014 | 0.005 | 0.008 | 0.015 |
| | B960909 | 3 | 17 | 40 | 2.4 | 2.6 | 0.011 | 0.018 | 0.037 | 0.012 | 0.020 | 0.040 |
| | B960912 | 3 | 17 | 40 | 4.3 | 3.9 | 0.020 | 0.033 | 0.067 | 0.018 | 0.030 | 0.060 |
| | B960913 | 8 | 41 | 12 | 1.5 | 18 | 0.003 | 0.004 | 0.009 | 0.031 | 0.052 | 0.104 |
| | B961058 | 8 | 17 | 34 | 1 | 2.4 | 0.002 | 0.003 | 0.006 | 0.004 | 0.007 | 0.014 |
| | B961321 | 9 | 43 | 10 | 4.7 | 6.9 | 0.007 | 0.012 | 0.024 | 0.011 | 0.018 | 0.036 |
| Wash St | H0751 | 46 | 0 | 0 | 0.15 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| | H0752 | 20 | 0 | 0 | 0.03 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H2538 | 32 | 0 | 0 | 0.03 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H1233 | 17 | 0 | 0 | 0.15 | 1 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 |
| | H0754 | 15.5 | 0 | 0 | 0.8 | 5.5 | 0.001 | 0.001 | 0.002 | 0.005 | 0.008 | 0.016 |
| | H4769 | 21 | 0 | 0 | 1.2 | 15 | 0.001 | 0.001 | 0.003 | 0.010 | 0.017 | 0.033 |
| | H4771 | 34.5 | 0 | 0 | 0.15 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |

## Table G-3a. Continued

| Source[a] | ID Number[b] | Percent N | Percent P | Percent K | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly Cd addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly Cd addition in kg/ha at 414 lb N/A 464 kg/ha | Yearly Pb addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly Pb addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly Pb addition in kg/ha at 414 lb N/A 464 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raven | Urea[d] | 46 | 0 | 0 | 0.1 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $NH_4NO_3$[e] | 34 | 0 | 0 | 0.1 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $NH_4SO_4$[e] | 21 | 0 | 0 | 0.1 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $NH_4SO_4$[e] | 21 | 0 | 0 | 0.1 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CDFA | 25042 | 20 | 0 | 0 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 21575 | 32 | 10 | 10 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 24276 | 14 | 3 | 7 | 0 | 2 | 0.000 | 0.000 | 0.000 | 0.002 | 0.003 | 0.007 |
| | 23106 | 7 | 2 | 2 | 0 | 3 | 0.000 | 0.000 | 0.000 | 0.006 | 0.010 | 0.020 |
| | 22080 | 34 | 17 | 0 | 47 | 2.5 | 0.019 | 0.032 | 0.064 | 0.001 | 0.002 | 0.003 |
| | 22216 | 9 | 4 | 4 | 12.5 | 71 | 0.019 | 0.032 | 0.064 | 0.110 | 0.182 | 0.366 |
| | 20891 | 16 | 4 | 8 | 23 | 255 | 0.020 | 0.033 | 0.067 | 0.222 | 0.368 | 0.740 |
| Average | | 23.2 | 2.4 | 2.5 | 6.2 | 69.6 | 0.006 | 0.009 | 0.018 | 0.031 | 0.051 | 0.103 |

a) Sources:
PDA: Pennsylvania Department of Agriculture (1998)
Wash St: Washington State Deparmtent of Ecology (1997)
Raven: Raven and Loeppert (1997)
CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) NPK rating not given, see Table 3-4.
e) NPK rating not given, granular grade used.

**Table G-3b. Yearly As and Cr Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content**

| Source[a] | ID Number[b] | Percent N | Percent P | Percent K | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at 124 lb N/A (139 kg/ha) | Yearly As addition in kg/ha at 206 lb N/A (231 kg/ha) | Yearly As addition in kg/ha at 414 lb N/A (464 kg/ha) | Yearly Cr addition in kg/ha at 124 lb N/A (139 kg/ha) | Yearly Cr addition in kg/ha at 206 lb N/A (231 kg/ha) | Yearly Cr addition in kg/ha at 414 lb N/A (464 kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PDA | B960243 | 19 | 19 | 19 | 6.6 | 45.4 | 0.005 | 0.008 | 0.016 | 0.033 | 0.055 | 0.111 |
| | B960244 | 12 | 24 | 24 | 9.8 | 59 | 0.011 | 0.019 | 0.038 | 0.068 | 0.114 | 0.228 |
| | B960249 | 7 | 35 | 12 | 9.7 | 66.8 | 0.019 | 0.032 | 0.064 | 0.133 | 0.220 | 0.443 |
| | B960282 | 9 | 44 | 9 | 13.2 | 90.7 | 0.020 | 0.034 | 0.068 | 0.140 | 0.233 | 0.468 |
| | B960325 | 10 | 21 | 15 | 7.2 | 46.3 | 0.010 | 0.017 | 0.033 | 0.064 | 0.107 | 0.215 |
| | B960333 | 8 | 32 | 16 | 11.2 | 68.1 | 0.019 | 0.032 | 0.065 | 0.118 | 0.197 | 0.395 |
| | B960389 | 19 | 19 | 19 | 5.2 | 43.5 | 0.004 | 0.006 | 0.013 | 0.032 | 0.053 | 0.106 |
| | B960412 | 7 | 26 | 26 | 6 | 51.8 | 0.012 | 0.020 | 0.040 | 0.103 | 0.171 | 0.343 |
| | B960418 | 19 | 19 | 19 | 7.5 | 62 | 0.005 | 0.009 | 0.018 | 0.045 | 0.075 | 0.151 |
| | B960441 | 9 | 34 | 10 | 10.7 | 67.4 | 0.017 | 0.027 | 0.055 | 0.104 | 0.173 | 0.347 |
| | B960442 | 9 | 3 | 10 | 9.2 | 88.8 | 0.014 | 0.024 | 0.047 | 0.137 | 0.228 | 0.458 |
| | B960453 | 10 | 20 | 20 | 3.6 | 68.7 | 0.005 | 0.008 | 0.017 | 0.095 | 0.159 | 0.319 |
| | B960475 | 9 | 40 | 5 | 10 | 107.9 | 0.015 | 0.026 | 0.052 | 0.167 | 0.277 | 0.556 |
| | B960510 | 9 | 43 | 10 | 11.2 | 79.4 | 0.017 | 0.029 | 0.058 | 0.123 | 0.204 | 0.409 |
| | B960580 | 10 | 10 | 10 | 4.1 | 51.4 | 0.006 | 0.009 | 0.019 | 0.071 | 0.119 | 0.238 |
| | B960584 | 10 | 20 | 20 | 6.9 | 52.8 | 0.010 | 0.016 | 0.032 | 0.073 | 0.122 | 0.245 |
| | B960599 | 15 | 15 | 15 | 4.9 | 42.5 | 0.005 | 0.008 | 0.015 | 0.039 | 0.065 | 0.131 |
| | B960611 | 19 | 19 | 19 | 0 | 160 | 0.000 | 0.000 | 0.000 | 0.117 | 0.195 | 0.391 |
| | B960639 | 6 | 2 | 0 | 4.7 | 40.3 | 0.011 | 0.018 | 0.036 | 0.093 | 0.155 | 0.312 |
| | B960708 | 7 | 27 | 11 | 9 | 73.2 | 0.018 | 0.030 | 0.060 | 0.145 | 0.242 | 0.485 |
| | B960711 | 8 | 24 | 8 | 3.5 | 60.5 | 0.006 | 0.010 | 0.020 | 0.105 | 0.175 | 0.351 |
| | B960713 | 10 | 20 | 10 | 5.4 | 42 | 0.008 | 0.012 | 0.025 | 0.058 | 0.097 | 0.195 |
| | B960715 | 15 | 15 | 15 | 4.7 | 28 | 0.004 | 0.007 | 0.015 | 0.026 | 0.043 | 0.087 |
| | B980726 | 19 | 19 | 19 | 7.8 | 48.8 | 0.006 | 0.009 | 0.019 | 0.036 | 0.059 | 0.119 |
| | B960820 | 26 | 9 | 9 | 4.1 | 34.2 | 0.002 | 0.004 | 0.007 | 0.018 | 0.030 | 0.061 |
| | B960896 | 10 | 20 | 20 | 7 | 39 | 0.010 | 0.016 | 0.032 | 0.054 | 0.090 | 0.181 |
| | B960900 | 10 | 20 | 20 | 7.4 | 201 | 0.010 | 0.017 | 0.034 | 0.279 | 0.464 | 0.933 |
| | B960909 | 3 | 17 | 40 | 5.1 | 34.3 | 0.024 | 0.039 | 0.079 | 0.159 | 0.264 | 0.531 |
| | B960912 | 3 | 17 | 40 | 10.5 | 67.4 | 0.049 | 0.981 | 0.162 | 0.312 | 0.519 | 1.042 |
| | B960913 | 8 | 41 | 12 | 6.2 | 68.3 | 0.011 | 0.018 | 0.036 | 0.119 | 0.197 | 0.396 |
| | B961058 | 8 | 17 | 34 | 3.1 | 30.8 | 0.005 | 0.009 | 0.018 | 0.054 | 0.089 | 0.179 |
| | B961321 | 9 | 43 | 10 | 10.7 | 69.8 | 0.017 | 0.027 | 0.055 | 0.108 | 0.179 | 0.360 |
| Wash St | H0751 | 46 | 0 | 0 | 1.5 | 2.2 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.002 |
| | H0752 | 20 | 0 | 0 | 0.3 | 0.05 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| | H2538 | 32 | 0 | 0 | 0.3 | 0.15 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H1233 | 17 | 0 | 0 | 1.5 | 2 | 0.001 | 0.002 | 0.004 | 0.002 | 0.003 | 0.005 |
| | H0754 | 15.5 | 0 | 0 | 8 | 1.4 | 0.007 | 0.012 | 0.024 | 0.001 | 0.002 | 0.004 |
| | H4769 | 21 | 0 | 0 | 1.5 | 0.7 | 0.001 | 0.002 | 0.003 | 0.000 | 0.001 | 0.002 |
| | H4771 | 34.5 | 0 | 0 | 1.5 | 0.25 | 0.001 | 0.001 | 0.002 | 0.000 | 0.000 | 0.000 |

## Table G-3b. Continued

| Source[a] | ID Number[b] | Percent N | Percent P | Percent K | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly As addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly As addition in kg/ha at 414 lb N/A 464 kg/ha | Yearly Cr addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly Cr addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly Cr addition in kg/ha at 414 lb N/A 464 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raven | Urea[d] | 46 | 0 | 0 | 0.2 | NR[e] | 0.000 | 0.000 | 0.000 | NC[f] | NC | NC |
| | $NH_4NO_3$[g] | 34 | 0 | 0 | 0.2 | NR | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| | $NH_4SO_4$[g] | 21 | 0 | 0 | 0.2 | NR | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| | $NH_4SO_4$[g] | 21 | 0 | 0 | 0.4 | 2.14 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.005 |
| CDFA | 25042 | 20 | 0 | 0 | 0 | NR | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| | 21575 | 32 | 10 | 10 | 0.6 | NR | 0.000 | 0.000 | 0.001 | NC | NC | NC |
| | 24276 | 14 | 3 | 7 | 1.5 | NR | 0.001 | 0.002 | 0.005 | NC | NC | NC |
| | 23106 | 7 | 2 | 2 | 0.15 | NR | 0.000 | 0.000 | 0.001 | NC | NC | NC |
| | 22080 | 34 | 17 | 0 | 4.5 | NR | 0.002 | 0.003 | 0.006 | NC | NC | NC |
| | 22216 | 9 | 4 | 4 | 4.3 | NR | 0.007 | 0.011 | 0.022 | NC | NC | NC |
| | 20891 | 16 | 4 | 8 | 8.4 | NR | 0.007 | 0.012 | 0.024 | NC | NC | NC |
| Average | | 23.2 | 2.35 | 2.5 | 3.4 | 1.1 | 0.008 | 0.013 | 0.027 | 0.081 | 0.134 | 0.270 |

a) Sources:
PDA: Pennsylvania Department of Agriculture (1998)
Wash St: Washington State Deparmtent of Ecology (1997)
Raven: Raven and Loeppert (1997)
CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) NPK rating not given, see Table 3-4.
e) NR = not reported.
f) NC = not calculated.
g) NPK rating not given, granular grade used.

## Table G-3c. Yearly Hg and Ni Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content

| | | Percent | | | | | Yearly Hg addition in kg/ha at | | | Yearly Ni addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 124 lb N/A | 206 lb N/A | 414 lb N/A | 124 lb N/A | 206 lb N/A | 414 lb N/A |
| Source[a] | ID Number[b] | N | P | K | Hg mg/kg | Ni mg/kg | 139 kg/ha | 231 kg/ha | 464 kg/ha | 139 kg/ha | 231 kg/ha | 464 kg/ha |
| PDA | B960243 | 19 | 19 | 19 | 0 | 11.2 | 0.000 | 0.000 | 0.000 | 0.008 | 0.014 | 0.027 |
| | B960244 | 12 | 24 | 24 | 0 | 14.7 | 0.000 | 0.000 | 0.000 | 0.017 | 0.028 | 0.057 |
| | B960249 | 7 | 35 | 12 | 0 | 20.9 | 0.000 | 0.000 | 0.000 | 0.042 | 0.069 | 0.139 |
| | B960282 | 9 | 44 | 9 | 0 | 14.5 | 0.000 | 0.000 | 0.000 | 0.022 | 0.037 | 0.075 |
| | B960325 | 10 | 21 | 15 | 0.17 | 13.4 | 0.000 | 0.000 | 0.001 | 0.019 | 0.031 | 0.062 |
| | B960333 | 8 | 32 | 16 | 0 | 14.9 | 0.000 | 0.000 | 0.000 | 0.026 | 0.043 | 0.086 |
| | B960389 | 19 | 19 | 19 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | B960412 | 7 | 26 | 26 | 0 | 11.5 | 0.000 | 0.000 | 0.000 | 0.023 | 0.038 | 0.076 |
| | B960418 | 19 | 19 | 19 | 0 | 9.2 | 0.000 | 0.000 | 0.000 | 0.007 | 0.011 | 0.022 |
| | B960441 | 9 | 34 | 10 | 0 | 12.2 | 0.000 | 0.000 | 0.000 | 0.019 | 0.031 | 0.063 |
| | B960442 | 9 | 3 | 10 | 0 | 14.5 | 0.000 | 0.000 | 0.000 | 0.022 | 0.037 | 0.075 |
| | B960453 | 10 | 20 | 20 | 0 | 18 | 0.000 | 0.000 | 0.000 | 0.025 | 0.042 | 0.084 |
| | B960475 | 9 | 40 | 5 | 0 | 29.2 | 0.000 | 0.000 | 0.000 | 0.045 | 0.075 | 0.151 |
| | B960510 | 9 | 43 | 10 | 0 | 17.8 | 0.000 | 0.000 | 0.000 | 0.027 | 0.046 | 0.092 |
| | B960580 | 10 | 10 | 10 | 0 | 14.6 | 0.000 | 0.000 | 0.000 | 0.020 | 0.034 | 0.068 |
| | B960584 | 10 | 20 | 20 | 0 | 15.7 | 0.000 | 0.000 | 0.000 | 0.022 | 0.036 | 0.073 |
| | B960599 | 15 | 15 | 15 | 0 | 11.4 | 0.000 | 0.000 | 0.000 | 0.011 | 0.018 | 0.035 |
| | B960611 | 19 | 19 | 19 | 0 | 36.9 | 0.000 | 0.000 | 0.000 | 0.027 | 0.045 | 0.090 |
| | B960639 | 6 | 2 | 0 | 0 | 11.2 | 0.000 | 0.000 | 0.000 | 0.026 | 0.043 | 0.087 |
| | B960708 | 7 | 27 | 11 | 0 | 22.7 | 0.000 | 0.000 | 0.000 | 0.045 | 0.075 | 0.150 |
| | B960711 | 8 | 24 | 8 | 0 | 11.9 | 0.000 | 0.000 | 0.000 | 0.021 | 0.034 | 0.069 |
| | B960713 | 10 | 20 | 10 | 0 | 10.1 | 0.000 | 0.000 | 0.000 | 0.014 | 0.023 | 0.047 |
| | B960715 | 15 | 15 | 15 | 0 | 6.2 | 0.000 | 0.000 | 0.000 | 0.006 | 0.010 | 0.019 |
| | B980726 | 19 | 19 | 19 | 0 | 11.5 | 0.000 | 0.000 | 0.000 | 0.008 | 0.014 | 0.028 |
| | B960820 | 26 | 9 | 9 | 0 | 8 | 0.000 | 0.000 | 0.000 | 0.004 | 0.007 | 0.014 |
| | B960896 | 10 | 20 | 20 | 0 | 8.6 | 0.000 | 0.000 | 0.000 | 0.012 | 0.020 | 0.040 |
| | B960900 | 10 | 20 | 20 | 0 | 85.7 | 0.000 | 0.000 | 0.000 | 0.119[c] | 0.198 | 0.398 |
| | B960909 | 3 | 17 | 40 | 0 | 5.7 | 0.000 | 0.000 | 0.000 | 0.026 | 0.044 | 0.088 |
| | B960912 | 3 | 17 | 40 | 0 | 12 | 0.000 | 0.000 | 0.000 | 0.056 | 0.092 | 0.186 |
| | B960913 | 8 | 41 | 12 | 0 | 14.8 | 0.000 | 0.000 | 0.000 | 0.026 | 0.043 | 0.086 |
| | B961058 | 8 | 17 | 34 | 0 | 8.9 | 0.000 | 0.000 | 0.000 | 0.015 | 0.026 | 0.052 |
| | B961321 | 9 | 43 | 10 | 0 | 13.3 | 0.000 | 0.000 | 0.000 | 0.021 | 0.034 | 0.069 |
| Wash St | H0751 | 46 | 0 | 0 | 0 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | H0752 | 20 | 0 | 0 | 0 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H2538 | 32 | 0 | 0 | 0 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H1233 | 17 | 0 | 0 | 0 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| | H0754 | 15.5 | 0 | 0 | 0 | 2.5 | 0.000 | 0.000 | 0.000 | 0.002 | 0.004 | 0.007 |
| | H4769 | 21 | 0 | 0 | 0.40 | 0.5 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.001 |
| | H4771 | 34.5 | 0 | 0 | 0 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| Raven | Urea[d] | 46 | 0 | 0 | 0.2 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $NH_4NO_3$[e] | 34 | 0 | 0[d] | 0.2 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $NH_4SO_4$[e] | 21 | 0 | 0[e] | 0.2 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table G-3c. Continued

| Source[a] | ID Number[b] | Percent N | Percent P | Percent K | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha at 124 lb N/A 139 kg/ha | 206 lb N/A 231 kg/ha | 414 lb N/A 464 kg/ha | Yearly Ni addition in kg/ha at 124 lb N/A 139 kg/ha | 206 lb N/A 231 kg/ha | 414 lb N/A 464 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $NH_4SO_4$[e] | 21 | 0 | 0[e] | 0.2 | 0.6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |

## Table G-3c. Continued

| Source[a] | ID Number[b] | Percent N | Percent P | Percent K | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly Hg addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly Hg addition in kg/ha at 414 lb N/A 464 kg/ha | Yearly Ni addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly Ni addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly Ni addition in kg/ha at 414 lb N/A 464 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 25042 | 20 | 0 | 0 | NR[f] | NR | NC[g] | NC | NC | NC | NC | NC |
| | 21575 | 32 | 10 | 10 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 24276 | 14 | 3 | 7 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 23106 | 7 | 2 | 2 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 22080 | 34 | 17 | 0 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 22216 | 9 | 4 | 4 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 20891 | 16 | 4 | 8 | NR | NR | NC | NC | NC | NC | NC | NC |
| Average | | 23.2 | 2.4 | 2.5 | 0.11 | 0.51 | 0.000 | 0.000 | 0.000 | 0.018 | 0.030 | 0.061 |

a) Sources:
   PDA: Pennsylvania Department of Agriculture (1998)
   Wash St: Washington State Deparmtent of Ecology (1997)
   Raven: Raven and Loeppert (1997)
   CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) NPK rating not given, see Table 3-4.
e) NPK rating not given, granular grade used.
f) NR = not reported.
g) NC = not calculated.

## Table G-3d. Yearly V and Cu Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content

| Source[a] | ID Number[b] | Percent N | Percent P | Percent K | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly V addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly V addition in kg/ha at 414 lb N/A 464 kg/ha | Yearly Cu addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly Cu addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly Cu addition in kg/ha at 414 lb N/A 464 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PDA | B960243 | 19 | 19 | 19 | 85.2 | 25.6 | 0.062 | 0.104 | 0.208 | 0.019 | 0.031 | 0.063 |
| | B960244 | 12 | 24 | 24 | 119 | 49.3 | 0.138 | 0.229 | 0.460 | 0.057 | 0.095 | 0.191 |
| | B960249 | 7 | 35 | 12 | 116 | 45 | 0.230 | 0.383 | 0.769 | 0.089 | 0.149 | 0.298 |
| | B960282 | 9 | 44 | 9 | 163 | 30.1 | 0.252 | 0.418 | 0.840 | 0.046 | 0.077 | 0.155 |
| | B960325 | 10 | 21 | 15 | 87.7 | 10.2 | 0.122 | 0.203 | 0.407 | 0.014 | 0.024 | 0.047 |
| | B960333 | 8 | 32 | 16 | 126 | 22.2 | 0.219 | 0.364 | 0.731 | 0.039 | 0.064 | 0.129 |
| | B960389 | 19 | 19 | 19 | 77.7 | 0 | 0.057 | 0.094 | 0.190 | 0.000 | 0.000 | 0.000 |
| | B960412 | 7 | 26 | 26 | 79.4 | 26.2 | 0.158 | 0.262 | 0.526 | 0.052 | 0.086 | 0.174 |
| | B960418 | 19 | 19 | 19 | 97.8 | 13.7 | 0.072 | 0.119 | 0.239 | 0.010 | 0.017 | 0.033 |
| | B960441 | 9 | 34 | 10 | 121 | 16.3 | 0.187 | 0.311 | 0.624 | 0.025 | 0.042 | 0.084 |
| | B960442 | 9 | 3 | 10 | 159 | 6.6 | 0.246 | 0.408 | 0.820 | 0.010 | 0.017 | 0.034 |
| | B960453 | 10 | 20 | 20 | 67.1 | 16.4 | 0.093 | 0.155 | 0.311 | 0.023 | 0.038 | 0.076 |
| | B960475 | 9 | 40 | 5 | 130 | 90.5 | 0.201 | 0.334 | 0.670 | 0.140 | 0.232 | 0.467 |
| | B960510 | 9 | 43 | 10 | 136 | 7.1 | 0.210 | 0.349 | 0.701 | 0.011 | 0.018 | 0.037 |
| | B960580 | 10 | 10 | 10 | 68.8 | 13.6 | 0.096 | 0.159 | 0.319 | 0.019 | 0.031 | 0.063 |
| | B960584 | 10 | 20 | 20 | 83.4 | 10.6 | 0.116 | 0.193 | 0.387 | 0.015 | 0.024 | 0.049 |
| | B960599 | 15 | 15 | 15 | 73.2 | 7.2 | 0.068 | 0.113 | 0.226 | 0.007 | 0.011 | 0.022 |
| | B960611 | 19 | 19 | 19 | 47.2 | 3.9 | 0.035 | 0.057 | 0.115 | 0.003 | 0.005 | 0.010 |
| | B960639 | 6 | 2 | 0 | 18.6 | 24.3 | 0.043 | 0.072 | 0.144 | 0.056 | 0.094 | 0.188 |
| | B960708 | 7 | 27 | 11 | 99.2 | 544 | 0.197 | 0.327 | 0.658 | 1.080[c] | 1.795 | 3.606 |
| | B960711 | 8 | 24 | 8 | 47.3 | 13.6 | 0.082 | 0.137 | 0.274 | 0.024 | 0.039 | 0.079 |
| | B960713 | 10 | 20 | 10 | 68.9 | 32 | 0.096 | 0.159 | 0.320 | 0.044 | 0.074 | 0.148 |
| | B960715 | 15 | 15 | 15 | 49.2 | 3.9 | 0.046 | 0.076 | 0.152 | 0.004 | 0.006 | 0.012 |
| | B980726 | 19 | 19 | 19 | 85.1 | 7.9 | 0.062 | 0.103 | 0.208 | 0.006 | 0.010 | 0.019 |
| | B960820 | 26 | 9 | 9 | 61.6 | 14.4 | 0.033 | 0.055 | 0.110 | 0.008 | 0.013 | 0.026 |
| | B960896 | 10 | 20 | 20 | 64.5 | 25.5 | 0.090 | 0.149 | 0.299 | 0.035 | 0.059 | 0.118 |
| | B960900 | 10 | 20 | 20 | 70.3 | 12.9 | 0.098 | 0.162 | 0.326 | 0.018 | 0.030 | 0.060 |
| | B960909 | 3 | 17 | 40 | 64.2 | 4.9 | 0.297 | 0.494 | 0.993 | 0.023 | 0.038 | 0.076 |
| | B960912 | 3 | 17 | 40 | 138 | 7.8 | 0.639 | 1.063 | 2.134 | 0.036 | 0.060 | 0.121 |
| | B960913 | 8 | 41 | 12 | 18.4 | 454 | 0.032 | 0.053 | 0.107 | 0.789 | 1.311 | 2.633 |
| | B961058 | 8 | 17 | 34 | 27.8 | 5 | 0.048 | 0.080 | 0.161 | 0.009 | 0.014 | 0.029 |
| | B961321 | 9 | 43 | 10 | 152 | 60.1 | 0.235 | 0.390 | 0.784 | 0.093 | 0.154 | 0.310 |
| Wash St | H0751 | 46 | 0 | 0 | 3.12 | 0.5 | 0.001 | 0.002 | 0.003 | 0.000 | 0.000 | 0.001 |
| | H0752 | 20 | 0 | 0 | 0.05 | 0.27 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | H2538 | 32 | 0 | 0 | 0.19 | 0.14 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H1233 | 17 | 0 | 0 | 0.1 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | H0754 | 15.5 | 0 | 0 | 0.5 | 2.5 | 0.000 | 0.001 | 0.002 | 0.002 | 0.004 | 0.007 |
| | H4769 | 21 | 0 | 0 | 0.41 | 0.5 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.001 |
| | H4771 | 34.5 | 0 | 0 | 0.1 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |

## Table G-3d. Continued

| Source[a] | ID Number[b] | Percent N | Percent P | Percent K | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly V addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly V addition in kg/ha at 414 lb N/A 464 kg/ha | Yearly Cu addition in kg/ha at 124 lb N/A 139 kg/ha | Yearly Cu addition in kg/ha at 206 lb N/A 231 kg/ha | Yearly Cu addition in kg/ha at 414 lb N/A 464 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raven | Urea[d] | 46 | 0 | 0 | 0.2 | 0.3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $NH_4NO_3$[e] | 34 | 0 | 0 | 0.1 | 0.3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $NH_4SO_4$[e] | 21 | 0 | 0 | 0.1 | 0.3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | $NH_4SO_4$[e] | 21 | 0 | 0 | 0.1 | 0.3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| CDFA | 25042 | 20 | 0 | 0 | NR[f] | 4 | NC[g] | NC | NC | 0.003 | 0.005 | 0.009 |
| | 21575 | 32 | 10 | 10 | NR | 10.5 | NC | NC | NC | 0.005 | 0.008 | 0.015 |
| | 24276 | 14 | 3 | 7 | NR | 21 | NC | NC | NC | 0.021 | 0.035 | 0.070 |
| | 23106 | 7 | 2 | 2 | NR | 40.5 | NC | NC | NC | 0.080 | 0.134 | 0.268 |
| | 22080 | 34 | 17 | 0 | NR | 17 | NC | NC | NC | 0.007 | 0.012 | 0.023 |
| | 22216 | 9 | 4 | 4 | NR | NR | NC | NC | NC | NR | NR | NR |
| | 20891 | 16 | 4 | 8 | NR | 265 | NC | NC | NC | 0.230 | 0.383 | 0.769 |
| Average | | 23.9 | 2.26 | 2.37 | 65.3 | 40.2 | 0.106 | 0.176 | 0.354 | 0.064 | 0.107 | 0.215 |

a) Sources:
PDA: Pennsylvania Department of Agriculture (1998)
Wash St: Washington State Deparmtent of Ecology (1997)
Raven: Raven and Loeppert (1997)
CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) NPK rating not given, see Table 3-4.
e) NPK rating not given, granular grade used.
f) NR = not reported.
g) NC = not calculated.

## Table G-3e. Yearly Zn Additions to Soil (kg/ha) from NPK Fertilizers Applied for N Content

| Source[a] | ID Number[b] | Percent | | | Zn mg/kg | Yearly Zn addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 124 lb N/A | 206 lb N/A | 414 lb N/A |
| | | N | P | K | | 139 kg/ha | 231 kg/ha | 464 kg/ha |
| PDA | B960243 | 19 | 19 | 19 | 36 | 0.026 | 0.044 | 0.088 |
| | B960244 | 12 | 24 | 24 | 44.5 | 0.052 | 0.086 | 0.172 |
| | B960249 | 7 | 35 | 12 | 55.1 | 0.109 | 0.182 | 0.365 |
| | B960282 | 9 | 44 | 9 | 49.8 | 0.077 | 0.128 | 0.257 |
| | B960325 | 10 | 21 | 15 | 872 | 1.212 | 2.014 | 4.046 |
| | B960333 | 8 | 32 | 16 | 43.9 | 0.076 | 0.127 | 0.255 |
| | B960389 | 19 | 19 | 19 | 0 | 0.000 | 0.000 | 0.000 |
| | B960412 | 7 | 26 | 26 | 37 | 0.073 | 0.122 | 0.245 |
| | B960418 | 19 | 19 | 19 | 33.1 | 0.024 | 0.040 | 0.081 |
| | B960441 | 9 | 34 | 10 | 34.6 | 0.053 | 0.089 | 0.178 |
| | B960441 | 9 | 3 | 10 | 53.1 | 0.082 | 0.136 | 0.274 |
| | B960453 | 10 | 20 | 20 | 60.9 | 0.085 | 0.141 | 0.283 |
| | B960475 | 9 | 40 | 5 | 4442 | 6.860[c] | **11.401[d]** | **22.901** |
| | B960510 | 9 | 43 | 10 | 66.2 | 0.102 | 0.170 | 0.341 |
| | B960580 | 10 | 10 | 10 | 803 | 1.116 | 1.855 | 3.726 |
| | B960584 | 10 | 20 | 20 | 0.48 | 0.001 | 0.001 | 0.002 |
| | B960599 | 15 | 15 | 15 | 0.55 | 0.001 | 0.001 | 0.002 |
| | B960611 | 19 | 19 | 19 | 6.93 | 0.005 | 0.008 | 0.017 |
| | B960639 | 6 | 2 | 0 | 1.1 | 0.003 | 0.004 | 0.009 |
| | B960708 | 7 | 27 | 11 | 57.8 | 0.115 | 0.191 | 0.383 |
| | B960711 | 8 | 24 | 8 | 177 | 0.308 | 0.511 | 1.027 |
| | B960713 | 10 | 20 | 10 | 84.5 | 0.117 | 0.195 | 0.392 |
| | B960715 | 15 | 15 | 15 | 0.3 | 0.000 | 0.000 | 0.001 |
| | B980726 | 19 | 19 | 19 | 74.5 | 0.055 | 0.091 | 0.182 |
| | B960820 | 26 | 9 | 9 | 45.7 | 0.024 | 0.041 | 0.082 |
| | B960896 | 10 | 20 | 20 | 23.6 | 0.033 | 0.055 | 0.110 |
| | B960900 | 10 | 20 | 20 | 25.5 | 0.035 | 0.059 | 0.118 |
| | B960909 | 3 | 17 | 40 | 39.5 | 0.183 | 0.304 | 0.611 |
| | B960912 | 3 | 17 | 40 | 52.2 | 0.242 | 0.402 | 0.807 |
| | B960913 | 8 | 41 | 12 | 484 | 0.841 | 1.398 | 2.807 |
| | B961058 | 8 | 17 | 34 | 18.3 | 0.032 | 0.053 | 0.106 |
| | B961321 | 9 | 43 | 10 | 44.8 | 0.069 | 0.115 | 0.231 |
| Wash St | H0751 | 46 | 0 | 0 | 7.7 | 0.002 | 0.004 | 0.008 |
| | H0752 | 20 | 0 | 0 | 3.90 | 0.003 | 0.005 | 0.009 |
| | H2538 | 32 | 0 | 0 | 0.5 | 0.000 | 0.000 | 0.001 |
| | H1233 | 17 | 0 | 0 | 0.2 | 0.000 | 0.000 | 0.001 |
| | H0754 | 15.5 | 0 | 0 | 1 | 0.001 | 0.001 | 0.003 |
| | H4769 | 21 | 0 | 0 | 17 | 0.011 | 0.019 | 0.038 |
| | H4771 | 34.5 | 0 | 0 | 2.5 | 0.001 | 0.002 | 0.003 |

## Table G-3e. Continued

| Source[a] | ID Number[b] | Percent N | Percent P | Percent K | Zn mg/kg | Yearly Zn addition in kg/ha at 124 lb N/A 139 kg/ha | 206 lb N/A 231 kg/ha | 414 lb N/A 464 kg/ha |
|---|---|---|---|---|---|---|---|---|
| Raven | Urea[e] | 46 | 0 | 0 | NR[f] | NC[g] | NC | NC |
| | $NH_4NO_3$[h] | 34 | 0 | 0 | NR | NC | NC | NC |
| | $NH_4SO_4$[h] | 21 | 0 | 0 | NR | NC | NC | NC |
| | $NH_4SO_4$[h] | 21 | 0 | 0 | NR | NC | NC | NC |
| CDFA | 25042 | 20 | 0 | 0 | NR[f] | NC[g] | NC | NC |
| | 21575 | 32 | 10 | 10 | NR | NC | NC | NC |
| | 24276 | 14 | 3 | 7 | NR | NC | NC | NC |
| | 23106 | 7 | 2 | 2 | NR | NC | NC | NC |
| | 22080 | 34 | 17 | 0 | NR | NC | NC | NC |
| | 22216 | 9 | 4 | 4 | NR | NC | NC | NC |
| | 20891 | 16 | 4 | 8 | NR | NC | NC | NC |
| Average | | 23.2 | 2.35 | 2.45 | 4.9 | 0.308 | 0.513 | 1.030 |

a) Sources:
PDA: Pennsylvania Department of Agriculture (1998)
Wash St: Washington State Deparmtent of Ecology (1997)
Raven: Raven and Loeppert (1997)
CDFA: California Department of Food & Agriculture (1997)

b) Sample identification used by author.
c) Shading indicates highest yearly addition values for this metal from NPK products applied for N content.
d) Bold indicates yearly addition exceeds the Canadian Fertilizers Act limit for this metal.
e) NPK rating not given, see Table 3-4.
f) NR = not reported.
g) NC = not calculated.
h) NPK rating not given, granular grade used.

## Table G-4a. Yearly Cd and Pb Additions to Soil (kg/ha) from Potash ($K_2O$) Fertilizers

| | | | | | Yearly Cd addition in kg/ha at | | | Yearly Pb addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 103 lb $K_2O$/A | 177 lb $K_2O$/A | 534 lb $K_2O$/A | 103 lb $K_2O$/A | 177 lb $K_2O$/A | 534 lb $K_2O$/A |
| Source[a] | ID[b] | Percent $K_2O$ | Cd mg/kg | Pb mg/kg | 115 kg/ha | 198 kg/ha | 598 kg/ha | 115 kg/ha | 198 kg/ha | 598 kg/ha |
| Charter | MP1[c] | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP2 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP3 | 60 | 1.3 | 4.5 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.004 |
| | MP4 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP5 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP6 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP7 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP8 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP9 | 60 | 1.3 | 4.5 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.004 |
| | MP10 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP11 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP12 | 60 | 1.3 | 12 | 0.000 | 0.000 | 0.001 | 0.002[d] | 0.004 | 0.012 |
| | MP13 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP14 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP15 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP16 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP17 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP18 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP19 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP20 | 60 | 1.9 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP21 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP22 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP23 | 60 | 1.9 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP24 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| | MP25 | 60 | 1.6 | 4.5 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| IMC | 8813185 | 22.6[e] | 0.05 | 0.95 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 |
| | 8813186 | 22.6[e] | 0.05 | 0.58 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 |
| | 8813187 | 51.3[f] | 0.05 | 0.74 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | 8813188 | 51.3[f] | 0.05 | 0.32 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813189 | 60[g] | 0.05 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813190 | 60[h] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813191 | 60[h] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813192 | 60[h] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813193 | 60[h] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813194 | 60[h] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Note: Footnotes may be found at the end of this table

## Table G-4a. (Continued)

| Source[a] | ID[b] | Percent $K_2O$ | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha at | | | Yearly Pb addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 103 lb $K_2O/A$ | 177 lb $K_2O/A$ | 534 lb $K_2O/A$ | 103 lb $K_2O/A$ | 177 lb $K_2O/A$ | 534 lb $K_2O/A$ |
| | | | | | 115 kg/ha | 198 kg/ha | 598 kg/ha | 115 kg/ha | 198 kg/ha | 598 kg/ha |
| Raven | KCl1 | 60[h] | 0.1 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | KCl2 | 60[h] | 0.1 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | $KMgSO_4$ | 22.6[i] | 0.1 | 1.4 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.004 |
| | $KMgSO_4$ | 22.6[i] | 0.8 | 1.1 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.003 |
| Wash St | H4767 | 62 | 0.15 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | H4765 | 46 | 0.15 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| CDFA | 25029 | 51.3[j] | 0 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| Average | | 55.6 | 1.0 | 5.8 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.003 |

a) Sources:
Charter: Charter et al. (1993)
IMC: International Mineral Company (1997)
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) MP = muriate of potash
d) Shading indicates highest yearly addition values of this metal from potash products.
e) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% $K_2O$, see Table 3-4.
f) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% $K_2O$, see Table 3-4.
g) Samples listed as "GMOP"- granular muriate of potash; assumed 60% $K_2O$ per Table 3-4.
h) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% $K_2O$, see Table 3-4.
i Samples listed as "Potassium magnesium sulfate"; assumed 22.6% $K_2O$.
j) Sample listed as "Potassium sulfate"; assumed 51.3% $K_2O$.

## Table G-4b. Yearly As and Cr Additions to Soil (kg/ha) from Potash ($K_2O$) Fertilizers

| | | | | | Yearly As addition in kg/ha at | | | Yearly Cr addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 103 lb $K_2O$/A | 177 lb $K_2O$/A | 534 lb $K_2O$/A | 103 lb $K_2O$/A | 177 lb $K_2O$/A | 534 lb $K_2O$/A |
| Source[a] | ID[b] | Percent $K_2O$ | As mg/kg | Cr mg/kg | 115 kg/ha | 198 kg/ha | 598 kg/ha | 115 kg/ha | 198 kg/ha | 598 kg/ha |
| Charter | MP1[c] | 60 | NR[d] | NR | NC[e] | NC | NC | NC | NC | NC |
| | MP2 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP3 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP4 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP5 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP6 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP7 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP8 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP9 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP10 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP11 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP12 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP13 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP14 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP15 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP16 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP17 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP18 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP19 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP20 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP21 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP22 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP23 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP24 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| | MP25 | 60 | NR | NR | NC | NC | NC | NC | NC | NC |
| IMC | 8813185 | 22.6[f] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813186 | 22.6[f] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813187 | 51.3[g] | 0.05 | 0.13 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813188 | 51.3[g] | 0.05 | 0.17 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813189 | 60[h] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813190 | 60[i] | 0.05 | 0.12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813191 | 60[i] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813192 | 60[i] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813193 | 60[i] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813194 | 60[i] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Note: Footnotes may be found at the end of this table

## Table G-4b. (Continued)

| Source[a] | ID[b] | Percent $K_2O$ | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at | | | Yearly Cr addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 103 lb $K_2O$/A | 177 lb $K_2O$/A | 534 lb $K_2O$/A | 103 lb $K_2O$/A | 177 lb $K_2O$/A | 534 lb $K_2O$/A |
| | | | | | 115 kg/ha | 198 kg/ha | 598 kg/ha | 115 kg/ha | 198 kg/ha | 598 kg/ha |
| Raven | KCl1 | 60[i] | 0.2 | 0.52 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | KCl2 | 60[i] | 0.2 | NR | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| | $KMgSO_4$ | 22.6[j] | 0.3 | 2.75 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.007 |
| | $KMgSO_4$ | 22.6[l] | 0.3 | NR | 0.000 | 0.000 | 0.001 | NC | NC | NC |
| Wash St | H4767 | 62 | 1.5 | 0.25 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| | H4765 | 46 | 1.5 | 2.5 | 0.000[k] | 0.001 | 0.002 | 0.001 | 0.001 | 0.003 |
| CDFA | 25029 | 51.3[l] | 0.2 | NR | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| Average | | 55.6 | 0.3 | 1.306 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |

a) Sources:
   Charter: Charter et al. (1995)
   IMC: International Mineral Company (1997)
   Raven: Raven and Loeppert (1997)
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) MP = muriate of potash
d) NR = not reported
e) NC = not calculated
f) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% $K_2O$, see Table 3-4.
g) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% $K_2O$, see Table 3-4.
h) Samples listed as "GMOP"- granular muriate of potash; assumed 60% $K_2O$, see Table 3-4.
i) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% $K_2O$, see Table 3-4.
j) Samples listed as "Potassium magnesium sulfate"; assumed 22.6% $K_2O$.
k) Shading indicates highest yearly addition values of this metal from potash products
l) Sample listed as "Potassium sulfate"; assumed 51.3% $K_2O$.

## Table G-4c. Yearly Hg and Ni Additions to Soil (kg/ha) from Potash ($K_2O$) Fertilizers

| Source[a] | ID[b] | Percent $K_2O$ | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha at 103 lb $K_2O$/A 115 kg/ha | Yearly Hg addition in kg/ha at 177 lb $K_2O$/A 198 kg/ha | Yearly Hg addition in kg/ha at 534 lb $K_2O$/A 598 kg/ha | Yearly Ni addition in kg/ha at 103 lb $K_2O$/A 115 kg/ha | Yearly Ni addition in kg/ha at 177 lb $K_2O$/A 198 kg/ha | Yearly Ni addition in kg/ha at 534 lb $K_2O$/A 598 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Charter | MP1[c] | 60 | NR[d] | 1.4 | NC[e] | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP2 | 60 | NR | 3.5 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| | MP3 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP4 | 60 | NR | 3.5 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| | MP5 | 60 | NR | 2.8 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| | MP6 | 60 | NR | 2.8 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| | MP7 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP8 | 60 | NR | 2.8 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| | MP9 | 60 | NR | 4.4 | NC | NC | NC | 0.001[f] | 0.002 | 0.004 |
| | MP10 | 60 | NR | 2.8 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| | MP11 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP12 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP13 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP14 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP15 | 60 | NR | 3.5 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| | MP16 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP17 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP18 | 60 | NR | 2.8 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| | MP19 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP20 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP21 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP22 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP23 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP24 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP25 | 60 | NR | 1.4 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| IMC | 8813185 | 22.6[g] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813186 | 22.6[g] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813187 | 51.3[h] | 0.05 | 2.6 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 |
| | 8813188 | 51.3[h] | 0.05 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | 8813189 | 60[i] | 0.05 | 0.25 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813190 | 60[j] | 0.05 | 0.14 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813191 | 60[j] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813192 | 60[j] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813193 | 60[j] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813194 | 60[j] | 0.05 | 0.82 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |

Note: Footnotes may be found at the end of the table

## Table G-4c. (Continued)

| Source[a] | ID[b] | Percent $K_2O$ | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha at | | | Yearly Ni addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 103 lb $K_2O$/A | 177 lb $K_2O$/A | 534 lb $K_2O$/A | 103 lb $K_2O$/A | 177 lb $K_2O$/A | 534 lb $K_2O$/A |
| | | | | | 115 kg/ha | 198 kg/ha | 598 kg/ha | 115 kg/ha | 198 kg/ha | 598 kg/ha |
| Raven | KCl1 | 60[j] | 0.2 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | KCl2 | 60[j] | 0.2 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $KMgSO_4$ | 22.6[k] | 0.2 | 0.5 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.001 |
| | $KMgSO_4$ | 22.6[k] | 0.2 | 0.3 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.001 |
| Wash St | H4767 | 62 | 0.003 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H4765 | 46 | 0.003 | 1.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 |
| CDFA | 25029 | 51.3[l] | NR | NR | NC | NC | NC | NC | NC | NC |
| Average | | 55.6 | 0.1 | 1.4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 |

a) Sources:
Charter: Charter et al. (1995)
IMC: International Mineral Company (1997)
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) MP = muriate of potash
d) NR = not reported
e) NC = not calculated
f) Shading indicates highest yearly addition values of this metal from potash products.
g) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% $K_2O$, see Table 3-4.
h) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% $K_2O$, see Table 3-4.
i) Samples listed as "GMOP"- granular muriate of potash; assumed 60% $K_2O$, see Table 3-4.
j) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% $K_2O$, see Table 3-4.
k) Samples listed as "Potassium magnesium sulfate"; assumed 22.6% $K_2O$.
l) Sample listed as "Potassium sulfate"; assumed 51.3% $K_2O$.

## Table G-4d. Yearly V and Cu Additions to Soil (kg/ha) from Potash ($K_2O$) Fertilizers

| Source[a] | ID[b] | Percent $K_2O$ | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at 103 lb $K_2O$/A 115 kg/ha | Yearly V addition in kg/ha at 177 lb $K_2O$/A 198 kg/ha | Yearly V addition in kg/ha at 534 lb $K_2O$/A 598 kg/ha | Yearly Cu addition in kg/ha at 103 lb $K_2O$/A 115 kg/ha | Yearly Cu addition in kg/ha at 177 lb $K_2O$/A 198 kg/ha | Yearly Cu addition in kg/ha at 534 lb $K_2O$/A 598 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Charter | MP1[c] | 60 | NR[d] | 0.75 | NC[e] | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP2 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP3 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP4 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP5 | 60 | NR | 2.1 | NC | NC | NC | 0.000 | 0.001 | 0.002 |
| | MP6 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP7 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP8 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP9 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP10 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP11 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP12 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP13 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP14 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP15 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP16 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP17 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP18 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP19 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP20 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP21 | 60 | NR | 2.6 | NC | NC | NC | 0.000 | 0.001 | 0.003 |
| | MP22 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP23 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP24 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| | MP25 | 60 | NR | 0.75 | NC | NC | NC | 0.000 | 0.000 | 0.001 |
| IMC | 8813185 | 22.6[f] | 0.05 | 0.36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | 8813186 | 22.6[f] | 1.1 | 0.05 | 0.001 | 0.001 | 0.003 | 0.000 | 0.000 | 0.000 |
| | 8813187 | 51.3[g] | 0.93 | 0.19 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| | 8813188 | 51.3[g] | 0.05 | 0.34 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813189 | 60[h] | 1.8 | 1.1 | 0.000 | 0.001 | 0.002 | 0.000 | 0.000 | 0.001 |
| | 8813190 | 60[i] | 1.3 | 0.05 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| | 8813191 | 60[i] | 2 | 0.3 | 0.000 | 0.001 | 0.002 | 0.000 | 0.000 | 0.000 |
| | 8813192 | 60[i] | 0.05 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 8813193 | 60[i] | 0.74 | 0.33 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| | 8813194 | 60[h] | 1.6 | 0.05 | 0.000 | 0.001 | 0.002 | 0.000 | 0.000 | 0.000 |

Note: Footnotes may be found at the end of the table.

## Table G-4d. (Continued)

| Source[a] | ID[b] | Percent $K_2O$ | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at 103 lb $K_2O$/A 115 kg/ha | Yearly V addition in kg/ha at 177 lb $K_2O$/A 198 kg/ha | Yearly V addition in kg/ha at 534 lb $K_2O$/A 598 kg/ha | Yearly Cu addition in kg/ha at 103 lb $K_2O$/A 115 kg/ha | Yearly Cu addition in kg/ha at 177 lb $K_2O$/A 198 kg/ha | Yearly Cu addition in kg/ha at 534 lb $K_2O$/A 598 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Raven | KCl1 | 60[i] | 0.3 | 3.5 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 |
| | KCl2 | 60[i] | 0.1 | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | $KMgSO_4$ | 22.6[j] | 0.7 | 5 | 0.000 | 0.001 | 0.002 | 0.002[k] | 0.004 | 0.013 |
| | $KMgSO_4$ | 22.6[j] | 9 | 1.4 | 0.005 | 0.008 | 0.024 | 0.001 | 0.001 | 0.004 |
| Wash St | H4767 | 62 | 0.1 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H4765 | 46 | 0.1 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| CDFA | 25029 | 51.3[l] | NR | 5 | NC | NC | NC | 0.001 | 0.002 | 0.006 |
| Arora | MP | 60 | NR | 3.1 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| Average | | 55.6 | 1.2 | 1.0 | 0.000 | 0.001 | 0.002 | 0.000 | 0.000 | 0.001 |

a) Sources:
Charter: Charter et al. (1995)
IMC: International Mineral Company (1997)
Raven: Raven and Loeppert (1997)
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) MP = muriate of potash
d) NR = not reported
e) NC = not calculated
f) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% $K_2O$, see Table 3-4.
g) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% $K_2O$, see Table 3-4.
h) Samples listed as "GMOP"- granular muriate of potash; assumed 60% $K_2O$, see Table 3-4.
i) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% $K_2O$, see Table 3-4.
j) Samples listed as "Potassium magnesium sulfate"; assumed 22.6% $K_2O$.
k) Shading indicates highest yearly addition values of this metal from potash products.
l) Sample listed as "Potassium sulfate"; assumed 51.3% $K_2O$.

## Table G-4e. Yearly Zn Additions to Soil (kg/ha) from Potash ($K_2O$) Fertilizers

| Source[a] | ID[b] | Percent $K_2O$ | Zn mg/kg | Yearly Zn addition in kg/ha at 103 lb $K_2O$/A 115 kg/ha | 177 lb $K_2O$/A 198 kg/ha | 534 lb $K_2O$/A 598 kg/ha |
|---|---|---|---|---|---|---|
| Charter | MP1[c] | 60 | 3 | 0.001 | 0.001 | 0.003 |
| | MP2 | 60 | 1.3 | 0.000 | 0.000 | 0.001 |
| | MP3 | 60 | 1.1 | 0.000 | 0.000 | 0.001 |
| | MP4 | 60 | 1.9 | 0.000 | 0.001 | 0.002 |
| | MP5 | 60 | 1.9 | 0.000 | 0.001 | 0.002 |
| | MP6 | 60 | 1.6 | 0.000 | 0.001 | 0.002 |
| | MP7 | 60 | 1.8 | 0.000 | 0.001 | 0.002 |
| | MP8 | 60 | 1.3 | 0.000 | 0.000 | 0.001 |
| | MP9 | 60 | 1.3 | 0.000 | 0.000 | 0.001 |
| | MP10 | 60 | 1.5 | 0.000 | 0.000 | 0.001 |
| | MP11 | 60 | 1.1 | 0.000 | 0.000 | 0.001 |
| | MP12 | 60 | 1.3 | 0.000 | 0.000 | 0.001 |
| | MP13 | 60 | 1.3 | 0.000 | 0.000 | 0.001 |
| | MP14 | 60 | 1.1 | 0.000 | 0.000 | 0.001 |
| | MP15 | 60 | 1.3 | 0.000 | 0.000 | 0.001 |
| | MP16 | 60 | 1.8 | 0.000 | 0.001 | 0.002 |
| | MP17 | 60 | 1.1 | 0.000 | 0.000 | 0.001 |
| | MP18 | 60 | 1.3 | 0.000 | 0.000 | 0.001 |
| | MP19 | 60 | 1.1 | 0.000 | 0.000 | 0.001 |
| | MP20 | 60 | 1.5 | 0.000 | 0.000 | 0.001 |
| | MP21 | 60 | 2.6 | 0.000 | 0.001 | 0.003 |
| | MP22 | 60 | 1 | 0.000 | 0.000 | 0.001 |
| | MP23 | 60 | 1.6 | 0.000 | 0.001 | 0.002 |
| | MP24 | 60 | 1.3 | 0.000 | 0.000 | 0.001 |
| | MP25 | 60 | 1.3 | 0.000 | 0.000 | 0.001 |
| IMC | 8813185 | 22.6[d] | 0.69 | 0.000 | 0.001 | 0.002 |
| | 8813186 | 22.6[d] | 0.92 | 0.000 | 0.001 | 0.002 |
| | 8813187 | 51.3[e] | 1.3 | 0.000 | 0.001 | 0.002 |
| | 8813188 | 51.3[e] | 2.1 | 0.000 | 0.001 | 0.002 |
| | 8813189 | 60[f] | 1.1 | 0.000 | 0.000 | 0.001 |
| | 8813190 | 60[g] | 0.81 | 0.000 | 0.000 | 0.001 |
| | 8813191 | 60[g] | 0.64 | 0.000 | 0.000 | 0.001 |
| | 8813192 | 60[g] | 0.39 | 0.000 | 0.000 | 0.000 |
| | 8813193 | 60[g] | 0.72 | 0.000 | 0.000 | 0.001 |
| | 8813194 | 60[g] | 0.19 | 0.000 | 0.000 | 0.000 |

Note: Footnotes may be found at the end of the table.

## Table G-4e. (Continued)

| Source[a] | ID[b] | Percent $K_2O$ | Zn mg/kg | Yearly Zn addition in kg/ha at 103 lb $K_2O$/A 115 kg/ha | 177 lb $K_2O$/A 198 kg/ha | 534 lb $K_2O$/A 598 kg/ha |
|---|---|---|---|---|---|---|
| Raven | KCl1 | 60[g] | 4.59 | 0.001 | 0.002 | 0.005 |
| | KCl2 | 60[g] | NR[h] | NC[i] | NC | NC |
| | $KMgSO_4$ | 22.6[j] | 8.75 | 0.004[k] | 0.008 | 0.023 |
| | $KMgSO_4$ | 22.6[j] | NR | NC | NC | NC |
| Wash St | H4767 | 62 | 0.69 | 0.000 | 0.000 | 0.001 |
| | H4765 | 46 | 0.73 | 0.000 | 0.000 | 0.001 |
| CDFA | 25029 | 51.3[l] | NR | NC | NC | NC |
| Average | | 55.6 | 1.8 | 0.000 | 0.001 | 0.002 |

a) Sources:
   Charter: Charter et al. (1995)
   IMC: International Mineral Company (1997)
   Raven: Raven and Loeppert (1997)
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) MP = muriate of potash
d) Samples listed as "SPM" or "GSPM"- sulfopotassium magnesium or granular SPM; assumed 22.6% $K_2O$, see Table 3-4.
e) Samples listed as "SSOP" or "GSOP"- standard/granular sulfate of potash; assumed 51.3% $K_2O$, see Table 3-4.
f) Samples listed as "GMOP"- granular muriate of potash; assumed 60% $K_2O$, see Table 3-4.
g) Samples listed as either "Ind White", "Ag. White", "Std KCl", "Coarse KCl", "Granular KCl", and indicated as all KCl products; assumed 60% $K_2O$, see Table 3-4.
h) NR = not reported
i) NC = not calculated
j) Samples listed as "Potassium magnesium sulfate"; assumed 22.6% $K_2O$.
k) Shading indicates highest yearly addition values of this metal from potash products.
l) Sample listed as "Potassium sulfate"; assumed 51.3% $K_2O$.

## Table G-5a. Yearly Cd and Pb Additions to Soil (kg/ha) from Zn Fertilizers

| Source[a] | ID[b] | Percent Zn in product | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha | Yearly Cd addition in kg/ha, at 10 lb Zn/A 11.2 kg/ha | Yearly Cd addition in kg/ha, at 20 lb Zn/A 22.4 kg/ha | Yearly Pb addition in kg/ha at 5 lb Zn/A 5.6 kg/ha | Yearly Pb addition in kg/ha at 10 lb Zn/A 11.2 kg/ha | Yearly Pb addition in kg/ha at 20 lb Zn/A 22.4 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Mortvedt | $ZnSO_4$ | 34 | 2165 | 60 | 0.036[c] | 0.071 | **0.143**[d] | 0.001 | 0.002 | 0.004 |
| | ZnOS-1 | 35.1 | 590 | 44000 | 0.009 | 0.019 | 0.038 | 0.702 | 1.404 | **2.808** |
| | ZnOS-2 | 41.5 | 1970 | 400 | 0.027 | 0.053 | **0.106** | 0.005 | 0.011 | 0.022 |
| | ZnOBP-1 | 58.3 | 243 | 1900 | 0.002 | 0.005 | 0.009 | 0.018 | 0.037 | 0.073 |
| | ZnOBP-2 | 34 | 1420 | 52000 | 0.023 | 0.047 | **0.094** | 0.856 | 1.713 | **3.426** |
| | ZnOBP-3 | 27.7 | 76 | 2470 | 0.002 | 0.003 | 0.006 | 0.050 | 0.100 | 0.200 |
| | Zn-ZnOBP | 89 | 500 | 11870 | 0.003 | 0.006 | 0.013 | 0.075 | 0.149 | 0.299 |
| | ZnFeBP1 | 9.2 | 4 | 50 | 0.000 | 0.000 | 0.001 | 0.003 | 0.006 | 0.012 |
| | ZnFePB2 | 13.3 | 26 | 1080 | 0.001 | 0.002 | 0.004 | 0.045 | 0.091 | 0.182 |
| Amrani | $ZnSO_4$ | 35.5 | 61 | 90 | 0.001 | 0.002 | 0.004 | 0.001 | 0.003 | 0.006 |
| | Zn20 | 20.4 | 75 | 158 | 0.002 | 0.004 | 0.008 | 0.004 | 0.009 | 0.017 |
| | Zn27 | 27.3 | 43 | 178 | 0.001 | 0.002 | 0.004 | 0.004 | 0.007 | 0.015 |
| | Zn40 | 39.9 | 28 | 293 | 0.000 | 0.001 | 0.002 | 0.004 | 0.008 | 0.016 |
| | ZnOxS | 37.7 | 43 | 1866 | 0.001 | 0.001 | 0.003 | 0.028 | 0.055 | 0.111 |
| | ZnOS | 17.5 | 435 | 23070 | 0.014 | 0.028 | 0.056 | 0.738 | 1.476 | **2.953** |
| | K061[e] | 15 | 359 | 19170 | 0.013 | 0.027 | 0.054 | 0.716 | 1.431 | **2.863** |
| Wash St | H1906 | 18 | 275 | 11300 | 0.009 | 0.017 | 0.034 | 0.352 | 0.703 | 1.406 |
| | GrZn | 18 | 52 | 1400 | 0.002 | 0.003 | 0.006 | 0.044 | 0.087 | 0.174 |
| CoZinco | 1 | 26.75 | NR[f] | 18700 | NC[g] | NC | NC | 0.391 | 0.783 | 1.566 |
| | 2 | 14.5 | NR | 20300 | NC | NC | NC | 0.784 | 1.568 | **3.136** |
| | 3 | 28.35 | NR | 1300 | NC | NC | NC | 0.026 | 0.051 | 0.103 |
| | 4 | 18.4 | NR | 1500 | NC | NC | NC | 0.046 | 0.091 | 0.183 |
| | 5 | 18.9 | NR | 600 | NC | NC | NC | 0.018 | 0.036 | 0.071 |
| | 6 | 13.8 | NR | 200 | NC | NC | NC | 0.008 | 0.016 | 0.032 |
| | 7 | 29.2 | NR | 20700 | NC | NC | NC | 0.397 | 0.794 | 1.588 |
| | 8 | 16.3 | NR | 10500 | NC | NC | NC | 0.361 | 0.721 | 1.443 |
| | 9 | 16.5 | NR | 14000 | NC | NC | NC | 0.475 | 0.950 | 1.901 |
| | 10 | 42.8 | NR | 2300 | NC | NC | NC | 0.030 | 0.060 | 0.120 |
| | 11 | 32 | NR | 29400 | NC | NC | NC | 0.515 | 1.029 | 2.058 |
| | 12 | 19 | NR | 15400 | NC | NC | NC | 0.454 | 0.908 | 1.816 |
| | 13 | 21.3 | NR | 17500 | NC | NC | NC | 0.460 | 0.920 | 1.840 |
| | 14 | 17.1 | NR | 13000 | NC | NC | NC | 0.426 | 0.851 | 1.703 |
| | 15 | 38.1 | NR | 0 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | 16 | 17.5 | NR | 9300 | NC | NC | NC | 0.298 | 0.595 | 1.190 |

Note: Footnotes may be found at the end of this table

## Table G-5a. (Continued)

| Source[a] | ID[b] | Percent Zn in product | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha | 10 lb Zn/A 11.2 kg/ha | 20 lb Zn/A 22.4 kg/ha | Yearly Pb addition in kg/ha at 5 lb Zn/A 5.6 kg/ha | 10 lb Zn/A 11.2 kg/ha | 20 lb Zn/A 22.4 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| CoZinco | 17 | 28.1 | NR | 23700 | NC | NC | NC | 0.472 | 0.945 | 1.889 |
| | 18 | 38.2 | NR | 12500 | NC | NC | NC | 0.183 | 0.366 | 0.733 |
| | 19 | 18.2 | NR | 6700 | NC | NC | NC | 0.206 | 0.412 | 0.825 |
| | 20 | 16.1 | NR | 15500 | NC | NC | NC | 0.539 | 1.078 | 2.157 |
| | 21 | 24.7 | NR | 15400 | NC | NC | NC | 0.349 | 0.698 | 1.397 |
| | 22 | 35.3 | NR | 0 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | 23 | 36 | NR | 0 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | 24 | 16.9 | NR | 2400 | NC | NC | NC | 0.080 | 0.159 | 0.318 |
| | 25 | 36 | NR | 0 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | 26 | 29.6 | NR | 700 | NC | NC | NC | 0.013 | 0.026 | 0.053 |
| | 27 | 24.6 | NR | 1000 | NC | NC | NC | 0.023 | 0.046 | 0.091 |
| | 28 | 22.4 | NR | 19000 | NC | NC | NC | 0.475 | 0.950 | 1.900 |
| | 29 | 19.5 | NR | 21400 | NC | NC | NC | 0.615 | 1.229 | **2.458** |
| | 30 | 24.5 | NR | 14800 | NC | NC | NC | 0.338 | 0.677 | 1.353 |
| | 31 | 40.5 | NR | 16100 | NC | NC | NC | 0.223 | 0.445 | 0.890 |
| | 32 | 22.5 | NR | 16500 | NC | NC | NC | 0.411 | 0.821 | 1.643 |
| | 33 | 23.5 | NR | 19200 | NC | NC | NC | 0.458 | 0.915 | 1.830 |
| | 34 | 19.5 | NR | 17200 | NC | NC | NC | 0.494 | 0.988 | 1.976 |
| | 35 | 10.5 | NR | 30 | NC | NC | NC | 0.002 | 0.003 | 0.006 |
| | 36 | 9.5 | NR | 1400 | NC | NC | NC | 0.083 | 0.165 | 0.330 |
| | 37 | 32.7 | NR | 30 | NC | NC | NC | 0.001 | 0.001 | 0.002 |
| | 38 | 41 | NR | 14800 | NC | NC | NC | 0.202 | 0.404 | 0.809 |
| | 39 | 40.7 | NR | 3700 | NC | NC | NC | 0.051 | 0.102 | 0.204 |
| | 40 | 32.6 | NR | 1900 | NC | NC | NC | 0.033 | 0.065 | 0.131 |
| | 41 | 35.6 | NR | 40 | NC | NC | NC | 0.001 | 0.001 | 0.003 |
| CDFA | 26160 | 12 | 2 | 18 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.003 |
| | 21351 | 18 | 370 | 10700 | 0.012 | 0.023 | 0.046 | 0.333 | 0.666 | 1.332 |
| | 22487 | 10 | 11.5 | 13 | 0.001 | 0.001 | 0.003 | 0.001 | 0.001 | 0.003 |
| | 22575 | 7 | 8 | 0 | 0.001 | 0.001 | 0.003 | 0.000 | 0.000 | 0.000 |
| Average | | 26.5 | 398 | 9219 | 0.007 | 0.014 | 0.029 | 0.221 | 0.442 | 0.884 |

a) Sources:
   Mortvedt: Mortvedt (1985)
   Amrani: Amrani et al. (1997)
   Wash St: Washington State Department of Ecology (1997)
   CoZinco: CoZinco Sales (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from zinc products
d) Bold indicates that the yearly addition exceeds the Canadian Fertilizer Act limits for this contaminant
e) Product specifically identified as recycled K061 waste
f) NR = not reported
g) NC = not calculated

## Table G-5b. Yearly As and Cr Additions to Soil (kg/ha) from Zn Fertilizers

| Source[a] | ID[b] | Percent Zn in product | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha | 10 lb Zn/A 11.2 kg/ha | 20 lb Zn/A 22.4 kg/ha | Yearly Cr addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha | 10 lb Zn/A 11.2 kg/ha | 20 lb Zn/A 22.4 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H1906 | 18 | 17 | 580 | 0.001 | 0.001 | 0.002 | 0.018[c] | 0.036 | 0.072 |
| | GrZn | 18 | 17 | 97.8 | 0.001 | 0.001 | 0.002 | 0.003 | 0.006 | 0.012 |
| CDFA | 26160 | 12 | 0.5 | NR[d] | 0.000 | 0.000 | 0.000 | NC[e] | NC | NC |
| | 21351 | 18 | 45.5 | NR | 0.001 | 0.003 | 0.006 | NC | NC | NC |
| | 22487 | 10 | 0 | NR | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| | 22575 | 7 | 0 | NR | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| Average | | 14 | 13 | 338.9 | 0.000 | 0.001 | 0.002 | 0.011 | 0.021 | 0.042 |

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from zinc products
d) NR = not reported
e) NC = not calculated

## Table G-5c. Yearly Hg and Ni Additions to Soil (kg/ha) from Zn Fertilizers

| Source[a] | ID[b] | Percent Zn in product | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha | 10 lb Zn/A 11.2 kg/ha | 20 lb Zn/A 22.4 kg/ha | Yearly Ni addition in kg/ha, at 5 lb Zn/A 5.6 kg/ha | 10 lb Zn/A 11.2 kg/ha | 20 lb Zn/A 22.4 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H1906 | 18 | 3.36 | 83 | 0.000[c] | 0.000 | 0.000 | 0.003 | 0.005 | 0.010 |
| | GrZn | 18 | NR[d] | 61.6 | NC[e] | NC | NC | 0.002 | 0.004 | 0.008 |
| Mortvedt | $ZnSO_4$ | 34 | NR | 92 | NC | NC | NC | 0.002 | 0.003 | 0.006 |
| | ZnOS1 | 35.1 | NR | 158 | NC | NC | NC | 0.003 | 0.005 | 0.010 |
| | ZnOS2 | 41.5 | NR | 19 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | ZnOBP1 | 58.3 | NR | 8950 | NC | NC | NC | 0.086 | 0.172 | 0.344 |
| | ZnOBP2 | 34 | NR | 250 | NC | NC | NC | 0.004 | 0.008 | 0.016 |
| | ZnOBP3 | 27.7 | NR | 24 | NC | NC | NC | 0.000 | 0.001 | 0.002 |
| | ZnZnO | 89 | NR | 10 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | ZnFeBP1 | 9.2 | NR | 82 | NC | NC | NC | 0.005 | 0.010 | 0.020 |
| | ZnFEBP2 | 13.3 | NR | 60 | NC | NC | NC | 0.003 | 0.005 | 0.010 |
| Average | | 34 | 3.36 | 890 | 0.000 | 0.000 | 0.000 | 0.010 | 0.019 | 0.039 |

a) Sources:
Wash St: Washington State Department of Ecology (1997)
Mortvedt: Mortvedt (1985))
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from zinc products
d) NR = not reported
e) NC = not calculated

## Table G-5d. Yearly V and Cu Additions to Soil (kg/ha) from Zn Fertilizers

| Source[a] | ID[b] | Percent Zn in product | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha, at | | | Yearly Cu addition in kg/ha, at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 5 lb Zn/A | 10 lb Zn/A | 20 lb Zn/A | 5 lb Zn/A | 10 lb Zn/A | 20 lb Zn/A |
| | | | | | 5.6 kg/ha | 11.2 kg/ha | 22.4 kg/ha | 5.6 kg/ha | 11.2 kg/ha | 22.4 kg/ha |
| Wash St | H1906 | 18 | 41 | 1680 | 0.001[c] | 0.003 | 0.005 | 0.052 | 0.105 | 0.209 |
| | GrZn | 18 | 0.5 | 672 | 0.000 | 0.000 | 0.000 | 0.021 | 0.042 | 0.084 |
| CDFA | 26160 | 12 | NR[d] | 3 | NC[e] | NC | NC | 0.000 | 0.000 | 0.001 |
| | 21351 | 18 | NR | 2050 | NC | NC | NC | 0.064 | 0.128 | 0.255 |
| | 22487 | 10 | NR | 0 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| | 22575 | 7 | NR | 0 | NC | NC | NC | 0.000 | 0.000 | 0.000 |
| Average | | 13.8 | 20.8 | 734 | 0.001 | 0.001 | 0.003 | 0.023 | 0.046 | 0.091 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from zinc products
d) NR = not reported
e) NC = not calculated

## Table G-5e. Yearly Zn Additions to Soil (kg/ha) from Zn Fertilizers

Not applicable

## Table G-6a.  Yearly Cd and Pb Additions to Soil (kg/hg) from Mn Fertilizers

| Source[a] | ID[b] | Percent Mn in product | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha soil at | | | Yearly Pb addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4 lb Mn/A | 10 lb Mn/A | 18 lb Mn/A | 4 lb Mn/A | 10 lb Mn/A | 18 lb Mn/A |
| | | | | | 4.48 kg/ha | 11.2 kg/ha | 20.16 kg/ha | 4.48 kg/ha | 11.2 kg/ha | 20.16 kg/ha |
| Wash St | H4753 | 29.5 | 1.5 | 50 | 0.000 | 0.000 | 0.000 | 0.001[c] | 0.002 | 0.003 |
| CDFA | 21791 | 24.7[d] | 3 | 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Average | | 27.1 | 2.25 | 27.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 |

a) Sources:
   Wash St:  Washington State Department of Ecology (1997)
   CDFA:  California Department of Food and Agriculture (1977)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.

## Table G-6b.  Yearly As and Cr Additions to Soil (kg/hg) from Mn Fertilizers

| Source[a] | ID[b] | Percent Mn in product | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha soil at | | | Yearly Cr addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4 lb Mn/A | 10 lb Mn/A | 18 lb Mn/A | 4 lb Mn/A | 10 lb Mn/A | 18 lb Mn/A |
| | | | | | 4.48 kg/ha | 11.2 kg/ha | 20.16 kg/ha | 4.48 kg/ha | 11.2 kg/ha | 20.16 kg/ha |
| Wash St | H4753 | 29.5 | 15 | 10 | 0.000[c] | 0.001 | 0.001 | 0.000 | 0.000 | 0.001 |
| CDFA | 21791 | 24.7[d] | 0.5 | NR[e] | 0.000 | 0.000 | 0.000 | NC[f] | NC | NC |
| Average | | 27.1 | 7.8 | 10 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.001 |

a) Sources:
   Wash St:  Washington State Department of Ecology (1997)
   CDFA:  California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.
e) NR = not reported
f) NC = not calculated

## Table G-6c. Yearly Hg and Ni Additions to Soil (kg/hg) from Mn Fertilizers

| Source[a] | ID[b] | Percent Mn in product | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha soil at | | | Yearly Ni addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4 lb Mn/A | 10 lb Mn/A | 18 lb Mn/A | 4 lb Mn/A | 10 lb Mn/A | 18 lb Mn/A |
| | | | | | 4.48 kg/ha | 11.2 kg/ha | 20.16 kg/ha | 4.48 kg/ha | 11.2 kg/ha | 20.16 kg/ha |
| Wash St | H4753 | 29.5 | 0.01 | 50 | 0.000[c] | 0.000 | 0.000 | 0.001 | 0.002 | 0.003 |
| CDFA | 21791 | 24.7[d] | NR[e] | NR | NC[f] | NC | NC | NC | NC | NC |
| Average | | 27.1 | 0.01 | 50 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.003 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.
e) NR = not reported
f) NC = not calculated

## Table G-6d. Yearly V and Cu Additions to Soil (kg/hg) from Mn Fertilizers

| Source[a] | ID[b] | Percent Mn in product | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha soil at | | | Yearly Cu addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4 lb Mn/A | 10 lb Mn/A | 18 lb Mn/A | 4 lb Mn/A | 10 lb Mn/A | 18 lb Mn/A |
| | | | | | 4.48 kg/ha | 11.2 kg/ha | 20.16 kg/ha | 4.48 kg/ha | 11.2 kg/ha | 20.16 kg/ha |
| Wash St | H4753 | 29.5 | 1.5 | 21 | 0.000[c] | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| CDFA | 21791 | 24.7[d] | NR[e] | 1.5 | NC[f] | NC | NC | 0.000 | 0.000 | 0.000 |
| Average | | 27 | 1.5 | 11.3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.
e) NR = not reported
f) NC = not calculated

## Table G-6e. Yearly Zn Additions to Soil (kg/hg) from Mn Fertilizers

| Source[a] | ID[b] | Percent Mn in product | Zn mg/kg | Yearly Zn addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|
| | | | | 4 lb Mn/A | 10 lb Mn/A | 18 lb Mn/A |
| | | | | 4.48 kg/ha | 11.2 kg/ha | 20.16 kg/ha |
| Wash St | H4753 | 29.5 | 60.8 | 0.001[c] | 0.002 | 0.004 |
| CDFA | 21791 | 24.7[d] | NR[e] | NC[f] | NC | NC |
| Average | | 27.1 | 60.8 | 0.001 | 0.002 | 0.004 |

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from manganese products
d) Sample listed as manganese sulfate; assumed 100% product ($MnSO_4 \cdot 4H_2O$) which has 24.7% Mn by weight.
e) NR = not reported
f) NC = not calculated

## Table G-7a. Yearly Cd and Pb Additions to Soil (kg/ha) from Boron Fertilizers

| Source[a] | ID[b] | Percent Boron in product | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha at | | | Yearly Pb addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2 lb B/A | 3 lb B/A | 4 lb B/A | 2 lb B/A | 3 lb B/A | 4 lb B/A |
| | | | | | 2.24 kg/ha | 3.36 kg/ha | 4.48 kg/ha | 2.24 kg/ha | 3.36 kg/ha | 4.48 kg/ha |
| Wash St | H0753 | 10 | 0.75 | 5.5 | 0.000[c] | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CDFA | 25030 | 21 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Average | | 15.5 | 0.38 | 2.75 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products

## Table G-7b. Yearly As and Cr Additions to Soil (kg/ha) from Boron Fertilizers

| Source[a] | ID[b] | Percent Boron in product | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at | | | Yearly Cr addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2 lb B/A | 3 lb B/A | 4 lb B/A | 2 lb B/A | 3 lb B/A | 4 lb B/A |
| | | | | | 2.24 kg/ha | 3.36 kg/ha | 4.48 kg/ha | 2.24 kg/ha | 3.36 kg/ha | 4.48 kg/ha |
| Wash St | H0753 | 10 | 1040 | 1.3 | 0.023[c] | 0.035 | 0.047 | 0.000 | 0.000 | 0.000 |
| CDFA | 25030 | 21 | 1 | NR[d] | 0.000 | 0.000 | 0.000 | NC[e] | NC | NC |
| Average | | 15.5 | 520.5 | 1.3 | 0.012 | 0.017 | 0.023 | 0.000 | 0.000 | 0.000 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products
d) NR = not reported
e) NC = not calculated

### Table G-7c. Yearly Hg and Ni Additions to Soil (kg/ha) from Boron Fertilizers

| Source[a] | ID[b] | Percent Boron in product | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha at 2 lb B/A 2.24 kg/ha | 3 lb B/A 3.36 kg/ha | 4 lb B/A 4.48 kg/ha | Yearly Ni addition in kg/ha at 2 lb B/A 2.24 kg/ha | 3 lb B/A 3.36 kg/ha | 4 lb B/A 4.48 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H0753 | 10 | 0.17 | 2.5 | 0.000[c] | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CDFA | 25030 | 21 | NR[d] | NR | NC[e] | NC | NC | NC | NC | NC |
| Average | | 16 | 0.17 | 2.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products
d) NR = not reported
e) NC = not calculated

### Table G-7d. Yearly V and Cu Additions to Soil (kg/ha) from Boron Fertilizers

| Source[a] | ID[b] | Percent Boron in product | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at 2 lb B/A 2.24 kg/ha | 3 lb B/A 3.36 kg/ha | 4 lb B/A 4.48 kg/ha | Yearly Cu addition in kg/ha at 2 lb B/A 2.24 kg/ha | 3 lb B/A 3.36 kg/ha | 4 lb B/A 4.48 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H0753 | 10 | 16.9 | 8.1 | 0.000[c] | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 |
| CDFA | 25030 | 21 | NR[d] | 0 | NC[e] | 0 | 0 | 0.000 | 0.000 | 0.000 |
| Average | | 16 | 16.9 | 4.0 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products
d) NR = not reported
e) NC = not calculated

### Table G-7e. Yearly Zn Additions to Soil (kg/ha) from Boron Fertilizers

| Source[a] | ID[b] | Percent Boron in product | Zn mg/kg | Yearly Zn addition in kg/ha at 2 lb B/A 2.24 kg/ha | 3 lb B/A 3.36 kg/ha | 4 lb B/A 4.48 kg/ha |
|---|---|---|---|---|---|---|
| Wash St | H0753 | 10 | 6 | 0.000[c] | 0.001 | 0.001 |
| CDFA | 25030 | 21 | NR[d] | NC[e] | NC | NC |
| Average | | 16 | 6 | 0.000 | 0.001 | 0.001 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from boron products
d) NR = not reported
e) NC = not calculated

## Table G-8a. Yearly Cd and Pd Additions to Soil (kg/ha) from Iron Fertilizers

| Source[a] | ID[b] | Percent Iron in product | Cd mg/kg | Pd mg/kg | Yearly Cd addition in kg/ha at | | | Yearly Pd addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10 lb Fe/A | 20 lb Fe/A | 30 lb Fe/A | 10 lb Fe/A | 20 lb Fe/A | 30 lb Fe/A |
| | | | | | 11.2 kg/ha | 22.4 kg/ha | 33.6 kg/ha | 11.2 kg/ha | 22.4 kg/ha | 33.6 kg/ha |
| CDFA | 22334 | 15 | 333.5 | 18750 | 0.025[c] | 0.050 | 0.075 | 1.400 | **2.800**[d] | **4.200** |
| | 25819 | 12 | 20.5 | 2625 | 0.002 | 0.004 | 0.006 | 0.245 | 0.490 | 0.735 |
| | 25835 | 15 | 0 | 29 | 0.000 | 0.000 | 0.000 | 0.002 | 0.004 | 0.006 |
| Average | | 14 | 118.0 | 7135 | 0.009 | 0.018 | 0.027 | 0.549 | 1.098 | 1.647 |

a) Sources:
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values for this metal from iron products
d) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal

## Table G-8b. Yearly As and Cr Additions to Soil (kg/ha) from Iron Fertilizers

| Source[a] | ID[b] | Percent Iron in product | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at | | | Yearly Cr addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10 lb Fe/A | 20 lb Fe/A | 30 lb Fe/A | 10 lb Fe/A | 20 lb Fe/A | 30 lb Fe/A |
| | | | | | 11.2 kg/ha | 22.4 kg/ha | 33.6 kg/ha | 11.2 kg/ha | 22.4 kg/ha | 33.6 kg/ha |
| CDFA | 22334 | 15 | 34.5 | NR[c] | 0.003 | 0.005 | 0.008 | NC[d] | NC | NC |
| | 25819 | 12 | 4950 | NR | **0.462**[e,f] | **0.924** | **1.386** | NC | NC | NC |
| | 25835 | 15 | 2.5 | NR | 0.000 | 0.000 | 0.001 | NC | NC | NC |
| Average | | 14 | 1662.3 | NR | 0.155 | 0.310 | **0.465** | NC | NC | NC |

a) Sources:
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Shading indicates highest yearly addition values for this metal from iron products
f) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal

## Table G-8c. Yearly Hg and Ni Additions to Soil (kg/ha) from Iron Fertilizers

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | **No available data** | | | | | |
| | | | | | | | | | | |

## Table G-8d. Yearly V and Cu Additions to Soil (kg/ha) from Iron Fertilizers

| Source[a] | ID[b] | Percent Iron in product | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at | | | Yearly Cu addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 10 lb Fe/A | 20 lb Fe/A | 30 lb Fe/A | 10 lb Fe/A | 20 lb Fe/A | 30 lb Fe/A |
| | | | | | 11.2 kg/ha | 22.4 kg/ha | 33.6 kg/ha | 11.2 kg/ha | 22.4 kg/ha | 33.6 kg/ha |
| CDFA | 22334 | 15 | NR[c] | 1750 | NC[d] | NC | NC | 0.131[e] | 0.261 | 0.392 |
| | 25819 | 12 | NR | 210 | NC | NC | NC | 0.020 | 0.039 | 0.059 |
| | 25835 | 15 | NR | 40 | NC | NC | NC | 0.003 | 0.006 | 0.009 |
| Average | | 14 | NC | 667 | NC | NC | NC | 0.051 | 0.102 | 0.153 |

a) Sources:
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Shading indicates highest yearly addition values for this metal from iron products

## Table G-8e. Yearly Zn Additions to Soil (kg/ha) from Iron Fertilizers

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | No available data | | | | | |

## Table G-9a. Yearly Cd and Pb Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

| Source[a] | ID[b] | Percent Sulfur in product | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha soil at 20lb S/A 22.4 kg/ha | 40lb S/A 44.8 kg/ha | 60 lb S/A 67.2 kg/ha | Yearly Pb addition in kg/ha soil at 20lb S/A 22.4 kg/ha | 40lb S/A 44.8 kg/ha | 60 lb S/A 67.2 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H2547 | 26 | 0.03 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H1231 | 40 | 0.03 | 0.2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H2532 | 14 | 145 | 4.4 | 0.023[c] | 0.046 | 0.070 | 0.001 | 0.001 | 0.002 |
| | H4769 | 24 | 1.2 | 15 | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 | 0.004 |
| CDFA | 26310 | 100[d] | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 21259 | 100 | 0 | 8.7 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | 21260 | 100 | 0 | 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 24884 | 100 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 24885 | 100 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Average | | 67 | 16 | 4 | 0.003 | 0.005 | 0.008 | 0.000 | 0.001 | 0.001 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products
d) Listed as "sulfur"; assumed 100% sulfur

## Table G-9b. Yearly As and Cr Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

| Source[a] | ID[b] | Percent Sulfur in product | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha soil at 20lb S/A 22.4 kg/ha | 40lb S/A 44.8 kg/ha | 60 lb S/A 67.2 kg/ha | Yearly Cr addition in kg/ha soil at 20lb S/A 22.4 kg/ha | 40lb S/A 44.8 kg/ha | 60 lb S/A 67.2 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H2547 | 26 | 0.3 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H1231 | 40 | 0.3 | 0.05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H2532 | 14 | 4.2 | 214 | 0.001[c] | 0.001 | 0.002 | 0.034 | 0.068 | 0.103 |
| | H4769 | 24 | 1.5 | 0.68 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CDFA | 26310 | 100[d] | 0.1 | NR[e] | 0.000 | 0.000 | 0.000 | NC[f] | NC | NC |
| | 21259 | 100 | 2 | 8.7 | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| | 21260 | 100 | 0.86 | 4 | 0.000 | 0.000 | 0.000 | NC | NC | NC |
| | 24884 | 100 | 17 | 0 | 0.000 | 0.001 | 0.001 | NC | NC | NC |
| | 24885 | 100 | 19 | 0 | 0.000 | 0.001 | 0.001 | NC | NC | NC |
| Average | | 67 | 5.0 | 54 | 0.000 | 0.000 | 0.001 | 0.009 | 0.017 | 0.026 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products
d) Listed as "sulfur"; assumed 100% sulfur
e) NR = not reported
f) NC = not calculated

## Table G-9c. Yearly Hg and Ni Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

| Source[a] | ID[b] | Percent Sulfur in product | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha soil at 20lb S/A 22.4 kg/ha | 40lb S/A 44.8 kg/ha | 60 lb S/A 67.2 kg/ha | Yearly Ni addition in kg/ha soil at 20lb S/A 22.4 kg/ha | 40lb S/A 44.8 kg/ha | 60 lb S/A 67.2 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H2547 | 26 | 0.01 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H1231 | 40 | 0 | 0.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H2532 | 14 | 0.024 | 195 | 0.000 | 0.000 | 0.000 | 0.031[c] | 0.062 | 0.094 |
| | H4769 | 24 | 0.403 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CDFA | 26310 | 100[d] | NR[e] | NR | NC[f] | NC | NC | NC | NC | NC |
| | 21259 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 21260 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 24884 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 24885 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| Average | | 67.1 | 0.11 | 48.9 | 0.000 | 0.000 | 0.000 | 0.008 | 0.016 | 0.023 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products
d) Listed as "sulfur"; assumed 100% sulfur
e) NR = not reported
f) NC = not calculated

## Table G-9d. Yearly V and Cu Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

| Source[a] | ID[b] | Percent Sulfur in product | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha soil at 20 lb S/A 22.4 kg/ha | 40 lb S/A 44.8 kg/ha | 60 lb S/A 67.2 kg/ha | Yearly Cu addition in kg/ha soil at 20 lb S/A 22.4 kg/ha | 40 lb S/A 44.8 kg/ha | 60 lb S/A 67.2 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Wash St | H2547 | 26 | 0.055 | 0.04 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H1231 | 40 | 0.046 | 0.094 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H2532 | 14 | 396 | 16 | 0.063[c] | 0.127 | 0.190 | 0.003 | 0.005 | 0.008 |
| | H4769 | 24 | 0.41 | 0.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CDFA | 26310 | 100[d] | NR[e] | 2 | NC[f] | NC | NC | 0.000 | 0.000 | 0.000 |
| | 21259 | 100 | NR | 109 | NC | NC | NC | 0.002 | 0.005 | 0.007 |
| | 21260 | 100 | NR | 61 | NC | NC | NC | 0.001 | 0.003 | 0.004 |
| | 24884 | 100 | NR | 16 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| | 24885 | 100 | NR | 14 | NC | NC | NC | 0.000 | 0.001 | 0.001 |
| Average | | 67 | 99.13 | 24.29 | 0.016 | 0.032 | 0.048 | 0.001 | 0.002 | 0.002 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products
d) Listed as "sulfur"; assumed 100% sulfur
e) NR = not reported
f) NC = not calculated

## Table G-9e. Yearly Zn Additions to Soil (kg/ha) from S (as Nutrient) Fertilizers

| Source[a] | ID[b] | Percent Sulfur in product | Zn mg/kg | Yearly Zn addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|
| | | | | 20 lb S/A | 40 lb S/A | 60 lb S/A |
| | | | | 22.4 kg/ha | 44.8 kg/ha | 67.2 kg/ha |
| Wash St | H2547 | 26 | 0.21 | 0.000 | 0.000 | 0.000 |
| | H1231 | 40 | 42 | 0.002 | 0.005 | 0.007 |
| | H2532 | 14 | 1480 | 0.237[c] | 0.474 | 0.710 |
| | H4769 | 24 | 17 | 0.002 | 0.003 | 0.005 |
| Average | | 26 | 385 | 0.060 | 0.120 | 0.181 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from sulfur nutrient products

## Table G-10a. Yearly Cd and Pb Additions to Soil (kg/ha) from S (as pH) Fertilizers

| | | | | | Yearly Cd addition in kg/ha soil at | | | Yearly Pb addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Source[a] | ID[b] | Percent Sulfur in product | Cd mg/kg | Pb mg/kg | 800 lb S/A 896 kg/ha | 2000 lb S/A 2240 kg/ha | 2500 lb S/A 2800 kg/ha | 800 lb S/A 896 kg/ha | 2000 lb S/A 2240 kg/ha | 2500 lb S/A 2800 kg/ha |
| CDFA | 26310 | 100[c] | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 21259 | 100 | 0 | 8.7 | 0.000 | 0.000 | 0.000 | 0.008[d] | 0.019 | 0.024 |
| | 21260 | 100 | 0 | 4 | 0.000 | 0.000 | 0.000 | 0.004 | 0.009 | 0.011 |
| | 24884 | 100 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 24885 | 100 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Average | | 100 | 0 | 2.5 | 0.000 | 0.000 | 0.000 | 0.002 | 0.006 | 0.007 |

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as “sulfur”; assumed 100% sulfur
d) Shading indicates highest yearly addition values of this metal from sulfur pH adjustment products

## Table G-10b. Yearly As and Cr Additions to Soil (kg/ha) from S (as pH) Fertilizers

| | | | | | Yearly As addition in kg/ha soil at | | | Yearly Cr addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Source[a] | ID[b] | Percent Sulfur in product | As mg/kg | Cr mg/kg | 800 lb S/A 896 kg/ha | 2000 lb S/A 2240 kg/ha | 2500 lb S/A 2800 kg/ha | 800 lb S/A 896 kg/ha | 2000 lb S/A 2240 kg/ha | 2500 lb S/A 2800 kg/ha |
| CDFA | 26310 | 100[c] | 0.1 | NR[d] | 0.000 | 0.000 | 0.000 | NC[e] | NC | NC |
| | 21259 | 100 | 2 | NR | 0.002 | 0.004 | 0.006 | NC | NC | NC |
| | 21260 | 100 | 0.86 | NR | 0.001 | 0.002 | 0.002 | NC | NC | NC |
| | 24884 | 100 | 17 | NR | 0.015 | 0.038 | 0.048 | NC | NC | NC |
| | 24885 | 100 | 19 | NR | 0.017[f] | 0.043 | 0.053 | NC | NC | NC |
| Average | | 100 | 7.8 | NC | 0.007 | 0.017 | 0.022 | NC | NC | NC |

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as “sulfur”; assumed 100% sulfur
d) NR = not reported
e) NC = not calculated
f) Shading indicates highest yearly addition values of this metal from sulfur pH adjustment products

## Table G-10c. Yearly Hg and Ni Additions to Soil (kg/ha) from S (as pH) Fertilizers

| Source[a] | ID[b] | Percent Sulfur in product | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha soil at 800 lb S/A 896 kg/ha | 2000 lb S/A 2240 kg/ha | 2500 lb S/A 2800 kg/ha | Yearly Ni addition in kg/ha soil at 800 lb S/A 896 kg/ha | 2000 lb S/A 2240 kg/ha | 2500 lb S/A 2800 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 26310 | 100[c] | NR[d] | NR | NC[e] | NC | NC | NC | NC | NC |
| | 21259 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 21260 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 24884 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 24885 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| Average | | 100 | NC | NC | NC | NC | NC | NC | NC | NC |

a) Sources:
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as "sulfur"; assumed 100% sulfur
d) NR = not reported
e) NC = not calculated

## Table G-10d. Yearly V and Cu Additions to Soil (kg/ha) from S (as pH) Fertilizers

| Source[a] | ID[b] | Percent Sulfur in product | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha soil at 800lb S/A 896 kg/ha | 2000lb S/A 2240 kg/ha | 2500 lb S/A 2800 kg/ha | Yearly Cu addition in kg/ha soil at 800lb S/A 896 kg/ha | 2000lb S/A 2240 kg/ha | 2500 lb S/A 2800 kg/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| CDFA | 26310 | 100[c] | NR[d] | 2 | NC[e] | NC | NC | 0.002 | 0.004 | 0.006 |
| | 21259 | 100 | NR | 109 | NC | NC | NC | 0.098[f] | 0.244 | 0.305 |
| | 21260 | 100 | NR | 61 | NC | NC | NC | 0.055 | 0.137 | 0.171 |
| | 24884 | 100 | NR | 16 | NC | NC | NC | 0.014 | 0.036 | 0.045 |
| | 24885 | 100 | NR | 14 | NC | NC | NC | 0.013 | 0.031 | 0.039 |
| Average | | 100 | NC | 40 | NC | NC | NC | 0.036 | 0.090 | 0.113 |

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as "sulfur"; assumed 100% sulfur
d) NR = not reported
e) NC = not calculated
f) Shading indicates highest yearly addition values of this metal from sulfur pH adjustment products

## Table G-10e. Yearly Zn Additions to Soil (kg/ha) from S (as pH) Fertilizers

| Source[a] | ID[b] | Percent Sulfur in product | Zn mg/kg | Yearly Zn addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|
| | | | | 800 lb S/A | 2000 lb S/A | 2500 lb S/A |
| | | | | 896 kg/ha | 2240 kg/ha | 2800 kg/ha |
| CDFA | 26310 | 100[c] | NR[d] | NC[e] | NC | NC |
| | 21259 | 100 | NR | NC | NC | NC |
| | 21260 | 100 | NR | NC | NC | NC |
| | 24884 | 100 | NR | NC | NC | NC |
| | 24885 | 100 | NR | NC | NC | NC |
| Average | | 100 | NC | NC | NC | NC |

a) Sources:
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Listed as "sulfur"; assumed 100% sulfur
d) NR = not reported
e) NC = not calculated

## Table G-11a. Yearly Cd and Pb Additions to Soil (kg/ha) from Liming Materials

| Source[a] | ID[b] | Percent $CaCO_3$ in product | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha soil at: | | | Yearly Pb addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4000 lb lime/A | 8000 lb lime/A | 15,000 lb lime/A | 4000 lb lime/A | 8000 lb lime/A | 15,000 lb lime/A |
| | | | | | 4480 kg/ha | 8960 kg/ha | 16,800 kg/ha | 4480 kg/ha | 8960 kg/ha | 16,800 kg/ha |
| Raven | calcite | 100 | 0.7 | 1.1 | 0.003 | 0.006 | 0.012 | 0.005 | 0.010 | 0.018 |
| | dolomite | 100 | 0.1 | 0.7 | 0.000 | 0.001 | 0.002 | 0.003 | 0.006 | 0.012 |
| Wash St | H2529 | 33 | 1.5 | 10 | 0.020 | 0.041 | 0.076 | 0.136 | 0.272 | 0.509 |
| | H4763 | 85 | 3.6 | 150 | 0.019 | 0.038 | 0.071 | 0.791 | 1.581 | **2.965**[c] |
| | H4775 | 7.6 | 0.75 | 125 | 0.044[d] | 0.088 | **0.165** | **7.368** | **14.737** | **27.632** |
| | H4759 | 96 | 1.5 | 1 | 0.007 | 0.014 | 0.026 | 0.005 | 0.009 | 0.018 |
| | H4764 | 91 | 1.5 | 10 | 0.007 | 0.015 | 0.028 | 0.049 | 0.098 | 0.185 |
| | H2550 | 100 | 0.75 | 49 | 0.003 | 0.007 | 0.013 | 0.220 | 0.439 | 0.823 |
| CDFA | 21827 | 100 | 8.1 | 45.5 | 0.036 | 0.073 | **0.136** | 0.204 | 0.408 | 0.764 |
| | 20882 | 100 | 6.5 | 53 | 0.029 | 0.058 | **0.109** | 0.237 | 0.475 | 0.890 |
| Average[e] | | 81.3 | 2.5 | 44.53 | 0.017 | 0.034 | 0.064 | 0.902 | 1.804 | **3.383** |
| 3-yr Avg[f] | | | | | 0.006 | 0.011 | 0.021 | 0.300 | 0.601 | 1.127 |

a) Sources:
   Raven: Raven and Loeppert (1997)
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Bold indicates that the yearly addition exceeds the Canadian Fertilizer Act limits for this metal
d) Shading indicates highest yearly addition values for this metal from liming materials
e) Yearly addition of metal for year in which the lime is added. Typically, lime is added once every 3 years
f) Average yearly addition of metal ammortized over the 3 year application period

## Table G-11b. Yearly As and Cr Additions to Soil (kg/ha) from Liming Materials

| Source[a] | ID[b] | Percent $CaCO_3$ in product | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha soil at: | | | Yearly Cr addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4000 lb lime/A | 8000 lb lime/A | 15,000 lb lime/A | 4000 lb lime/A | 8000 lb lime/A | 15,000 lb lime/A |
| | | | | | 4480 kg/ha | 8960 kg/ha | 16,800 kg/ha | 4480 kg/ha | 8960 kg/ha | 16,800 kg/ha |
| Raven | calcite | 100 | 1 | NR[c] | 0.004 | 0.009 | 0.017 | NC[d] | NC | NC |
| | dolomite | 100 | 1.2 | 32.3 | 0.005 | 0.011 | 0.020 | 0.145 | 0.289 | 0.543 |
| Wash St | H2529 | 33 | 15 | 2.5 | 0.204 | **0.407**[e] | **0.764** | 0.034 | 0.068 | 0.127 |
| | H4763 | 85 | 37 | 73 | 0.195 | **0.390** | **0.731** | 0.385 | 0.770 | 1.443 |
| | H4775 | 7.6 | 48 | 34 | **2.829**[f] | **5.659** | **0.611** | 2.004 | 4.008 | 7.515 |
| | H4759 | 96 | 15 | 2.5 | 0.070 | 0.140 | 0.263 | 0.012 | 0.023 | 0.044 |
| | H4764 | 91 | 15 | 2.5 | 0.074 | 0.148 | 0.277 | 0.012 | 0.025 | 0.046 |
| | H2550 | 100 | 7.5 | 1.25 | 0.034 | 0.067 | 0.126 | 0.006 | 0.011 | 0.021 |
| CDFA | 21827 | 100 | 1.1 | NR | 0.005 | 0.010 | 0.018 | NC | NC | NC |
| | 20882 | 100 | 5.1 | NR | 0.023 | 0.046 | 0.086 | NC | NC | NC |
| Average[g] | | 81.3 | 14.6 | 21.2 | **0.344** | **0.689** | **1.292** | 0.371 | 0.742 | 1.391 |
| 3 yr Avg[h] | | | | | 0.115 | 0.230 | **0.431** | 0.124 | 0.247 | 0.464 |

a) Sources:
   Raven: Raven and Loeppert (1997)
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Bold indicates that the yearly addition exceeds the Canadian Fertilizer Act limits for this metal
f) Shading indicates highest yearly addition values of this metal from liming materials
g) Yearly addition of metal for year in which the lime is added. Typically, lime is added only once every 3 years
h) Average yearly addition of metal ammortized over the 3 year application period

## Table G-11c. Yearly Hg and Ni Additions to Soil (kg/ha) from Liming Materials

| Source[a] | ID[b] | Percent $CaCO_3$ in product | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha soil at: | | | Yearly Ni addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4000 lb lime/A | 8000 lb lime/A | 15,000 lb lime/A | 4000 lb lime/A | 8000 lb lime/A | 15,000 lb lime/A |
| | | | | | 4480 kg/ha | 8960 kg/ha | 16,800 kg/ha | 4480 kg/ha | 8960 kg/ha | 16,800 kg/ha |
| Raven | calcite | 100 | 0.2 | 1.4 | 0.001 | 0.002 | 0.003 | 0.006 | 0.013 | 0.024 |
| | dolomite | 100 | 0.2 | 3.3 | 0.001 | 0.002 | 0.003 | 0.015 | 0.300 | 0.055 |
| Wash St | H2529 | 33 | 0.01 | 5 | 0.000 | 0.000 | 0.000 | 0.068 | 0.136 | 0.255 |
| | H4763 | 85 | 0.041 | 18 | 0.000 | 0.000 | 0.001 | 0.095 | 0.190 | 0.356 |
| | H4775 | 7.6 | 0.414 | 23 | **0.024**[c,d] | **0.049** | **0.086** | **1.356** | **2.712** | **5.085** |
| | H4759 | 96 | 0.01 | 5 | 0.000 | 0.000 | 0.000 | 0.023 | 0.047 | 0.088 |
| | H4764 | 91 | 0.01 | 5 | 0.000 | 0.000 | 0.000 | 0.025 | 0.049 | 0.092 |
| | H2550 | 100 | 0.022 | 2.5 | 0.000 | 0.000 | 0.000 | 0.011 | 0.022 | 0.042 |
| CDFA | 21827 | 100 | NR[e] | NR | NC[f] | NC | NC | NC | NC | NC |
| | 20882 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| Average[g] | | 81.3 | 0.11 | 11.6 | 0.003 | 0.007 | 0.013 | 0.200 | 0.400 | 0.750 |
| 3 yr Avg[h] | | | | | 0.001 | 0.002 | 0.004 | 0.067 | 0.133 | 0.250 |

a) Sources:
   Raven: Raven and Loeppert (1997)
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values for this metal from liming materials
d) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal
e) NR = not reported
f) NC = not calculated
g) Yearly addition of metal for year in which the lime is added. Typically, lime is added only once every 3 years
h) Average yearly addition of metal ammortized over the 3 year application period

## Table G-11d. Yearly V and Cu Additions to Soil (kg/ha) from Liming Materials

| Source[a] | ID[b] | Percent $CaCO_3$ in product | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha soil at: 4000 lb lime/A | | | Yearly Cu addition in kg/ha soil at: 4000 lb lime/A | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4000 lb lime/A | 8000 lb lime/A | 15,000 lb lime/A | 4000 lb lime/A | 8000 lb lime/A | 15,000 lb lime/A |
| | | | | | 4480 kg/ha | 8960 kg/ha | 16,800 kg/ha | 4480 kg/ha | 8960 kg/ha | 16,800 kg/ha |
| Raven | calcite | 100 | 3 | 2.3 | 0.013 | 0.027 | 0.050 | 0.010 | 0.021 | 0.039 |
| | dolomite | 100 | 15 | NR[c] | 0.067 | 0.134 | 0.252 | NC[d] | NC | NC |
| Wash St | H2529 | 33 | 1 | 5 | 0.014 | 0.027 | 0.051 | 0.068 | 0.136 | 0.255 |
| | H4763 | 85 | 49 | 158 | 0.258 | 0.517 | 0.968 | 0.833 | 1.666 | 3.123 |
| | H4775 | 7.6 | 41 | 116 | 2.417[e] | 4.834 | 9.064 | 6.838 | 13.676 | 25.643 |
| | H4759 | 96 | 1 | 5 | 0.005 | 0.009 | 0.018 | 0.023 | 0.047 | 0.088 |
| | H4764 | 91 | 1 | 5 | 0.005 | 0.010 | 0.018 | 0.025 | 0.049 | 0.092 |
| | H2550 | 100 | 1.1 | 3 | 0.005 | 0.010 | 0.018 | 0.013 | 0.027 | 0.050 |
| CDFA | 21827 | 100 | NR | 38 | NC | NC | NC | 0.170 | 0.340 | 0.638 |
| | 20882 | 100 | NR | 46 | NC | NC | NC | 0.206 | 0.412 | 0.773 |
| Average[f] | | 81 | 14 | 42 | 0.348 | 0.696 | 1.305 | 0.910 | 1.819 | 3.411 |
| 3 yr Avg[g] | | | | | 0.116 | 0.232 | 0.435 | 0.303 | 0.606 | 1.137 |

a) Sources:
   Raven: Raven and Loeppert (1997)
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Shading indicates highest yearly addition values for this metals from liming agents
f) Yearly addition of metal for year in which the lime is added. Typically, lime is added only once every 3 years
g) Average yearly addition of metal ammortized over the 3 year application period

## Table G-11e. Yearly Zn Additions to Soil (kg/ha) from Liming Materials

| Source[a] | ID[b] | Percent $CaCO_3$ in product | Zn mg/kg | Yearly Zn addition in kg/ha soil at 4000 lb lime/A 4480 kg/ha | 8000 lb lime/A 8960 kg/ha | 15,000 lb lime/A 16,800 kg/ha |
|---|---|---|---|---|---|---|
| Raven | calcite | 100 | NR[c] | NC[d] | NC | NC |
| | dolomite | 100 | 8.01 | 0.036 | 0.072 | 0.135 |
| Wash St | H2529 | 33 | 7.7 | 0.105 | 0.209 | 0.392 |
| | H4763 | 85 | 1770 | **9.329**[e] | **18.658** | **34.984** |
| | H4775 | 7.6 | 424 | **24.994**[f] | **49.987** | **93.726** |
| | H4759 | 96 | 16 | 0.075 | 0.149 | 0.280 |
| | H4764 | 91 | 21 | 0.103 | 0.207 | 0.388 |
| | H2550 | 100 | 224 | 1.004 | 2.007 | 3.763 |
| CDFA | 21827 | 100 | NR | NC | NC | NC |
| | 20882 | 100 | NR | NC | NC | NC |
| Average[g] | | 81.26 | 353.0 | 4.456 | **8.911** | **16.708** |
| 3 yr Avg[h] | | | | 1.485 | 2.970 | 5.569 |

a) Sources:
   Raven: Raven and Loeppert (1997)
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) NR = not reported
d) NC = not calculated
e) Bold indicates that the yearly addition exceeds the Canadian Fertilizers Act limits for this metal
f) Shading indicates highest yearly addition values for this metal from liming materials
g) Yearly addition of metal for year in which the lime is added. Typically, lime is added only once every 3 years
h) Average yearly addition of metal ammortized over the 3 year application period

## Table G-12a. Yearly Cd and Pb Additions to Soil (kg/ha) from Gypsum Products

| | | | | | Yearly Cd addition in kg/ha soil at: | | | Yearly Pb addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2000 lb gyp/A | 4000 lb gyp/A | 8000 lb gyp/A | 2000 lb gyp/A | 4000 lb gyp/A | 8000 lb gyp/A |
| Source[a] | ID[b] | Percent Gypsum | Cd mg/kg | Pb mg/kg | 2240 kg/ha | 4480 kg/ha | 8960 kg/ha | 2240 kg/ha | 4480 kg/ha | 8960 kg/ha |
| Wash St | H4766 | 100[c] | 0.8 | 11 | 0.002 | 0.004 | 0.007 | 0.025[d] | 0.049 | 0.099 |
| CDFA | 25855 | 100 | 0 | 3 | 0.000 | 0.000 | 0.000 | 0.007 | 0.013 | 0.027 |
| | 25854 | 100 | 0 | 3 | 0.000 | 0.000 | 0.000 | 0.007 | 0.013 | 0.027 |
| | 25853 | 100 | 2.5 | 1.5 | 0.006 | 0.011 | 0.022 | 0.003 | 0.007 | 0.013 |
| Average | | 100 | 0.8 | 4.6 | 0.002 | 0.004 | 0.007 | 0.010 | 0.021 | 0.041 |

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products

## Table G-12b. Yearly As and Cr Additions to Soil (kg/ha) from Gypsum Products

| | | | | | Yearly As addition in kg/ha soil at: | | | Yearly Cr addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2000 lb gyp/A | 4000 lb gyp/A | 8000 lb gyp/A | 2000 lb gyp/A | 4000 lb gyp/A | 8000 lb gyp/A |
| Source[a] | ID[b] | Percent Gypsum | As mg/kg | Cr mg/kg | 2240 kg/ha | 4480 kg/ha | 8960 kg/ha | 2240 kg/ha | 4480 kg/ha | 8960 kg/ha |
| Wash St | H4766 | 100[c] | 8.5 | 1.4 | 0.019[d] | 0.038 | 0.076 | 0.003 | 0.006 | 0.013 |
| CDFA | 25855 | 100 | 3 | NR[e] | 0.007 | 0.013 | 0.027 | NC[f] | NC | NC |
| | 25854 | 100 | 3.4 | NR | 0.008 | 0.015 | 0.030 | NC | NC | NC |
| | 25853 | 100 | 3 | NR | 0.007 | 0.013 | 0.027 | NC | NC | NC |
| Average | | 100 | 4.5 | 1.4 | 0.010 | 0.020 | 0.040 | 0.003 | 0.006 | 0.013 |

a) Sources:
Wash St: Washington State Department of Ecology (1997)
CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products
e) NR = not reported
f) NC = not calculated

## Table G-12c. Yearly Hg and Ni Additions to Soil (kg/ha) from Gypsum Products

| | | | | | Yearly Hg addition in kg/ha soil at: | | | Yearly Ni addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2000 lb gyp/A | 4000 lb gyp/A | 8000 lb gyp/A | 2000 lb gyp/A | 4000 lb gyp/A | 8000 lb gyp/A |
| Source[a] | ID[b] | Percent Gypsum | Hg mg/kg | Ni mg/kg | 2240 kg/ha | 4480 kg/ha | 8960 kg/ha | 2240 kg/ha | 4480 kg/ha | 8960 kg/ha |
| Wash St | H4766 | 100[c] | 0.011 | 3 | 0.000[d] | 0.000 | 0.000 | 0.007 | 0.013 | 0.027 |
| CDFA | 25855 | 100 | NR[e] | NR | NC[f] | NC | NC | NC | NC | NC |
| | 25854 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| | 25853 | 100 | NR | NR | NC | NC | NC | NC | NC | NC |
| Average | | 100 | 0.011 | 3 | 0.000 | 0.000 | 0.000 | 0.007 | 0.013 | 0.027 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products
e) NR = not reported
f) NC = not calculated

## Table G-12d. Yearly V and Cu Additions to Soil (kg/ha) from Gypsum Products

| | | | | | Yearly V addition in kg/ha soil at: | | | Yearly Cu addition in kg/ha soil at: | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2000 lb gyp/A | 4000 lb gyp/A | 8000 lb gyp/A | 2000 lb gyp/A | 4000 lb gyp/A | 8000 lb gyp/A |
| Source[a] | ID[b] | Percent Gypsum | V mg/kg | Cu mg/kg | 2240 kg/ha | 4480 kg/ha | 8960 kg/ha | 2240 kg/ha | 4480 kg/ha | 8960 kg/ha |
| Wash St | H4766 | 100[c] | 1.4 | 7.2 | 0.003 | 0.006 | 0.013 | 0.016 | 0.032 | 0.065 |
| CDFA | 25855 | 100 | 43 | 25 | 0.096 | 0.193 | 0.385 | 0.056 | 0.112 | 0.224 |
| | 25854 | 100 | 41 | 42 | 0.092 | 0.184 | 0.367 | 0.094[d] | 0.188 | 0.376 |
| | 25853 | 100 | 50 | 20.5 | 0.112 | 0.224 | 0.448 | 0.046 | 0.092 | 0.184 |
| Average | | 100 | 33.9 | 23.7 | 0.076 | 0.152 | 0.303 | 0.053 | 0.106 | 0.212 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products

## Table G-12e. Yearly Zn Additions to Soil (kg/ha) from Gypsum Products

| Source[a] | ID[b] | Percent Gypsum in product | Zn mg/kg | Yearly Zn addition in kg/ha soil at 2000 lb gypsum/A 2240 kg/ha | 4000 lb gypsum/A 4480 kg/ha | 8000 lb gypsum/A 8960 kg/ha |
|---|---|---|---|---|---|---|
| Wash St | H4766 | 100[c] | 53.8 | 0.121[d] | 0.241 | 0.482 |
| CDFA | 25855 | 100 | NR[e] | NC[f] | NC | NC |
| | 25854 | 100 | NR | NC | NC | NC |
| | 25853 | 100 | NR | NC | NC | NC |
| Average | | 100 | 53.8 | 0.121 | 0.241 | 0.482 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
   CDFA: California Department of Food and Agriculture (1997)
b) Sample identification used by author
c) Assumed 100% product for application
d) Shading indicates highest yearly addition values of this metal from gypsum products
e) NR = not reported
f) NC = not calculated

### Table G-13a. Yearly Cd and Pb Additions to Soil (kg/ha) from Micronutrient Mixes

| Source[a] | ID[b] | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha soil at 7.5 lb mix/A 8.4 kg/ha | 30 lb mix/A 33.6 kg/ha | 36 lb mix/A 40.3 kg/ha | Yearly Pb addition in kg/ha soil at 7.5 lb mix/A 8.4 kg/ha | 30 lb mix/A 33.6 kg/ha | 36 lb mix/A 40.3 kg/ha |
|---|---|---|---|---|---|---|---|---|---|
| Wash St | H4772 | 0.85 | 5.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H4756 | 55 | 3590 | 0.000[c] | 0.002 | 0.002 | 0.030 | 0.121 | 0.145 |
| Average | | 27.93 | 1797.8 | 0.000 | 0.001 | 0.001 | 0.015 | 0.060 | 0.072 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

### Table G-13b. Yearly As and Cr Additions to Soil (kg/ha) from Micronutrient Mixes

| Source[a] | ID[b] | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha soil at 7.5 lb mix/A 8.4 kg/ha | 30 lb mix/A 33.6 kg/ha | 36 lb mix/A 40.3 kg/ha | Yearly Cr addition in kg/ha soil at 7.5 lb mix/A 8.4 kg/ha | 30 lb mix/A 33.6 kg/ha | 36 lb mix/A 40.3 kg/ha |
|---|---|---|---|---|---|---|---|---|---|
| Wash St | H4772 | 0.85 | 3.1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | H4756 | 83 | 457 | 0.001[c] | 0.003 | 0.003 | 0.004 | 0.015 | 0.018 |
| Average | | 41.93 | 230.1 | 0.000 | 0.001 | 0.002 | 0.002 | 0.008 | 0.009 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

### Table G-13c. Yearly Hg and Ni Additions to Soil (kg/ha) from Micronutrient Mixes

| Source[a] | ID[b] | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha soil at 7.5 lb mix/A 8.4 kg/ha | 30 lb mix/A 33.6 kg/ha | 36 lb mix/A 40.3 kg/ha | Yearly Ni addition in kg/ha soil at 7.5 lb mix/A 8.4 kg/ha | 30 lb mix/A 33.6 kg/ha | 36 lb mix/A 40.3 kg/ha |
|---|---|---|---|---|---|---|---|---|---|
| Wash St | H4772 | 0.03 | 21 | 0.000 | 0.000 | 0.000 | 0.000[c] | 0.001 | 0.001 |
| | H4756 | 0.226 | 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Average | | 0.127 | 12.5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |

a) Sources:
   Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

## Table G-13d. Yearly V and Cu Additions to Soil (kg/ha) from Micronutrient Mixes

| Source[a] | ID[b] | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha soil at | | | Yearly Cu addition in kg/ha soil at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 7.5 lb mix/A | 30 lb mix/A | 36 lb mix/A | 7.5 lb mix/A | 30 lb mix/A | 36 lb mix/A |
| | | | | 8.4 kg/ha | 33.6 kg/ha | 40.3 kg/ha | 8.4 kg/ha | 33.6 kg/ha | 40.3 kg/ha |
| Wash St | H4772 | 0.5 | 19400 | 0.000 | 0.000 | 0.000 | 0.163 | 0.652 | 0.782 |
| | H4756 | 33 | 39900 | 0.000[c] | 0.001 | 0.001 | 0.335 | 1.341 | 1.608 |
| Average | | 16.8 | 29650 | 0.000 | 0.001 | 0.001 | 0.249 | 0.996 | 1.195 |

a) Sources:
Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

## Table G-13e. Yearly Zn Additions to Soil (kg/ha) from Micronutrient Mixes

| Source[a] | ID[b] | Zn mg/kg | Yearly Zn addition in kg/ha soil at | | |
|---|---|---|---|---|---|
| | | | 7.5 lb mix/A | 30 lb mix/A | 36 lb mix/A |
| | | | 8.4 kg/ha | 33.6 kg/ha | 40.3 kg/ha |
| Wash St | H4772 | 60300 | 0.507 | 2.026 | 2.430 |
| | H4756 | 94300 | 0.792[c] | 3.168 | 3.800 |
| Average | | 77300 | 0.649 | 2.597 | 3.115 |

a) Sources:
Wash St: Washington State Department of Ecology (1997)
b) Sample identification used by author
c) Shading indicates highest yearly addition values of this metal from micronutrient mixes

# APPENDIX H
# HEAVY METALS IN FERTILIZER DATA SUBMITTED TO EPA BY THE PENNSYLVANIA DEPARTMENT OF AGRICULTURE (PDA)

## Table H-1. Concentrations of Heavy Metals in Solid NPK Fertilizer Blends

| | | | Concentration of metal, mg/kg | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Type | ID[b] | Grade[c] | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
| Ag Blend | B960243 | 19-19-19 | 3.5 | 2.2 | 6.6 | 45.4 | 0.0 | 11.2 | 85.2 | 25.6 | 36.0 |
| | B960244 | 12-24-24 | 4.3 | 4.6 | 9.8 | 59.0 | 0.0 | 14.7 | 119.0 | 49.3 | 44.5 |
| | B960249 | 7-35-12 | 4.6 | 3.9 | 9.7 | 66.8 | 0.0 | 20.9 | 116.0 | 45.0 | 55.1 |
| | B960282 | 9-44-9 | 2.3 | 3.5 | 13.2 | 90.7 | 0.0 | 14.5 | 163.0 | 30.1 | 49.8 |
| | B960325 | 10-21-15 | 2.7 | 11.1 | 7.2 | 46.3 | 0.2 | 13.4 | 87.7 | 10.2 | 872.0 |
| | B960333 | 8-32-16 | 3.9 | 5.3 | 11.2 | 68.1 | 0.0 | 14.9 | 126.0 | 22.2 | 43.9 |
| | B960389 | 19-19-19 | 1.6 | 1.4 | 5.2 | 43.5 | 0.0 | 0.0 | 77.7 | 0.0 | 0.0 |
| | B960412 | 7-26-26 | 2.6 | 2.8 | 6.0 | 51.8 | 0.0 | 11.5 | 79.4 | 26.2 | 37.0 |
| | B960418 | 19-19-19 | 2.2 | 3.8 | 7.5 | 62.0 | 0.0 | 9.2 | 97.8 | 13.7 | 33.1 |
| | B960441 | 9-34-10 | 3.3 | 3.6 | 10.7 | 67.4 | 0.0 | 12.2 | 121.0 | 16.3 | 34.6 |
| | B960442 | 9-3-10 | 3.6 | 3.0 | 9.2 | 88.8 | 0.0 | 14.5 | 159.0 | 6.6 | 53.1 |
| | B960453 | 10-20-20 | 4.3 | 3.0 | 3.6 | 68.7 | 0.0 | 18.0 | 67.1 | 16.4 | 60.9 |
| | B960475 | 9-40-5 | 14.3 | 422.0 | 10.0 | 107.9 | 0.0 | 29.2 | 130.0 | 90.5 | 4442 |
| | B960510 | 9-43-10 | 5.2 | 1.7 | 11.2 | 79.4 | 0.0 | 17.8 | 136.0 | 7.1 | 66.2 |
| | B960580 | 10-10-10 | 1.8 | 3.6 | 4.1 | 51.4 | 0.0 | 14.6 | 68.8 | 13.6 | 803.0 |
| | B960584 | 10-20-20 | 2.6 | 2.5 | 6.9 | 52.8 | 0.0 | 15.7 | 83.4 | 10.6 | 0.5 |
| | B960599 | 15-15-15 | 2.1 | 2.1 | 4.9 | 42.5 | 0.0 | 11.4 | 73.2 | 7.2 | 0.6 |
| | B960611 | 19-19-19 | 24.4 | 1.1 | 0.0 | 160.0 | 0.0 | 36.9 | 47.2 | 3.9 | 6.9 |
| | B960639 | 6-2-0 | 5.7 | 6.9 | 4.7 | 40.3 | 0.0 | 11.2 | 18.6 | 24.3 | 1.1 |
| | B960708 | 7-27-11 | 6.4 | 153.0 | 9.0 | 73.2 | 0.0 | 22.7 | 99.2 | 544.0 | 57.8 |
| Ag ammoniated | B960711 | 8-24-8 | 9.5 | 14.0 | 3.5 | 60.5 | 0.0 | 11.9 | 47.3 | 13.6 | 177.0 |
| Ag Blended | B960713 | 10-20-10 | 2.4 | 6.7 | 5.4 | 42.0 | 0.0 | 10.1 | 68.9 | 32.0 | 84.5 |
| | B960715 | 15-15-15 | 2.0 | 1.8 | 4.7 | 28.0 | 0.0 | 6.2 | 49.2 | 3.9 | 0.3 |
| | B980726 | 19-19-19 | 4.1 | 3.7 | 7.8 | 48.8 | 0.0 | 11.5 | 85.1 | 7.9 | 74.5 |
| | B960820 | 26-9-9 | 2.0 | 2.3 | 4.1 | 34.2 | 0.0 | 8.0 | 61.6 | 14.4 | 45.7 |
| | B960896 | 10-20-20 | 3.3 | 3.6 | 7.0 | 39.0 | 0.0 | 8.6 | 64.5 | 25.5 | 23.6 |
| | B960900 | 10-20-20 | 3.1 | 3.3 | 7.4 | 201.0 | 0.0 | 85.7 | 70.3 | 12.9 | 25.5 |
| | B960909 | 3-17-40 | 2.4 | 2.6 | 5.1 | 34.3 | 0.0 | 5.7 | 64.2 | 4.9 | 39.5 |
| | B960912 | 3-17-40 | 4.3 | 3.9 | 10.5 | 67.4 | 0.0 | 12.0 | 138.0 | 7.8 | 52.2 |
| | B960913 | 8-41-12 | 1.5 | 18.0 | 6.2 | 68.3 | 0.0 | 14.8 | 18.4 | 454.0 | 484.0 |
| | B961058 | 8-17-34 | 1.0 | 2.4 | 3.1 | 30.8 | 0.0 | 8.9 | 27.8 | 5.0 | 18.3 |
| | B961321 | 9-43-10 | 4.7 | 6.9 | 10.7 | 69.8 | 0.0 | 13.3 | 152.0 | 60.1 | 44.8 |

a) Sample type as listed by Pennsylvania Department of Agriculture.
b) Sample identification as listed by Pennsylvania Department of Agriculture.
c) NPK rating of fertilizer as listed by Pennsylvania Department of Agriculture.

## Table H-2. Concentrations of Heavy Metals in Solid NPK Fertilizers Blended with Micronutrient Fertilizers

| | Concentrations of Metals, mg/kg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source** | **ID** | **Grade** | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| Ag Blend w/Micros | B960278 | 8-24-8 | 5.9 | 129 | 10.1 | 97.8 | 0.53 | 59.8 | 96.2 | 919 | 12342 |
| Ag Blend w/Micros | B960292 | 8-24-8 | 4.7 | 108 | 8.8 | 87.6 | 0.42 | 54.5 | 84.4 | 843 | 49.8 |
| Ag ammoniated w/Micros | B960345 | 10-10-10 | 7.8 | 43.6 | | 64.1 | | 11.9 | 12 | 39.5 | 43.9 |
| Ag ammoniated w/Micros | B960355 | 8-32-18 | 10.6 | 56.9 | 5.9 | 97.8 | | 13.4 | 97.3 | 43.2 | 732 |
| Ag ammoniated w/Micros | B960429 | 8-24-8 | 9.8 | 9.5 | 3.9 | 86.9 | | 15.3 | 64.9 | 34 | 7516 |
| Ag Blend w/Micros | B960463 | 13-13-13 | 2.7 | 2.6 | 3.6 | 27.1 | | 4.2 | 52.7 | 7.8 | 12353 |
| Ag Blend w/Micros | B960468 | 8-24-8 | 4.1 | 66.4 | 8.9 | 82.5 | 0.21 | 46.3 | 85.7 | 622 | 10180 |
| Ag Blend w/Micros | B960518 | 10-20-10 | 9.7 | 31.6 | 7.4 | 100.5 | | 31.9 | 52.3 | 82.9 | 1065 |
| Ag Blend w/Micros | B960640 | 10-20-20 | 2.8 | 46.2 | 5.8 | 48.6 | 0.29 | 20.9 | 58 | 325 | 20.9 |
| Ag Blend w/Micros | B960722 | 9-24-9 | 8 | 313 | 10.4 | 78.7 | | 32.4 | 79.8 | 813 | 4322 |
| Ag Blend w/Micros | B960735 | 8-24-8 | 4.5 | 58.2 | 5.8 | 67.2 | | 15.8 | 63 | 145 | 2773 |
| Ag ammoniated w/Micros | B960738 | 10-20-20 | 6.6 | 7.9 | 3.6 | 56.6 | | 6.3 | 55.6 | 6.9 | 172 |
| Ag ammoniated w/Micros | B960745 | 10-20-20 | 6.9 | 36.1 | 3.5 | 53.2 | | 6.5 | 50 | 20.2 | 494 |
| Ag Blend w/Micros | B960757 | 8-24-8 | 4.2 | 337 | 13.6 | 80.1 | 0.14 | 52 | 71.6 | 1183 | 15173 |
| Ag Blend w/Micros | B960934 | 10-20-20 | 3.6 | 26.6 | 19.4 | 48 | | 23.9 | 61.2 | 981 | 1661 |
| Ag Blend w/Micros | B960984 | 10-20-10 | 3.3 | 99.3 | 5.9 | 42 | | 18.9 | 60.7 | 83.7 | 1916 |
| Ag Blend w/Micros | B961019 | 10-20-10 | 6.3 | 200 | 8.9 | 56.7 | | 22.8 | 72.4 | 633 | 3026 |
| Ag Blend w/Micros | B961102 | 3-9-36 | 0.6 | 1.5 | 2.1 | 25.4 | | 6.3 | 23 | 18.2 | 16 |
| Ag Blend w/Micros | B961114 | 8-24-8 | 4.6 | 115 | 6.9 | 72.2 | | 27.3 | 67.2 | 747 | 1980 |
| Ag ammoniated w/Micros | B961154 | 10-20-20 | 7.8 | 59.1 | 3.4 | 59.1 | | 6.9 | 50.5 | 20.1 | 677 |

# Table H-3. Concentrations of Heavy Metals in Liquid NPK Fertilizer Blends

| | Concentrations of Metals, mg/kg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Source | ID | Grade | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
| Ag Liquid | B960360 | 30-0-0 | | 0.15 | | | | | | 0.19 | 0.72 |
| Ag Liquid | B960673 | 10-34-0 | 9.54 | | 6.4 | 98.3 | | 7.4 | 58.9 | 7.82 | 92.3 |
| Ag Liquid | B960674 | 9-18-9 | | 0.32 | 41.5 | 4.16 | | | | 1.7 | 0.85 |
| Ag Liquid | B960675 | 5-15-15 | 0.06 | 0.63 | 41.2 | 4.06 | | 0.54 | 0.28 | 5.75 | 4.38 |
| Ag Liquid | B960810 | 7-22-5 | 12.5 | | 8.46 | 109 | | 11.6 | 6.6 | 8.2 | 139 |
| Ag Liquid | B960811 | 7-22-5 | 12.1 | | 8.98 | 109 | | 11.4 | 6.62 | 8.4 | 139 |
| Ag Liquid | B960966 | 4-8-10 | 4.01 | | 1.1 | | | 0.94 | | 1.33 | 62.9 |
| Ag Liquid | B961106 | 7-21-7 | 7.7 | 0.13 | 2.13 | 101 | | | 30.1 | 0.15 | 405 |
| Ag Liquid | B961111 | 30-0-0 | 0.06 | 0.21 | | 2.45 | | | 4.82 | 0.38 | 2.06 |
| Ag Liquid | B961128 | 1-4-14 | 2.74 | 0.15 | 1.27 | 20.6 | | 1.6 | 12.4 | 2.29 | 19 |
| Ag Liquid | B961193 | 2-6-12 | 3.77 | 0.12 | | 40.2 | | | 11.1 | 0.14 | 52.1 |
| Ag Liquid | B961194 | 4-10-10 | 5.28 | | 2.23 | 58.5 | | 2.04 | 23.2 | 1.59 | 63 |
| Ag Liquid | B961195 | 4-8-10 | 4.83 | 0.1 | 1.4 | 51.3 | | 1.54 | 19.9 | 3.41 | 54.6 |
| Ag Liquid | B961196 | 4-5-10 | 3.12 | 0.17 | 0.86 | 32.4 | | 0.97 | 12.5 | 2.49 | 34.2 |
| Ag Liquid | B961207 | 8-26-4 | 12.5 | 0.11 | 19.8 | 142 | | 6.08 | 60.9 | 4.59 | 145 |
| Ag Liquid | B961246 | 10-34-0 | 19.6 | 0.17 | 12.7 | 184 | | 14.3 | 104 | 8.27 | 178 |
| Ag Liquid | B961251 | 4-10-10 | 5.81 | 0.24 | 1.92 | 58.6 | | 2.38 | 24.7 | 1.94 | 60.8 |
| Ag Liquid | B961252 | 4-5-10 | 2.86 | 0.15 | 1.07 | 28.8 | | 1.07 | 12 | 4.17 | 29.9 |
| Ag Liquid | B961253 | 4-10-10 | 6.02 | 0.1 | 3.68 | 47.1 | | 3.95 | 28.9 | 6.24 | 41.5 |
| Ag Liquid | B961254 | 4-5-10 | 3.59 | | 1.78 | 27.2 | | 2.27 | 16.5 | 4.81 | 24.3 |
| Ag Liquid | B961255 | 4-8-10 | 5.46 | | 3.09 | 40.4 | | 3.48 | 24.4 | 6.03 | 36.1 |
| Ag Liquid | B961284 | 7-21-6.5 | 9.15 | 0.32 | 5.73 | 100 | | 3.91 | 43.3 | 4.27 | |

## Table H-4.  Concentrations of Heavy Metals in Specialty Fertilizers for Residential Market

| | Concentrations of Metals, mg/kg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source** | **ID** | **Grade** | **Cd** | **Pb** | **As** | **Cr** | **Hg** | **Ni** | **V** | **Cu** | **Zn** |
| Specialty/Liquid | B960205 | 10-60-10 | | | 2.8 | | 0.2 | | 4.1 | | 533 |
| Specialty/Liquid | B960262 | 10-60-10 | | | 2.3 | | 0.13 | | 5.6 | | 517 |
| Specialty Fish Liquid | B960424 | 2-4-0.5 | 0.09 | | 4.1 | 0.65 | 0.04 | | 0.58 | 0.35 | 8.51 |
| Specialty/Poly Coated Urea | B960192 | 18-6-12 | | 2 | | 2.2 | | 2.5 | 13.4 | 19 | 5.1 |
| Specialty/Fish | B960266 | 5-1-1 | | 1 | 12.3 | 2.4 | | | | 28.2 | 33 |
| Specialty | B960648 | 18-24-12 | 4.1 | 2.1 | 3.4 | 54.5 | | 6 | 61.5 | 18 | 1.08 |
| Specialty Organic | B960763 | .05-.05-.05 | 14 | 5.7 | 40.1 | | 25.9 | 40.7 | 74.5 | 89 | |
| Specialty Blend | B960814 | 18-24-5 | 4.8 | 5.6 | 8.3 | 71 | | 15.7 | 117 | 47.1 | 41.2 |
| Specialty Fish | B960836 | 3-2-2 | 0.1 | 0.16 | 7.81 | 0.66 | | | 0.48 | 5.6 | 7.8 |
| Specialty Organic | B960851 | 2-1-2 | | 12.5 | | 17.8 | | 11.9 | 39.5 | 32.7 | 92.4 |
| Specialty Organic | B960891 | 18-8-6 | 2 | 23 | 4.6 | 2455 | | 21.4 | 47.4 | 136 | 340 |
| Specialty Bio-solid | B960894 | 6-2-0 | 3.9 | 88.9 | 4.1 | 306 | 0.67 | 53 | 8.6 | 272 | 517 |
| Specialty Blend | B960969 | 19-26-6 | 2.1 | 1.2 | 6.1 | 46.5 | | 6.3 | 81.3 | 8.7 | 21.4 |
| Specialty Organic | B960992 | 3-2-3 | 5.9 | 8.1 | 3.2 | 233 | 0.12 | 9.6 | | 104 | 517 |
| Specialty ammoniated | B961077 | 13-25-12 | 8.3 | 11.5 | 4.2 | 83.8 | | 12.5 | 66.4 | 41.9 | 210 |
| Specialty Organic | B961082 | 5-4-5 | 3.6 | 85.2 | 11.7 | 123 | 0.4 | 30.9 | 12.6 | 270 | 3488 |
| Specialty Organic | B961083 | 14-2-5 | | 19 | 12.1 | 40 | 0.11 | 10.8 | 16.4 | 201 | 626 |
| Specialty Blend | B961087 | 16-8-8 | 2.9 | 79.9 | 4.3 | 47.9 | | 21.6 | 24.9 | 496 | 1886 |
| Specialty Organic | B961094 | 8-2-2 | | 6.2 | | 13.1 | | 9.1 | 7.3 | 1060 | 282 |
| Specialty Organic | B961095 | 1-1-1 | | 14.5 | 5.7 | 24.3 | | 13.7 | 22.3 | 461 | 308 |
| Specialty Bio-solid | B961145 | 6-2-0 | 5.2 | 54.3 | 3.7 | 391 | 0.59 | 29.9 | | 236 | 414 |
| Specialty | B961152 | 17-4-28 | | | | 1.9 | 0.09 | | | 128 | 83.7 |
| Specialty Blend | B961286 | 10-20-20 | 3 | 20 | 6.3 | 43.7 | 0.38 | 11.1 | 60 | 70.9 | 136 |
| Specialty Blend | B961297 | 27-3-3 | 2.7 | 1.7 | | 22.5 | | 4.6 | | 17.4 | 25.6 |
| Specialty Organic | B961326 | 1-1-1 | | 6.9 | | 7.5 | 0.2 | 10.1 | | 34.1 | 83.3 |

## Table H-4. Continued

| | Concentrations of Metals, mg/kg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Source | ID | Grade | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
| Specialty Organic | B961327 | .49-.14-.29 | 26.6 | | 4.3 | 0.1 | | | 20.6 | 82.3 | |
| Specialty/Micros | B960193 | 17-6-12 | 1.7 | 1.7 | | 3 | | 8.4 | 14.7 | 584 | 457 |
| Specialty w/Micros | B960221 | 4-12-4 | 3.4 | 49.2 | 4.4 | 47.5 | | 27 | 48.2 | 972 | 1729 |
| Specialty w/Micros | B960344 | 18-6-12 | | 1.9 | | 22.5 | | 8 | 18.7 | 486 | 525 |
| Specialty w/Micros | B960536 | 20-20-20 | | 0.8 | | 5.6 | | 3.2 | | 512.7 | 556 |
| Specialty w/Micros | B960539 | 13-25-12 | 7.8 | 6.5 | 4 | 76.6 | | 11.6 | 65.2 | 43.6 | 171 |
| Specialty w/Micros | B960626 | 18-3-18 | 2.3 | 1.9 | 3.8 | 37.2 | | 11.6 | 11.1 | 63.5 | 4.02 |
| Specialty w/Micros | B960634 | 12-10-10 | 11.9 | 4.2 | | 70.9 | | 20.9 | 17.4 | 43.9 | 3.41 |
| Specialty w/Micros | B960680 | Organic | 1.9 | 28.9 | 4.8 | 1864 | | 22.7 | 23.3 | 465 | 14.6 |
| Specialty w/Micros | B960687 | 5-20-10 | 11.7 | 5.4 | 3.7 | 96.8 | | 21 | 53.8 | 59 | 2.51 |
| Specialty w/Micros | B960793 | Organic | 2.6 | 25.6 | 6.8 | 608 | 0.06 | 13.5 | 10.3 | 478 | 592 |
| Specialty w/Micros | B960923 | Organic | 3.4 | 274 | 19.8 | 60.4 | | 44.9 | 62.4 | 711 | 13460 |
| Specialty w/Micros | B961150 | 20-27-5 | 4 | 5 | 6 | 59 | | 11.4 | 109 | 9.1 | 36 |

## Table H-5. Concentrations of Heavy Metals in Fertilizer Ingredients

| | Concentrations of Metals, mg/kg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Source | ID | Grade | Cd | Pb | As | Cr | Hg | Ni | V | Cu | Zn |
| Urea | B960368 | 46-0-0 | | | | 5.3 | | | 4.2 | | 46.6 |
| Monoammonium phosphate | B960557 | 11-52-0 | 4.8 | 1.9 | 13 | 92.6 | | 19.9 | 160 | 5.7 | 64.5 |
| Diammonium phosphate | B960582 | 18-48-0 | 4.6 | 4.4 | 13.8 | 77.6 | | 16.8 | 151 | 11.3 | 0.83 |
| Ammonium Nitrate | B960601 | 34-0-0 | | | | 3.1 | | | | | 0.06 |
| Ammonium Sulfate | B960603 | 21-0-0 | | | | | | | | | 0.02 |
| Specialty WIN | B960750 | 38-0-0 | | | | | | | | 2.5 | 1.8 |
| Ammonium Sulfate | B960834 | 21-0-0 | | 0.8 | | 2.9 | | | | 6.5 | 4 |
| Muriate of Potash | B960839 | 0-0-60 | | 2 | | 1.3 | | | | 1.9 | 2 |
| Ammonium Nitrate | B960878 | 34-0-0 | | | | 0.8 | | | | | 1.6 |
| Muriate of Potash | B960897 | 0-0-62 | | | | 3.1 | | | | | 3 |
| Ammonium Sulfate | B961007 | 21-0-0 | | 0.8 | | 1.5 | | | | 15 | 4.9 |
| Monoammonium phosphate | B961304 | 10-50-0 | 3.4 | 4.6 | 13.2 | 72.9 | | 16.7 | 133 | 32.3 | 40.5 |
| Ammonium Sulfate | B970433 | 21-0-0 | | 1.2 | | 3.1 | | | | 29.7 | 6.2 |
| Triple Super Phosphate | B970434 | 0-46-0 | 6.4 | 13.2 | 13.9 | 90.1 | | 21.9 | 132 | 45.1 | 87.1 |
| Muriate of Potash | B970435 | 0-0-60 | | 1.1 | | 2.5 | | | | 2.5 | 2.3 |
| Urea | B970436 | 46-0-0 | | 1.3 | | 1.5 | | | | | 5.4 |
| Monoammonium phosphate | B970437 | 11-52-0 | 4.9 | 6.8 | 18.7 | 96.3 | | 19.4 | 132 | 24.2 | 59.4 |
| Diammonium phosphate | B970438 | 18-46-0 | 3.4 | 6.1 | 16.3 | 74.4 | | 16.7 | 95.2 | 25.6 | 43 |
| Limestone filler | B970439 | 0-0-0 | 0.9 | 10.3 | | 41.3 | | 25.7 | 3.9 | 169 | 20.4 |
| Micro-mix | B960991 | 20% Zn | 9 | 1202 | 76.6 | 363 | 2.7 | 448 | 46.5 | 180 | 192645 |

## Table H-6. Yearly Cd and Pb Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content

| Source | %N $\%P_2O_5$ $\%K_2O$ | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha at | | | Yearly Pb addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ |
| Ag Blend B960243 19-19-19 | 19 | 3.5 | 2.2 | 0.003 | 0.004 | 0.009 | 0.002 | 0.003 | 0.005 |
| | 19 | 3.5 | 2.2 | 0.002 | 0.004 | 0.005 | 0.001 | 0.002 | 0.003 |
| | 19 | 3.5 | 2.2 | 0.002 | 0.004 | 0.011 | 0.001 | 0.002 | 0.007 |
| Ag Blend B960244 12-24-24 | 12 | 4.3 | 4.6 | 0.005 | 0.008 | 0.017 | 0.005 | 0.009 | 0.018 |
| | 24 | 4.3 | 4.6 | 0.002 | 0.003 | 0.005 | 0.002 | 0.004 | 0.005 |
| | 24 | 4.3 | 4.6 | 0.002 | 0.004 | 0.011 | 0.002 | 0.004 | 0.011 |
| Ag Blend B960249 7-35-12 | 7 | 4.6 | 3.9 | 0.009 | 0.015 | 0.030 | 0.008 | 0.013 | 0.026 |
| | 35 | 4.6 | 3.9 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | 12 | 4.6 | 3.9 | 0.004 | 0.008 | 0.023 | 0.004 | 0.006 | 0.019 |
| Ag Blend B960282 9-44-9 | 9 | 2.3 | 3.5 | 0.004 | 0.006 | 0.012 | 0.005 | 0.009 | 0.018 |
| | 44 | 2.3 | 3.5 | 0.000 | 0.001 | 0.001 | 0.001 | 0.002 | 0.002 |
| | 9 | 2.3 | 3.5 | 0.003 | 0.005 | 0.015 | 0.004 | 0.008 | 0.023 |
| Ag Blend B960325 10-21-15 | 10 | 2.7 | 11.1 | 0.004 | 0.006 | 0.013 | 0.015 | 0.026 | 0.052 |
| | 21 | 2.7 | 11.1 | 0.001 | 0.002 | 0.004 | 0.005 | 0.010 | 0.015 |
| | 15 | 2.7 | 11.1 | 0.002 | 0.004 | 0.011 | 0.009 | 0.015 | 0.044 |
| Ag Blend B960333 8-32-16 | 8 | 3.9 | 5.3 | 0.007 | 0.011 | 0.023 | 0.009 | 0.015 | 0.031 |
| | 32 | 3.9 | 5.3 | 0.001 | 0.002 | 0.003 | 0.002 | 0.003 | 0.005 |
| | 16 | 3.9 | 5.3 | 0.003 | 0.005 | 0.015 | 0.004 | 0.007 | 0.020 |
| Ag Blend B960389 19-19-19 | 19 | 1.6 | 1.4 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.003 |
| | 19 | 1.6 | 1.4 | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.002 |
| | 19 | 1.6 | 1.4 | 0.001 | 0.002 | 0.005 | 0.001 | 0.001 | 0.004 |
| Ag Blend B960412 7-26-26 | 7 | 2.6 | 2.8 | 0.005 | 0.009 | 0.017 | 0.006 | 0.009 | 0.019 |
| | 26 | 2.6 | 2.8 | 0.001 | 0.002 | 0.003 | 0.001 | 0.002 | 0.003 |
| | 26 | 2.6 | 2.8 | 0.001 | 0.002 | 0.006 | 0.001 | 0.002 | 0.006 |
| Ag Blend B960418 19-19-19 | 19 | 2.2 | 3.8 | 0.002 | 0.003 | 0.005 | 0.003 | 0.005 | 0.009 |
| | 19 | 2.2 | 3.8 | 0.001 | 0.002 | 0.003 | 0.002 | 0.004 | 0.006 |
| | 19 | 2.2 | 3.8 | 0.001 | 0.002 | 0.007 | 0.002 | 0.004 | 0.012 |
| Ag Blend B960441 9-34-10 | 9 | 3.3 | 3.6 | 0.005 | 0.008 | 0.017 | 0.006 | 0.009 | 0.019 |
| | 34 | 3.3 | 3.6 | 0.001 | 0.002 | 0.003 | 0.001 | 0.002 | 0.003 |
| | 10 | 3.3 | 3.6 | 0.004 | 0.007 | 0.020 | 0.004 | 0.007 | 0.022 |
| Ag Blend B960442 9-3-10 | 9 | 3.6 | 3 | 0.006 | 0.009 | 0.019 | 0.005 | 0.008 | 0.015 |
| | 3 | 3.6 | 3 | 0.011 | 0.023 | 0.034 | 0.009 | 0.019 | 0.028 |
| | 10 | 3.6 | 3 | 0.004 | 0.007 | 0.022 | 0.003 | 0.006 | 0.018 |
| Ag Blend B960453 10-20-20 | 10 | 4.3 | 3 | 0.006 | 0.010 | 0.020 | 0.004 | 0.007 | 0.014 |
| | 20 | 4.3 | 3 | 0.002 | 0.004 | 0.006 | 0.001 | 0.003 | 0.004 |
| | 20 | 4.3 | 3 | 0.002 | 0.004 | 0.013 | 0.002 | 0.003 | 0.009 |
| Ag Blend B960475 9-40-5 | 9 | 14.3 | 422 | 0.022 | 0.037 | 0.074 | 0.652 | 1.083 | 2.176 |
| | 40 | 14.3 | 422 | 0.003 | 0.007 | 0.010 | 0.099 | 0.205 | 0.298 |

**Table H-6. Continued**

| Source | %N %$P_2O_5$ %$K_2O$ | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha at | | | Yearly Pb addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ |
| | 5 | 14.3 | 422 | 0.033 | 0.057 | 0.171 | 0.971 | 1.671 | 5.047 |
| Ag Blend B960510 9-43-10 | 9 | 5.2 | 1.7 | 0.008 | 0.013 | 0.027 | 0.003 | 0.004 | 0.009 |
| | 43 | 5.2 | 1.7 | 0.001 | 0.002 | 0.003 | 0.000 | 0.001 | 0.001 |
| | 10 | 5.2 | 1.7 | 0.006 | 0.010 | 0.031 | 0.002 | 0.003 | 0.010 |
| Ag Blend B960580 10-10-10 | 10 | 1.8 | 3.6 | 0.003 | 0.004 | 0.008 | 0.005 | 0.008 | 0.017 |
| | 10 | 1.8 | 3.6 | 0.002 | 0.003 | 0.005 | 0.003 | 0.007 | 0.010 |
| | 10 | 1.8 | 3.6 | 0.002 | 0.004 | 0.011 | 0.004 | 0.007 | 0.022 |
| Ag Blend B960584 10-20-20 | 10 | 2.6 | 2.5 | 0.004 | 0.006 | 0.012 | 0.003 | 0.006 | 0.012 |
| | 20 | 2.6 | 2.5 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.004 |
| | 20 | 2.6 | 2.5 | 0.001 | 0.003 | 0.008 | 0.001 | 0.002 | 0.007 |
| Ag Blend B960599 15-15-15 | 15 | 2.1 | 2.1 | 0.002 | 0.003 | 0.006 | 0.002 | 0.003 | 0.006 |
| | 15 | 2.1 | 2.1 | 0.001 | 0.003 | 0.004 | 0.001 | 0.003 | 0.004 |
| | 15 | 2.1 | 2.1 | 0.002 | 0.003 | 0.008 | 0.002 | 0.003 | 0.008 |
| Ag Blend B960611 19-19-19 | 19 | 24.35 | 1.1 | 0.018 | 0.030 | 0.059 | 0.001 | 0.001 | 0.003 |
| | 19 | 24.35 | 1.1 | 0.012 | 0.025 | 0.036 | 0.001 | 0.001 | 0.002 |
| | 19 | 24.35 | 1.1 | 0.015 | 0.025 | 0.077 | 0.001 | 0.001 | 0.003 |
| Ag Blend B960639 6-2-0 | 6 | 5.7 | 6.9 | 0.013 | 0.022 | 0.044 | 0.016 | 0.027 | 0.053 |
| | 2 | 5.7 | 6.9 | 0.027 | 0.055 | 0.080 | 0.032 | 0.067 | 0.097 |
| | 0 | 5.7 | 6.9 | ERR | ERR | ERR | ERR | ERR | ERR |
| Ag Blend B960708 7-27-11 | 7 | 6.4 | 153 | 0.013 | 0.021 | 0.042 | 0.304 | 0.505 | 1.014 |
| | 27 | 6.4 | 153 | 0.002 | 0.005 | 0.007 | 0.053 | 0.110 | 0.160 |
| | 11 | 6.4 | 153 | 0.007 | 0.012 | 0.035 | 0.160 | 0.275 | 0.832 |
| Ag ammoniated B960711 8-24-8 | 8 | 9.5 | 14 | 0.017 | 0.027 | 0.055 | 0.024 | 0.040 | 0.081 |
| | 24 | 9.5 | 14 | 0.004 | 0.008 | 0.011 | 0.005 | 0.011 | 0.016 |
| | 8 | 9.5 | 14 | 0.014 | 0.024 | 0.071 | 0.020 | 0.035 | 0.105 |
| Ag Blend B960713 10-20-10 | 10 | 2.4 | 6.7 | 0.003 | 0.006 | 0.011 | 0.009 | 0.015 | 0.031 |
| | 20 | 2.4 | 6.7 | 0.001 | 0.002 | 0.003 | 0.003 | 0.006 | 0.009 |
| | 10 | 2.4 | 6.7 | 0.003 | 0.005 | 0.014 | 0.008 | 0.013 | 0.040 |
| Ag Blend B960715 15-15-15 | 15 | 2 | 1.8 | 0.002 | 0.003 | 0.006 | 0.002 | 0.003 | 0.006 |
| | 15 | 2 | 1.8 | 0.001 | 0.003 | 0.004 | 0.001 | 0.002 | 0.003 |
| | 15 | 2 | 1.8 | 0.002 | 0.003 | 0.008 | 0.001 | 0.002 | 0.007 |
| Ag Blend B980726 19-19-19 | 19 | 4.1 | 3.7 | 0.003 | 0.005 | 0.010 | 0.003 | 0.004 | 0.009 |
| | 19 | 4.1 | 3.7 | 0.002 | 0.004 | 0.006 | 0.002 | 0.004 | 0.005 |
| | 19 | 4.1 | 3.7 | 0.002 | 0.004 | 0.013 | 0.002 | 0.004 | 0.012 |
| AG Blend B960820 26-9-9 | 26 | 2 | 2.3 | 0.001 | 0.002 | 0.004 | 0.001 | 0.002 | 0.004 |
| | 9 | 2 | 2.3 | 0.002 | 0.004 | 0.006 | 0.002 | 0.005 | 0.007 |
| | 9 | 2 | 2.3 | 0.003 | 0.004 | 0.013 | 0.003 | 0.005 | 0.015 |
| Ag Blend B960896 10-20-20 | 10 | 3.3 | 3.6 | 0.005 | 0.008 | 0.015 | 0.005 | 0.008 | 0.017 |
| | 20 | 3.3 | 3.6 | 0.002 | 0.003 | 0.005 | 0.002 | 0.003 | 0.005 |

## Table H-6. Continued

| Source | %N $\%P_2O_5$ $\%K_2O$ | Cd mg/kg | Pb mg/kg | Yearly Cd addition in kg/ha at | | | Yearly Pb addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ |
| | 20 | 3.3 | 3.6 | 0.002 | 0.003 | 0.010 | 0.002 | 0.004 | 0.011 |
| Ag Blend B960900 10-20-20 | 10 | 3.1 | 3.3 | 0.004 | 0.007 | 0.014 | 0.005 | 0.008 | 0.015 |
| | 20 | 3.1 | 3.3 | 0.001 | 0.003 | 0.004 | 0.002 | 0.003 | 0.005 |
| | 20 | 3.1 | 3.3 | 0.002 | 0.003 | 0.009 | 0.002 | 0.003 | 0.010 |
| Ag Blend B960909 3-17-40 | 3 | 2.4 | 2.6 | 0.011 | 0.018 | 0.037 | 0.012 | 0.020 | 0.040 |
| | 17 | 2.4 | 2.6 | 0.001 | 0.003 | 0.004 | 0.001 | 0.003 | 0.004 |
| | 40 | 2.4 | 2.6 | 0.001 | 0.001 | 0.004 | 0.001 | 0.001 | 0.004 |
| Ag Blend B960912 3-17-40 | 3 | 4.3 | 3.9 | 0.020 | 0.033 | 0.067 | 0.018 | 0.030 | 0.060 |
| | 17 | 4.3 | 3.9 | 0.002 | 0.005 | 0.007 | 0.002 | 0.004 | 0.006 |
| | 40 | 4.3 | 3.9 | 0.001 | 0.002 | 0.006 | 0.001 | 0.002 | 0.006 |
| Ag Blend B960913 8-41-12 | 8 | 1.5 | 18 | 0.003 | 0.004 | 0.009 | 0.031 | 0.052 | 0.104 |
| | 41 | 1.5 | 18 | 0.000 | 0.001 | 0.001 | 0.004 | 0.009 | 0.012 |
| | 12 | 1.5 | 18 | 0.001 | 0.002 | 0.007 | 0.017 | 0.030 | 0.090 |
| Ag Blend B961058 8-17-34 | 8 | 1 | 2.4 | 0.002 | 0.003 | 0.006 | 0.004 | 0.007 | 0.014 |
| | 17 | 1 | 2.4 | 0.001 | 0.001 | 0.002 | 0.001 | 0.003 | 0.004 |
| | 34 | 1 | 2.4 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 |
| Ag Blend B961321 9-43-10 | 9 | 4.7 | 6.9 | 0.007 | 0.012 | 0.024 | 0.011 | 0.018 | 0.036 |
| | 43 | 4.7 | 6.9 | 0.001 | 0.002 | 0.003 | 0.002 | 0.003 | 0.005 |
| | 10 | 4.7 | 6.9 | 0.005 | 0.009 | 0.028 | 0.008 | 0.014 | 0.041 |

## Table H-7. Yearly As and Cr Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content

| Source | %N<br>$\%P_2O_5$<br>$\%K_2O$ | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at | | | Yearly Cr addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N<br>84 $P_2O_5$<br>103 $K_2O$ | 206 N<br>173 $P_2O_5$<br>177 $K_2O$ | 414 N<br>252 $P_2O_5$<br>534 $K_2O$ | 124 N<br>84 $P_2O_5$<br>103 $K_2O$ | 206 N<br>173 $P_2O_5$<br>177 $K_2O$ | 414 N<br>252 $P_2O_5$<br>534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N<br>94 $P_2O_5$<br>115 $K_2O$ | 231 N<br>194 $P_2O_5$<br>198 $K_2O$ | 464 N<br>282 $P_2O_5$<br>598 $K_2O$ | 139 N<br>94 $P_2O_5$<br>115 $K_2O$ | 231 N<br>194 $P_2O_5$<br>198 $K_2O$ | 464 N<br>282 $P_2O_5$<br>598 $K_2O$ |
| Ag Blend B960243 19-19-19 | 19 | 6.6 | 45.4 | 0.005 | 0.008 | 0.016 | 0.033 | 0.055 | 0.111 |
| | 19 | 6.6 | 45.4 | 0.003 | 0.007 | 0.010 | 0.022 | 0.046 | 0.067 |
| | 19 | 6.6 | 45.4 | 0.004 | 0.007 | 0.021 | 0.027 | 0.047 | 0.143 |
| Ag Blend B960244 12-24-24 | 12 | 9.8 | 59 | 0.011 | 0.019 | 0.038 | 0.068 | 0.114 | 0.228 |
| | 24 | 9.8 | 59 | 0.004 | 0.008 | 0.012 | 0.023 | 0.048 | 0.069 |
| | 24 | 9.8 | 59 | 0.005 | 0.008 | 0.024 | 0.028 | 0.049 | 0.147 |
| Ag Blend B960249 7-35-12 | 7 | 9.7 | 66.8 | 0.019 | 0.032 | 0.064 | 0.133 | 0.220 | 0.443 |
| | 35 | 9.7 | 66.8 | 0.003 | 0.005 | 0.008 | 0.018 | 0.037 | 0.054 |
| | 12 | 9.7 | 66.8 | 0.009 | 0.016 | 0.048 | 0.064 | 0.110 | 0.333 |
| Ag Blend B960282 9-44-9 | 9 | 13.2 | 90.7 | 0.020 | 0.034 | 0.068 | 0.140 | 0.233 | 0.468 |
| | 44 | 13.2 | 90.7 | 0.003 | 0.006 | 0.008 | 0.019 | 0.040 | 0.058 |
| | 9 | 13.2 | 90.7 | 0.017 | 0.029 | 0.088 | 0.116 | 0.200 | 0.603 |
| Ag Blend B960325 10-21-15 | 10 | 7.2 | 46.3 | 0.010 | 0.017 | 0.033 | 0.064 | 0.107 | 0.215 |
| | 21 | 7.2 | 46.3 | 0.003 | 0.007 | 0.010 | 0.021 | 0.043 | 0.062 |
| | 15 | 7.2 | 46.3 | 0.006 | 0.010 | 0.029 | 0.035 | 0.061 | 0.185 |
| Ag Blend B960333 8-32-16 | 8 | 11.2 | 68.1 | 0.019 | 0.032 | 0.065 | 0.118 | 0.197 | 0.395 |
| | 32 | 11.2 | 68.1 | 0.003 | 0.007 | 0.010 | 0.020 | 0.041 | 0.060 |
| | 16 | 11.2 | 68.1 | 0.008 | 0.014 | 0.042 | 0.049 | 0.084 | 0.255 |
| Ag Blend B960389 19-19-19 | 19 | 5.2 | 43.5 | 0.004 | 0.006 | 0.013 | 0.032 | 0.053 | 0.106 |
| | 19 | 5.2 | 43.5 | 0.003 | 0.005 | 0.008 | 0.022 | 0.044 | 0.065 |
| | 19 | 5.2 | 43.5 | 0.003 | 0.005 | 0.016 | 0.026 | 0.045 | 0.137 |
| Ag Blend B960412 7-26-26 | 7 | 6 | 51.8 | 0.012 | 0.020 | 0.040 | 0.103 | 0.171 | 0.343 |
| | 26 | 6 | 51.8 | 0.002 | 0.004 | 0.007 | 0.019 | 0.039 | 0.056 |
| | 26 | 6 | 51.8 | 0.003 | 0.005 | 0.014 | 0.023 | 0.039 | 0.119 |
| Ag Blend B960418 19-19-19 | 19 | 7.5 | 62 | 0.005 | 0.009 | 0.018 | 0.045 | 0.075 | 0.151 |
| | 19 | 7.5 | 62 | 0.004 | 0.008 | 0.011 | 0.031 | 0.063 | 0.092 |
| | 19 | 7.5 | 62 | 0.005 | 0.008 | 0.024 | 0.038 | 0.065 | 0.195 |
| Ag Blend B960441 9-34-10 | 9 | 10.7 | 67.4 | 0.017 | 0.027 | 0.055 | 0.104 | 0.173 | 0.347 |
| | 34 | 10.7 | 67.4 | 0.003 | 0.006 | 0.009 | 0.019 | 0.038 | 0.056 |
| | 10 | 10.7 | 67.4 | 0.012 | 0.021 | 0.064 | 0.078 | 0.133 | 0.403 |
| Ag Blend B960442 9-3-10 | 9 | 9.2 | 88.8 | 0.014 | 0.024 | 0.047 | 0.137 | 0.228 | 0.458 |
| | 3 | 9.2 | 88.8 | 0.029 | 0.059 | 0.086 | 0.278 | 0.574 | 0.835 |
| | 10 | 9.2 | 88.8 | 0.011 | 0.018 | 0.055 | 0.102 | 0.176 | 0.531 |
| Ag Blend B960453 10-20-20 | 10 | 3.6 | 68.7 | 0.005 | 0.008 | 0.017 | 0.095 | 0.159 | 0.319 |
| | 20 | 3.6 | 68.7 | 0.002 | 0.003 | 0.005 | 0.032 | 0.067 | 0.097 |
| | 20 | 3.6 | 68.7 | 0.002 | 0.004 | 0.011 | 0.040 | 0.068 | 0.205 |

## Table H-7. Continued

| Source | %N %$P_2O_5$ %$K_2O$ | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at lb/A: 124 N 84 $P_2O_5$ 103 $K_2O$ (kg/ha: 139 N 94 $P_2O_5$ 115 $K_2O$) | 206 N 173 $P_2O_5$ 177 $K_2O$ (kg/ha: 231 N 194 $P_2O_5$ 198 $K_2O$) | 414 N 252 $P_2O_5$ 534 $K_2O$ (kg/ha: 464 N 282 $P_2O_5$ 598 $K_2O$) | Yearly Cr addition in kg/ha at lb/A: 124 N 84 $P_2O_5$ 103 $K_2O$ (kg/ha: 139 N 94 $P_2O_5$ 115 $K_2O$) | 206 N 173 $P_2O_5$ 177 $K_2O$ (kg/ha: 231 N 194 $P_2O_5$ 198 $K_2O$) | 414 N 252 $P_2O_5$ 534 $K_2O$ (kg/ha: 464 N 282 $P_2O_5$ 598 $K_2O$) |
|---|---|---|---|---|---|---|---|---|---|
| Ag Blend B960475 9-40-5 | 9 | 10 | 107.9 | 0.015 | 0.026 | 0.052 | 0.167 | 0.277 | 0.556 |
| | 40 | 10 | 107.9 | 0.002 | 0.005 | 0.007 | 0.025 | 0.052 | 0.076 |
| | 5 | 10 | 107.9 | 0.023 | 0.040 | 0.120 | 0.248 | 0.427 | 1.290 |
| Ag Blend B960510 9-43-10 | 9 | 11.2 | 79.4 | 0.017 | 0.029 | 0.058 | 0.123 | 0.204 | 0.409 |
| | 43 | 11.2 | 79.4 | 0.002 | 0.005 | 0.007 | 0.017 | 0.036 | 0.052 |
| | 10 | 11.2 | 79.4 | 0.013 | 0.022 | 0.067 | 0.091 | 0.157 | 0.475 |
| Ag Blend B960580 10-10-10 | 10 | 4.1 | 51.4 | 0.006 | 0.009 | 0.019 | 0.071 | 0.119 | 0.238 |
| | 10 | 4.1 | 51.4 | 0.004 | 0.008 | 0.012 | 0.048 | 0.100 | 0.145 |
| | 10 | 4.1 | 51.4 | 0.005 | 0.008 | 0.025 | 0.059 | 0.102 | 0.307 |
| Ag Blend B960584 10-20-20 | 10 | 6.9 | 52.8 | 0.010 | 0.016 | 0.032 | 0.073 | 0.122 | 0.245 |
| | 20 | 6.9 | 52.8 | 0.003 | 0.007 | 0.010 | 0.025 | 0.051 | 0.074 |
| | 20 | 6.9 | 52.8 | 0.004 | 0.007 | 0.021 | 0.030 | 0.052 | 0.158 |
| Ag Blend B960599 15-15-15 | 15 | 4.9 | 42.5 | 0.005 | 0.008 | 0.015 | 0.039 | 0.065 | 0.131 |
| | 15 | 4.9 | 42.5 | 0.003 | 0.006 | 0.009 | 0.027 | 0.055 | 0.080 |
| | 15 | 4.9 | 42.5 | 0.004 | 0.006 | 0.020 | 0.033 | 0.056 | 0.169 |
| Ag Blend B960611 19-19-19 | 19 | 0 | 160 | 0.000 | 0.000 | 0.000 | 0.117 | 0.195 | 0.391 |
| | 19 | 0 | 160 | 0.000 | 0.000 | 0.000 | 0.079 | 0.163 | 0.237 |
| | 19 | 0 | 160 | 0.000 | 0.000 | 0.000 | 0.097 | 0.167 | 0.504 |
| Ag Blend B960639 6-2-0 | 6 | 4.7 | 40.3 | 0.011 | 0.018 | 0.036 | 0.093 | 0.155 | 0.312 |
| | 2 | 4.7 | 40.3 | 0.022 | 0.046 | 0.066 | 0.189 | 0.391 | 0.568 |
| | 0 | 4.7 | 40.3 | ERR | ERR | ERR | ERR | ERR | ERR |
| Ag Blend B960708 7-27-11 | 7 | 9 | 73.2 | 0.018 | 0.030 | 0.060 | 0.145 | 0.242 | 0.485 |
| | 27 | 9 | 73.2 | 0.003 | 0.006 | 0.009 | 0.025 | 0.053 | 0.076 |
| | 11 | 9 | 73.2 | 0.009 | 0.016 | 0.049 | 0.077 | 0.132 | 0.398 |
| Ag ammoniated B960711 8-24-8 | 8 | 3.5 | 60.5 | 0.006 | 0.010 | 0.020 | 0.105 | 0.175 | 0.351 |
| | 24 | 3.5 | 60.5 | 0.001 | 0.003 | 0.004 | 0.024 | 0.049 | 0.071 |
| | 8 | 3.5 | 60.5 | 0.005 | 0.009 | 0.026 | 0.087 | 0.150 | 0.452 |
| Ag Blend B960713 10-20-10 | 10 | 5.4 | 42 | 0.008 | 0.012 | 0.025 | 0.058 | 0.097 | 0.195 |
| | 20 | 5.4 | 42 | 0.003 | 0.005 | 0.008 | 0.020 | 0.041 | 0.059 |
| | 10 | 5.4 | 42 | 0.006 | 0.011 | 0.032 | 0.048 | 0.083 | 0.251 |
| Ag Blend B960715 15-15-15 | 15 | 4.7 | 28 | 0.004 | 0.007 | 0.015 | 0.026 | 0.043 | 0.087 |
| | 15 | 4.7 | 28 | 0.003 | 0.006 | 0.009 | 0.018 | 0.036 | 0.053 |
| | 15 | 4.7 | 28 | 0.004 | 0.006 | 0.019 | 0.021 | 0.037 | 0.112 |
| Ag Blend B980726 19-19-19 | 19 | 7.8 | 48.8 | 0.006 | 0.009 | 0.019 | 0.036 | 0.059 | 0.119 |
| | 19 | 7.8 | 48.8 | 0.004 | 0.008 | 0.012 | 0.024 | 0.050 | 0.072 |
| | 19 | 7.8 | 48.8 | 0.005 | 0.008 | 0.025 | 0.030 | 0.051 | 0.154 |
| AG Blend B960820 26-9-9 | 26 | 4.1 | 34.2 | 0.002 | 0.004 | 0.007 | 0.018 | 0.030 | 0.061 |
| | 9 | 4.1 | 34.2 | 0.004 | 0.009 | 0.013 | 0.036 | 0.074 | 0.107 |
| | 9 | 4.1 | 34.2 | 0.005 | 0.009 | 0.027 | 0.044 | 0.075 | 0.227 |

## Table H-7. Continued

| Source | %N $\%P_2O_5$ $\%K_2O$ | As mg/kg | Cr mg/kg | Yearly As addition in kg/ha at lb/A: 124 N 84 $P_2O_5$ 103 $K_2O$; kg/ha: 139 N 94 $P_2O_5$ 115 $K_2O$ | lb/A: 206 N 173 $P_2O_5$ 177 $K_2O$; kg/ha: 231 N 194 $P_2O_5$ 198 $K_2O$ | lb/A: 414 N 252 $P_2O_5$ 534 $K_2O$; kg/ha: 464 N 282 $P_2O_5$ 598 $K_2O$ | Yearly Cr addition in kg/ha at lb/A: 124 N 84 $P_2O_5$ 103 $K_2O$; kg/ha: 139 N 94 $P_2O_5$ 115 $K_2O$ | lb/A: 206 N 173 $P_2O_5$ 177 $K_2O$; kg/ha: 231 N 194 $P_2O_5$ 198 $K_2O$ | lb/A: 414 N 252 $P_2O_5$ 534 $K_2O$; kg/ha: 464 N 282 $P_2O_5$ 598 $K_2O$ |
|---|---|---|---|---|---|---|---|---|---|
| Ag Blend B960896 10-20-20 | 10 | 7 | 39 | 0.010 | 0.016 | 0.032 | 0.054 | 0.090 | 0.181 |
| | 20 | 7 | 39 | 0.003 | 0.007 | 0.010 | 0.018 | 0.038 | 0.055 |
| | 20 | 7 | 39 | 0.004 | 0.007 | 0.021 | 0.022 | 0.039 | 0.117 |
| Ag Blend B960900 10-20-20 | 10 | 7.4 | 201 | 0.010 | 0.017 | 0.034 | 0.279 | 0.464 | 0.933 |
| | 20 | 7.4 | 201 | 0.003 | 0.007 | 0.010 | 0.094 | 0.195 | 0.283 |
| | 20 | 7.4 | 201 | 0.004 | 0.007 | 0.022 | 0.116 | 0.199 | 0.601 |
| Ag Blend B960909 3-17-40 | 3 | 5.1 | 34.3 | 0.024 | 0.039 | 0.079 | 0.159 | 0.264 | 0.531 |
| | 17 | 5.1 | 34.3 | 0.003 | 0.006 | 0.008 | 0.019 | 0.039 | 0.057 |
| | 40 | 5.1 | 34.3 | 0.001 | 0.003 | 0.008 | 0.010 | 0.017 | 0.051 |
| Ag Blend B960912 3-17-40 | 3 | 10.5 | 67.4 | 0.049 | 0.081 | 0.162 | 0.312 | 0.519 | 1.042 |
| | 17 | 10.5 | 67.4 | 0.006 | 0.012 | 0.017 | 0.037 | 0.077 | 0.112 |
| | 40 | 10.5 | 67.4 | 0.003 | 0.005 | 0.016 | 0.019 | 0.033 | 0.101 |
| Ag Blend B960913 8-41-12 | 8 | 6.2 | 68.3 | 0.011 | 0.018 | 0.036 | 0.119 | 0.197 | 0.396 |
| | 41 | 6.2 | 68.3 | 0.001 | 0.003 | 0.004 | 0.016 | 0.032 | 0.047 |
| | 12 | 6.2 | 68.3 | 0.006 | 0.010 | 0.031 | 0.065 | 0.113 | 0.340 |
| Ag Blend B961058 8-17-34 | 8 | 3.1 | 30.8 | 0.005 | 0.009 | 0.018 | 0.054 | 0.089 | 0.179 |
| | 17 | 3.1 | 30.8 | 0.002 | 0.004 | 0.005 | 0.017 | 0.035 | 0.051 |
| | 34 | 3.1 | 30.8 | 0.001 | 0.002 | 0.005 | 0.010 | 0.018 | 0.054 |
| Ag Blend B961321 9-43-10 | 9 | 10.7 | 69.8 | 0.017 | 0.027 | 0.055 | 0.108 | 0.179 | 0.360 |
| | 43 | 10.7 | 69.8 | 0.002 | 0.005 | 0.007 | 0.015 | 0.031 | 0.046 |
| | 10 | 10.7 | 69.8 | 0.012 | 0.021 | 0.064 | 0.080 | 0.138 | 0.417 |

**Table H-8. Yearly Hg and Ni Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content**

| Source | %N %$P_2O_5$ %$K_2O$ | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha at | | | Yearly Ni addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ |
| Ag Blend B960243 19-19-19 | 19 | 0 | 11.2 | 0.000 | 0.000 | 0.000 | 0.008 | 0.014 | 0.027 |
| | 19 | 0 | 11.2 | 0.000 | 0.000 | 0.000 | 0.006 | 0.011 | 0.017 |
| | 19 | 0 | 11.2 | 0.000 | 0.000 | 0.000 | 0.007 | 0.012 | 0.035 |
| Ag Blend B960244 12-24-24 | 12 | 0 | 14.7 | 0.000 | 0.000 | 0.000 | 0.017 | 0.028 | 0.057 |
| | 24 | 0 | 14.7 | 0.000 | 0.000 | 0.000 | 0.006 | 0.012 | 0.017 |
| | 24 | 0 | 14.7 | 0.000 | 0.000 | 0.000 | 0.007 | 0.012 | 0.037 |
| Ag Blend B960249 7-35-12 | 7 | 0 | 20.9 | 0.000 | 0.000 | 0.000 | 0.042 | 0.069 | 0.139 |
| | 35 | 0 | 20.9 | 0.000 | 0.000 | 0.000 | 0.006 | 0.012 | 0.017 |
| | 12 | 0 | 20.9 | 0.000 | 0.000 | 0.000 | 0.020 | 0.034 | 0.104 |
| Ag Blend B960282 9-44-9 | 9 | 0 | 14.5 | 0.000 | 0.000 | 0.000 | 0.022 | 0.037 | 0.075 |
| | 44 | 0 | 14.5 | 0.000 | 0.000 | 0.000 | 0.003 | 0.006 | 0.009 |
| | 9 | 0 | 14.5 | 0.000 | 0.000 | 0.000 | 0.019 | 0.032 | 0.096 |
| Ag Blend B960325 10-21-15 | 10 | 0.17 | 13.4 | 0.000 | 0.000 | 0.001 | 0.019 | 0.031 | 0.062 |
| | 21 | 0.17 | 13.4 | 0.000 | 0.000 | 0.000 | 0.006 | 0.012 | 0.018 |
| | 15 | 0.17 | 13.4 | 0.000 | 0.000 | 0.001 | 0.010 | 0.018 | 0.053 |
| Ag Blend B960333 8-32-16 | 8 | 0 | 14.9 | 0.000 | 0.000 | 0.000 | 0.026 | 0.043 | 0.086 |
| | 32 | 0 | 14.9 | 0.000 | 0.000 | 0.000 | 0.004 | 0.009 | 0.013 |
| | 16 | 0 | 14.9 | 0.000 | 0.000 | 0.000 | 0.011 | 0.018 | 0.056 |
| Ag Blend B960389 19-19-19 | 19 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 19 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 19 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ag Blend B960412 7-26-26 | 7 | 0 | 11.5 | 0.000 | 0.000 | 0.000 | 0.023 | 0.038 | 0.076 |
| | 26 | 0 | 11.5 | 0.000 | 0.000 | 0.000 | 0.004 | 0.009 | 0.012 |
| | 26 | 0 | 11.5 | 0.000 | 0.000 | 0.000 | 0.005 | 0.009 | 0.026 |
| Ag Blend B960418 19-19-19 | 19 | 0 | 9.2 | 0.000 | 0.000 | 0.000 | 0.007 | 0.011 | 0.022 |
| | 19 | 0 | 9.2 | 0.000 | 0.000 | 0.000 | 0.005 | 0.009 | 0.014 |
| | 19 | 0 | 9.2 | 0.000 | 0.000 | 0.000 | 0.006 | 0.010 | 0.029 |
| Ag Blend B960441 9-34-10 | 9 | 0 | 12.2 | 0.000 | 0.000 | 0.000 | 0.019 | 0.031 | 0.063 |
| | 34 | 0 | 12.2 | 0.000 | 0.000 | 0.000 | 0.003 | 0.007 | 0.010 |
| | 10 | 0 | 12.2 | 0.000 | 0.000 | 0.000 | 0.014 | 0.024 | 0.073 |
| Ag Blend B960442 9-3-10 | 9 | 0 | 14.5 | 0.000 | 0.000 | 0.000 | 0.022 | 0.037 | 0.075 |
| | 3 | 0 | 14.5 | 0.000 | 0.000 | 0.000 | 0.045 | 0.094 | 0.136 |
| | 10 | 0 | 14.5 | 0.000 | 0.000 | 0.000 | 0.017 | 0.029 | 0.087 |
| Ag Blend B960453 10-20-20 | 10 | 0 | 18 | 0.000 | 0.000 | 0.000 | 0.025 | 0.042 | 0.084 |
| | 20 | 0 | 18 | 0.000 | 0.000 | 0.000 | 0.008 | 0.017 | 0.025 |
| | 20 | 0 | 18 | 0.000 | 0.000 | 0.000 | 0.010 | 0.018 | 0.054 |

## Table H-8. Continued

| Source | %N $\%P_2O_5$ $\%K_2O$ | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha at | | | Yearly Ni addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ |
| Ag Blend | 9 | 0 | 29.2 | 0.000 | 0.000 | 0.000 | 0.045 | 0.075 | 0.151 |
| B960475 | 40 | 0 | 29.2 | 0.000 | 0.000 | 0.000 | 0.007 | 0.014 | 0.021 |
| 9-40-5 | 5 | 0 | 29.2 | 0.000 | 0.000 | 0.000 | 0.067 | 0.116 | 0.349 |
| Ag Blend | 9 | 0 | 17.8 | 0.000 | 0.000 | 0.000 | 0.027 | 0.046 | 0.092 |
| B960510 | 43 | 0 | 17.8 | 0.000 | 0.000 | 0.000 | 0.004 | 0.008 | 0.012 |
| 9-43-10 | 10 | 0 | 17.8 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 | 0.106 |
| Ag Blend | 10 | 0 | 14.6 | 0.000 | 0.000 | 0.000 | 0.020 | 0.034 | 0.068 |
| B960580 | 10 | 0 | 14.6 | 0.000 | 0.000 | 0.000 | 0.014 | 0.028 | 0.041 |
| 10-10-10 | 10 | 0 | 14.6 | 0.000 | 0.000 | 0.000 | 0.017 | 0.029 | 0.087 |
| Ag Blend | 10 | 0 | 15.7 | 0.000 | 0.000 | 0.000 | 0.022 | 0.036 | 0.073 |
| B960584 | 20 | 0 | 15.7 | 0.000 | 0.000 | 0.000 | 0.007 | 0.015 | 0.022 |
| 10-20-20 | 20 | 0 | 15.7 | 0.000 | 0.000 | 0.000 | 0.009 | 0.016 | 0.047 |
| Ag Blend | 15 | 0 | 11.4 | 0.000 | 0.000 | 0.000 | 0.011 | 0.018 | 0.035 |
| B960599 | 15 | 0 | 11.4 | 0.000 | 0.000 | 0.000 | 0.007 | 0.015 | 0.021 |
| 15-15-15 | 15 | 0 | 11.4 | 0.000 | 0.000 | 0.000 | 0.009 | 0.015 | 0.045 |
| Ag Blend | 19 | 0 | 36.9 | 0.000 | 0.000 | 0.000 | 0.027 | 0.045 | 0.090 |
| B960611 | 19 | 0 | 36.9 | 0.000 | 0.000 | 0.000 | 0.018 | 0.038 | 0.055 |
| 19-19-19 | 19 | 0 | 36.9 | 0.000 | 0.000 | 0.000 | 0.022 | 0.038 | 0.116 |
| Ag Blend | 6 | 0 | 11.2 | 0.000 | 0.000 | 0.000 | 0.026 | 0.043 | 0.087 |
| B960639 | 2 | 0 | 11.2 | 0.000 | 0.000 | 0.000 | 0.053 | 0.109 | 0.158 |
| 6-2-0 | 0 | 0 | 11.2 | ERR | ERR | ERR | ERR | ERR | ERR |
| Ag Blend | 7 | 0 | 22.7 | 0.000 | 0.000 | 0.000 | 0.045 | 0.075 | 0.150 |
| B960708 | 27 | 0 | 22.7 | 0.000 | 0.000 | 0.000 | 0.008 | 0.016 | 0.024 |
| 7-27-11 | 11 | 0 | 22.7 | 0.000 | 0.000 | 0.000 | 0.024 | 0.041 | 0.123 |
| Ag ammoniated | 8 | 0 | 11.9 | 0.000 | 0.000 | 0.000 | 0.021 | 0.034 | 0.069 |
| B960711 | 24 | 0 | 11.9 | 0.000 | 0.000 | 0.000 | 0.005 | 0.010 | 0.014 |
| 8-24-8 | 8 | 0 | 11.9 | 0.000 | 0.000 | 0.000 | 0.017 | 0.029 | 0.089 |
| Ag Blend | 10 | 0 | 10.1 | 0.000 | 0.000 | 0.000 | 0.014 | 0.023 | 0.047 |
| B960713 | 20 | 0 | 10.1 | 0.000 | 0.000 | 0.000 | 0.005 | 0.010 | 0.014 |
| 10-20-10 | 10 | 0 | 10.1 | 0.000 | 0.000 | 0.000 | 0.012 | 0.020 | 0.060 |
| Ag Blend | 15 | 0 | 6.2 | 0.000 | 0.000 | 0.000 | 0.006 | 0.010 | 0.019 |
| B960715 | 15 | 0 | 6.2 | 0.000 | 0.000 | 0.000 | 0.004 | 0.008 | 0.012 |
| 15-15-15 | 15 | 0 | 6.2 | 0.000 | 0.000 | 0.000 | 0.005 | 0.008 | 0.025 |
| Ag Blend | 19 | 0 | 11.5 | 0.000 | 0.000 | 0.000 | 0.008 | 0.014 | 0.028 |
| B980726 | 19 | 0 | 11.5 | 0.000 | 0.000 | 0.000 | 0.006 | 0.012 | 0.017 |
| 19-19-19 | 19 | 0 | 11.5 | 0.000 | 0.000 | 0.000 | 0.007 | 0.012 | 0.036 |
| AG Blend | 26 | 0 | 8 | 0.000 | 0.000 | 0.000 | 0.004 | 0.007 | 0.014 |
| B960820 | 9 | 0 | 8 | 0.000 | 0.000 | 0.000 | 0.008 | 0.017 | 0.025 |
| 26-9-9 | 9 | 0 | 8 | 0.000 | 0.000 | 0.000 | 0.010 | 0.018 | 0.053 |

## Table H-8. Continued

| Source | %N<br>$\%P_2O_5$<br>$\%K_2O$ | Hg mg/kg | Ni mg/kg | Yearly Hg addition in kg/ha at | | | Yearly Ni addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N<br>84 $P_2O_5$<br>103 $K_2O$ | 206 N<br>173 $P_2O_5$<br>177 $K_2O$ | 414 N<br>252 $P_2O_5$<br>534 $K_2O$ | 124 N<br>84 $P_2O_5$<br>103 $K_2O$ | 206 N<br>173 $P_2O_5$<br>177 $K_2O$ | 414 N<br>252 $P_2O_5$<br>534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N<br>94 $P_2O_5$<br>115 $K_2O$ | 231 N<br>194 $P_2O_5$<br>198 $K_2O$ | 464 N<br>282 $P_2O_5$<br>598 $K_2O$ | 139 N<br>94 $P_2O_5$<br>115 $K_2O$ | 231 N<br>194 $P_2O_5$<br>198 $K_2O$ | 464 N<br>282 $P_2O_5$<br>598 $K_2O$ |
| Ag Blend B960896 10-20-20 | 10 | 0 | 8.6 | 0.000 | 0.000 | 0.000 | 0.012 | 0.020 | 0.040 |
| | 20 | 0 | 8.6 | 0.000 | 0.000 | 0.000 | 0.004 | 0.008 | 0.012 |
| | 20 | 0 | 8.6 | 0.000 | 0.000 | 0.000 | 0.005 | 0.009 | 0.026 |
| Ag Blend B960900 10-20-20 | 10 | 0 | 85.7 | 0.000 | 0.000 | 0.000 | 0.119 | 0.198 | 0.398 |
| | 20 | 0 | 85.7 | 0.000 | 0.000 | 0.000 | 0.040 | 0.083 | 0.121 |
| | 20 | 0 | 85.7 | 0.000 | 0.000 | 0.000 | 0.049 | 0.085 | 0.256 |
| Ag Blend B960909 3-17-40 | 3 | 0 | 5.7 | 0.000 | 0.000 | 0.000 | 0.026 | 0.044 | 0.088 |
| | 17 | 0 | 5.7 | 0.000 | 0.000 | 0.000 | 0.003 | 0.007 | 0.009 |
| | 40 | 0 | 5.7 | 0.000 | 0.000 | 0.000 | 0.002 | 0.003 | 0.009 |
| Ag Blend B960912 3-17-40 | 3 | 0 | 12 | 0.000 | 0.000 | 0.000 | 0.056 | 0.092 | 0.186 |
| | 17 | 0 | 12 | 0.000 | 0.000 | 0.000 | 0.007 | 0.014 | 0.020 |
| | 40 | 0 | 12 | 0.000 | 0.000 | 0.000 | 0.003 | 0.006 | 0.018 |
| Ag Blend B960913 8-41-12 | 8 | 0 | 14.8 | 0.000 | 0.000 | 0.000 | 0.026 | 0.043 | 0.086 |
| | 41 | 0 | 14.8 | 0.000 | 0.000 | 0.000 | 0.003 | 0.007 | 0.010 |
| | 12 | 0 | 14.8 | 0.000 | 0.000 | 0.000 | 0.014 | 0.024 | 0.074 |
| Ag Blend B961058 8-17-34 | 8 | 0 | 8.9 | 0.000 | 0.000 | 0.000 | 0.015 | 0.026 | 0.052 |
| | 17 | 0 | 8.9 | 0.000 | 0.000 | 0.000 | 0.005 | 0.010 | 0.015 |
| | 34 | 0 | 8.9 | 0.000 | 0.000 | 0.000 | 0.003 | 0.005 | 0.016 |
| Ag Blend B961321 9-43-10 | 9 | 0 | 13.3 | 0.000 | 0.000 | 0.000 | 0.021 | 0.034 | 0.069 |
| | 43 | 0 | 13.3 | 0.000 | 0.000 | 0.000 | 0.003 | 0.006 | 0.009 |
| | 10 | 0 | 13.3 | 0.000 | 0.000 | 0.000 | 0.015 | 0.026 | 0.080 |

## Table H-9. Yearly V and Cu Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content

| Source | %N<br>$\%P_2O_5$<br>$\%K_2O$ | V<br>mg/kg | Cu<br>mg/kg | Yearly V addition in kg/ha at | | | Yearly Cu addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N<br>84 $P_2O_5$<br>103 $K_2O$ | 206 N<br>173 $P_2O_5$<br>177 $K_2O$ | 414 N<br>252 $P_2O_5$<br>534 $K_2O$ | 124 N<br>84 $P_2O_5$<br>103 $K_2O$ | 206 N<br>173 $P_2O_5$<br>177 $K_2O$ | 414 N<br>252 $P_2O_5$<br>534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N<br>94 $P_2O_5$<br>115 $K_2O$ | 231 N<br>194 $P_2O_5$<br>198 $K_2O$ | 464 N<br>282 $P_2O_5$<br>598 $K_2O$ | 139 N<br>94 $P_2O_5$<br>115 $K_2O$ | 231 N<br>194 $P_2O_5$<br>198 $K_2O$ | 464 N<br>282 $P_2O_5$<br>598 $K_2O$ |
| Ag Blend B960243 19-19-19 | 19 | 85.2 | 25.6 | 0.062 | 0.104 | 0.208 | 0.019 | 0.031 | 0.063 |
| | 19 | 85.2 | 25.6 | 0.042 | 0.087 | 0.126 | 0.013 | 0.026 | 0.038 |
| | 19 | 85.2 | 25.6 | 0.052 | 0.089 | 0.268 | 0.015 | 0.027 | 0.081 |
| Ag Blend B960244 12-24-24 | 12 | 119 | 49.3 | 0.138 | 0.229 | 0.460 | 0.057 | 0.095 | 0.191 |
| | 24 | 119 | 49.3 | 0.047 | 0.096 | 0.140 | 0.019 | 0.040 | 0.058 |
| | 24 | 119 | 49.3 | 0.057 | 0.098 | 0.297 | 0.024 | 0.041 | 0.123 |
| Ag Blend B960249 7-35-12 | 7 | 116 | 45 | 0.230 | 0.383 | 0.769 | 0.089 | 0.149 | 0.298 |
| | 35 | 116 | 45 | 0.031 | 0.064 | 0.093 | 0.012 | 0.025 | 0.036 |
| | 12 | 116 | 45 | 0.111 | 0.191 | 0.578 | 0.043 | 0.074 | 0.224 |
| Ag Blend B960282 9-44-9 | 9 | 163 | 30.1 | 0.252 | 0.418 | 0.840 | 0.046 | 0.077 | 0.155 |
| | 44 | 163 | 30.1 | 0.035 | 0.072 | 0.104 | 0.006 | 0.013 | 0.019 |
| | 9 | 163 | 30.1 | 0.208 | 0.359 | 1.083 | 0.038 | 0.066 | 0.200 |
| Ag Blend B960325 10-21-15 | 10 | 87.7 | 10.2 | 0.122 | 0.203 | 0.407 | 0.014 | 0.024 | 0.047 |
| | 21 | 87.7 | 10.2 | 0.039 | 0.081 | 0.118 | 0.005 | 0.009 | 0.014 |
| | 15 | 87.7 | 10.2 | 0.067 | 0.116 | 0.350 | 0.008 | 0.013 | 0.041 |
| Ag Blend B960333 8-32-16 | 8 | 126 | 22.2 | 0.219 | 0.364 | 0.731 | 0.039 | 0.064 | 0.129 |
| | 32 | 126 | 22.2 | 0.037 | 0.076 | 0.111 | 0.007 | 0.013 | 0.020 |
| | 16 | 126 | 22.2 | 0.091 | 0.156 | 0.471 | 0.016 | 0.027 | 0.083 |
| Ag Blend B960389 19-19-19 | 19 | 77.7 | 0 | 0.057 | 0.094 | 0.190 | 0.000 | 0.000 | 0.000 |
| | 19 | 77.7 | 0 | 0.038 | 0.079 | 0.115 | 0.000 | 0.000 | 0.000 |
| | 19 | 77.7 | 0 | 0.047 | 0.081 | 0.245 | 0.000 | 0.000 | 0.000 |
| Ag Blend B960412 7-26-26 | 7 | 79.4 | 26.2 | 0.158 | 0.262 | 0.526 | 0.052 | 0.086 | 0.174 |
| | 26 | 79.4 | 26.2 | 0.029 | 0.059 | 0.086 | 0.009 | 0.020 | 0.028 |
| | 26 | 79.4 | 26.2 | 0.035 | 0.060 | 0.183 | 0.012 | 0.020 | 0.060 |
| Ag Blend B960418 19-19-19 | 19 | 97.8 | 13.7 | 0.072 | 0.119 | 0.239 | 0.010 | 0.017 | 0.033 |
| | 19 | 97.8 | 13.7 | 0.048 | 0.100 | 0.145 | 0.007 | 0.014 | 0.020 |
| | 19 | 97.8 | 13.7 | 0.059 | 0.102 | 0.308 | 0.008 | 0.014 | 0.043 |
| Ag Blend B960441 9-34-10 | 9 | 121 | 16.3 | 0.187 | 0.311 | 0.624 | 0.025 | 0.042 | 0.084 |
| | 34 | 121 | 16.3 | 0.033 | 0.069 | 0.100 | 0.005 | 0.009 | 0.014 |
| | 10 | 121 | 16.3 | 0.139 | 0.240 | 0.724 | 0.019 | 0.032 | 0.097 |
| Ag Blend B960442 9-3-10 | 9 | 159 | 6.6 | 0.246 | 0.408 | 0.820 | 0.010 | 0.017 | 0.034 |
| | 3 | 159 | 6.6 | 0.498 | 1.028 | 1.495 | 0.021 | 0.043 | 0.062 |
| | 10 | 159 | 6.6 | 0.183 | 0.315 | 0.951 | 0.008 | 0.013 | 0.039 |
| Ag Blend B960453 10-20-20 | 10 | 67.1 | 16.4 | 0.093 | 0.155 | 0.311 | 0.023 | 0.038 | 0.076 |
| | 20 | 67.1 | 16.4 | 0.032 | 0.065 | 0.095 | 0.008 | 0.016 | 0.023 |
| | 20 | 67.1 | 16.4 | 0.039 | 0.066 | 0.201 | 0.009 | 0.016 | 0.049 |

## Table H-9. Continued

| Source | %N %$P_2O_5$ %$K_2O$ | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at | | | Yearly Cu addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ |
| Ag Blend B960475 9-40-5 | 9 | 130 | 90.5 | 0.201 | 0.334 | 0.670 | 0.140 | 0.232 | 0.467 |
| | 40 | 130 | 90.5 | 0.031 | 0.063 | 0.092 | 0.021 | 0.044 | 0.064 |
| | 5 | 130 | 90.5 | 0.299 | 0.515 | 1.555 | 0.208 | 0.358 | 1.082 |
| Ag Blend B960510 9-43-10 | 9 | 136 | 7.1 | 0.210 | 0.349 | 0.701 | 0.011 | 0.018 | 0.037 |
| | 43 | 136 | 7.1 | 0.030 | 0.061 | 0.089 | 0.002 | 0.003 | 0.005 |
| | 10 | 136 | 7.1 | 0.156 | 0.269 | 0.813 | 0.008 | 0.014 | 0.042 |
| Ag Blend B960580 10-10-10 | 10 | 68.8 | 13.6 | 0.096 | 0.159 | 0.319 | 0.019 | 0.031 | 0.063 |
| | 10 | 68.8 | 13.6 | 0.065 | 0.133 | 0.194 | 0.013 | 0.026 | 0.038 |
| | 10 | 68.8 | 13.6 | 0.079 | 0.136 | 0.411 | 0.016 | 0.027 | 0.081 |
| Ag Blend B960584 10-20-20 | 10 | 83.4 | 10.6 | 0.116 | 0.193 | 0.387 | 0.015 | 0.024 | 0.049 |
| | 20 | 83.4 | 10.6 | 0.039 | 0.081 | 0.118 | 0.005 | 0.010 | 0.015 |
| | 20 | 83.4 | 10.6 | 0.048 | 0.083 | 0.249 | 0.006 | 0.010 | 0.032 |
| Ag Blend B960599 15-15-15 | 15 | 73.2 | 7.2 | 0.068 | 0.113 | 0.226 | 0.007 | 0.011 | 0.022 |
| | 15 | 73.2 | 7.2 | 0.046 | 0.095 | 0.138 | 0.005 | 0.009 | 0.014 |
| | 15 | 73.2 | 7.2 | 0.056 | 0.097 | 0.292 | 0.006 | 0.010 | 0.029 |
| Ag Blend B960611 19-19-19 | 19 | 47.2 | 3.9 | 0.035 | 0.057 | 0.115 | 0.003 | 0.005 | 0.010 |
| | 19 | 47.2 | 3.9 | 0.023 | 0.048 | 0.070 | 0.002 | 0.004 | 0.006 |
| | 19 | 47.2 | 3.9 | 0.029 | 0.049 | 0.149 | 0.002 | 0.004 | 0.012 |
| Ag Blend B960639 6-2-0 | 6 | 18.6 | 24.3 | 0.043 | 0.072 | 0.144 | 0.056 | 0.094 | 0.188 |
| | 2 | 18.6 | 24.3 | 0.087 | 0.180 | 0.262 | 0.114 | 0.236 | 0.343 |
| | 0 | 18.6 | 24.3 | ERR | ERR | ERR | ERR | ERR | ERR |
| Ag Blend B960708 7-27-11 | 7 | 99.2 | 544 | 0.197 | 0.327 | 0.658 | 1.080 | 1.795 | 3.606 |
| | 27 | 99.2 | 544 | 0.035 | 0.071 | 0.104 | 0.189 | 0.391 | 0.568 |
| | 11 | 99.2 | 544 | 0.104 | 0.179 | 0.539 | 0.569 | 0.979 | 2.957 |
| Ag ammoniated B960711 8-24-8 | 8 | 47.3 | 13.6 | 0.082 | 0.137 | 0.274 | 0.024 | 0.039 | 0.079 |
| | 24 | 47.3 | 13.6 | 0.019 | 0.038 | 0.056 | 0.005 | 0.011 | 0.016 |
| | 8 | 47.3 | 13.6 | 0.068 | 0.117 | 0.354 | 0.020 | 0.034 | 0.102 |
| Ag Blend B960713 10-20-10 | 10 | 68.9 | 32 | 0.096 | 0.159 | 0.320 | 0.044 | 0.074 | 0.148 |
| | 20 | 68.9 | 32 | 0.032 | 0.067 | 0.097 | 0.015 | 0.031 | 0.045 |
| | 10 | 68.9 | 32 | 0.079 | 0.136 | 0.412 | 0.037 | 0.063 | 0.191 |
| Ag Blend B960715 15-15-15 | 15 | 49.2 | 3.9 | 0.046 | 0.076 | 0.152 | 0.004 | 0.006 | 0.012 |
| | 15 | 49.2 | 3.9 | 0.031 | 0.064 | 0.092 | 0.002 | 0.005 | 0.007 |
| | 15 | 49.2 | 3.9 | 0.038 | 0.065 | 0.196 | 0.003 | 0.005 | 0.016 |
| Ag Blend B980726 19-19-19 | 19 | 85.1 | 7.9 | 0.062 | 0.103 | 0.208 | 0.006 | 0.010 | 0.019 |
| | 19 | 85.1 | 7.9 | 0.042 | 0.087 | 0.126 | 0.004 | 0.008 | 0.012 |
| | 19 | 85.1 | 7.9 | 0.052 | 0.089 | 0.268 | 0.005 | 0.008 | 0.025 |
| AG Blend B960820 26-9-9 | 26 | 61.6 | 14.4 | 0.033 | 0.055 | 0.110 | 0.008 | 0.013 | 0.026 |
| | 9 | 61.6 | 14.4 | 0.064 | 0.133 | 0.193 | 0.015 | 0.031 | 0.045 |
| | 9 | 61.6 | 14.4 | 0.079 | 0.136 | 0.409 | 0.018 | 0.032 | 0.096 |

# Table H-9. Continued

| Source | %N %$P_2O_5$ %$K_2O$ | V mg/kg | Cu mg/kg | Yearly V addition in kg/ha at | | | Yearly Cu addition in kg/ha at | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | lb/A | | | lb/A | | |
| | | | | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ | 124 N 84 $P_2O_5$ 103 $K_2O$ | 206 N 173 $P_2O_5$ 177 $K_2O$ | 414 N 252 $P_2O_5$ 534 $K_2O$ |
| | | | | kg/ha | | | kg/ha | | |
| | | | | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ | 139 N 94 $P_2O_5$ 115 $K_2O$ | 231 N 194 $P_2O_5$ 198 $K_2O$ | 464 N 282 $P_2O_5$ 598 $K_2O$ |
| Ag Blend B960896 10-20-20 | 10 | 64.5 | 25.5 | 0.090 | 0.149 | 0.299 | 0.035 | 0.059 | 0.118 |
| | 20 | 64.5 | 25.5 | 0.030 | 0.063 | 0.091 | 0.012 | 0.025 | 0.036 |
| | 20 | 64.5 | 25.5 | 0.037 | 0.064 | 0.193 | 0.015 | 0.025 | 0.076 |
| Ag Blend B960900 10-20-20 | 10 | 70.3 | 12.9 | 0.098 | 0.162 | 0.326 | 0.018 | 0.030 | 0.060 |
| | 20 | 70.3 | 12.9 | 0.033 | 0.068 | 0.099 | 0.006 | 0.013 | 0.018 |
| | 20 | 70.3 | 12.9 | 0.040 | 0.070 | 0.210 | 0.007 | 0.013 | 0.039 |
| Ag Blend B960909 3-17-40 | 3 | 64.2 | 4.9 | 0.297 | 0.494 | 0.993 | 0.023 | 0.038 | 0.076 |
| | 17 | 64.2 | 4.9 | 0.035 | 0.073 | 0.106 | 0.003 | 0.006 | 0.008 |
| | 40 | 64.2 | 4.9 | 0.018 | 0.032 | 0.096 | 0.001 | 0.002 | 0.007 |
| Ag Blend B960912 3-17-40 | 3 | 138 | 7.8 | 0.639 | 1.063 | 2.134 | 0.036 | 0.060 | 0.121 |
| | 17 | 138 | 7.8 | 0.076 | 0.157 | 0.229 | 0.004 | 0.009 | 0.013 |
| | 40 | 138 | 7.8 | 0.040 | 0.068 | 0.206 | 0.002 | 0.004 | 0.012 |
| Ag Blend B960913 8-41-12 | 8 | 18.4 | 454 | 0.032 | 0.053 | 0.107 | 0.789 | 1.311 | 2.633 |
| | 41 | 18.4 | 454 | 0.004 | 0.009 | 0.013 | 0.104 | 0.215 | 0.312 |
| | 12 | 18.4 | 454 | 0.018 | 0.030 | 0.092 | 0.435 | 0.749 | 2.262 |
| Ag Blend B961058 8-17-34 | 8 | 27.8 | 5 | 0.048 | 0.080 | 0.161 | 0.009 | 0.014 | 0.029 |
| | 17 | 27.8 | 5 | 0.015 | 0.032 | 0.046 | 0.003 | 0.006 | 0.008 |
| | 34 | 27.8 | 5 | 0.009 | 0.016 | 0.049 | 0.002 | 0.003 | 0.009 |
| Ag Blend B961321 9-43-10 | 9 | 152 | 60.1 | 0.235 | 0.390 | 0.784 | 0.093 | 0.154 | 0.310 |
| | 43 | 152 | 60.1 | 0.033 | 0.069 | 0.100 | 0.013 | 0.027 | 0.039 |
| | 10 | 152 | 60.1 | 0.175 | 0.301 | 0.909 | 0.069 | 0.119 | 0.359 |

## Table H-10. Yearly Zn Additions to Soil (kg/ha) from NPK Fertilizers, Fertilizers Applied for N, P, or K Content

| Source | %N<br>%$P_2O_5$<br>%$K_2O$ | Zn<br>mg/kg | Yearly Zn addition in kg/ha at | | |
|---|---|---|---|---|---|
| | | | lb/A | | |
| | | | 124 N<br>84 $P_2O_5$<br>103 $K_2O$ | 206 N<br>173 $P_2O_5$<br>177 $K_2O$ | 414 N<br>252 $P_2O_5$<br>534 $K_2O$ |
| | | | kg/ha | | |
| | | | 139 N<br>94 $P_2O_5$<br>115 $K_2O$ | 231 N<br>194 $P_2O_5$<br>198 $K_2O$ | 464 N<br>282 $P_2O_5$<br>598 $K_2O$ |
| Ag Blend B960243<br>19-19-19 | 19 | 19 | 0.026 | 0.044 | 0.088 |
| | 19 | 36 | 0.018 | 0.037 | 0.053 |
| | 19 | 36 | 0.022 | 0.038 | 0.113 |
| Ag Blend B960244<br>12-24-24 | 12 | 44.5 | 0.052 | 0.086 | 0.172 |
| | 24 | 44.5 | 0.017 | 0.036 | 0.052 |
| | 24 | 44.5 | 0.021 | 0.037 | 0.111 |
| Ag Blend B960249<br>7-35-12 | 7 | 55.1 | 0.109 | 0.182 | 0.365 |
| | 35 | 55.1 | 0.015 | 0.031 | 0.044 |
| | 12 | 55.1 | 0.053 | 0.091 | 0.275 |
| Ag Blend B960282<br>9-44-9 | 9 | 49.8 | 0.077 | 0.128 | 0.257 |
| | 44 | 49.8 | 0.011 | 0.022 | 0.032 |
| | 9 | 49.8 | 0.064 | 0.110 | 0.331 |
| Ag Blend B960325<br>10-21-15 | 10 | 872 | 1.212 | 2.014 | 4.046 |
| | 21 | 872 | 0.390 | 0.806 | 1.171 |
| | 15 | 872 | 0.669 | 1.151 | 3.476 |
| Ag Blend B960333<br>8-32-16 | 8 | 43.9 | 0.076 | 0.127 | 0.255 |
| | 32 | 43.9 | 0.013 | 0.027 | 0.039 |
| | 16 | 43.9 | 0.032 | 0.054 | 0.164 |
| Ag Blend B960389<br>19-19-19 | 19 | 0 | 0.000 | 0.000 | 0.000 |
| | 19 | 0 | 0.000 | 0.000 | 0.000 |
| | 19 | 0 | 0.000 | 0.000 | 0.000 |
| Ag Blend B960412<br>7-26-26 | 7 | 37 | 0.073 | 0.122 | 0.245 |
| | 26 | 37 | 0.013 | 0.028 | 0.040 |
| | 26 | 37 | 0.016 | 0.028 | 0.085 |
| Ag Blend B960418<br>19-19-19 | 19 | 33.1 | 0.024 | 0.040 | 0.081 |
| | 19 | 33.1 | 0.016 | 0.034 | 0.049 |
| | 19 | 33.1 | 0.020 | 0.034 | 0.104 |
| Ag Blend B960441<br>9-34-10 | 9 | 34.6 | 0.053 | 0.089 | 0.178 |
| | 34 | 34.6 | 0.010 | 0.020 | 0.029 |
| | 10 | 34.6 | 0.040 | 0.069 | 0.207 |
| Ag Blend B960442<br>9-3-10 | 9 | 53.1 | 0.082 | 0.136 | 0.274 |
| | 3 | 53.1 | 0.166 | 0.343 | 0.499 |
| | 10 | 53.1 | 0.061 | 0.105 | 0.318 |
| Ag Blend B960453<br>10-20-20 | 10 | 60.9 | 0.085 | 0.141 | 0.283 |
| | 20 | 60.9 | 0.029 | 0.059 | 0.086 |
| | 20 | 60.9 | 0.035 | 0.060 | 0.182 |

## Table H-10. Continued

| Source | %N<br>$\%P_2O_5$<br>$\%K_2O$ | Zn<br>mg/kg | Yearly Zn addition in kg/ha at | | |
|---|---|---|---|---|---|
| | | | lb/A | | |
| | | | 124 N<br>84 $P_2O_5$<br>103 $K_2O$ | 206 N<br>173 $P_2O_5$<br>177 $K_2O$ | 414 N<br>252 $P_2O_5$<br>534 $K_2O$ |
| | | | kg/ha | | |
| | | | 139 N<br>94 $P_2O_5$<br>115 $K_2O$ | 231 N<br>194 $P_2O_5$<br>198 $K_2O$ | 464 N<br>282 $P_2O_5$<br>598 $K_2O$ |
| Ag Blend B960475<br>9-40-5 | 9 | 4442 | 6.860 | 11.401 | 22.901 |
| | 40 | 4442 | 1.044 | 2.154 | 3.132 |
| | 5 | 4442 | 10.217 | 17.590 | 53.126 |
| Ag Blend B960510<br>9-43-10 | 9 | 66.2 | 0.102 | 0.170 | 0.341 |
| | 43 | 66.2 | 0.014 | 0.030 | 0.043 |
| | 10 | 66.2 | 0.076 | 0.131 | 0.396 |
| Ag Blend B960580<br>10-10-10 | 10 | 803 | 1.116 | 1.855 | 3.726 |
| | 10 | 803 | 0.755 | 1.558 | 2.264 |
| | 10 | 803 | 0.923 | 1.590 | 4.802 |
| Ag Blend B960584<br>10-20-20 | 10 | 0.48 | 0.001 | 0.001 | 0.002 |
| | 20 | 0.48 | 0.000 | 0.000 | 0.001 |
| | 20 | 0.48 | 0.000 | 0.000 | 0.001 |
| Ag Blend B960599<br>15-15-15 | 15 | 0.55 | 0.001 | 0.001 | 0.002 |
| | 15 | 0.55 | 0.000 | 0.001 | 0.001 |
| | 15 | 0.55 | 0.000 | 0.001 | 0.002 |
| Ag Blend B960611<br>19-19-19 | 19 | 6.93 | 0.005 | 0.008 | 0.017 |
| | 19 | 6.93 | 0.003 | 0.007 | 0.010 |
| | 19 | 6.93 | 0.004 | 0.007 | 0.022 |
| Ag Blend B960639<br>6-2-0 | 6 | 1.1 | 0.003 | 0.004 | 0.009 |
| | 2 | 1.1 | 0.005 | 0.011 | 0.016 |
| | 0 | 1.1 | ERR | ERR | ERR |
| Ag Blend B960708<br>7-27-11 | 7 | 57.8 | 0.115 | 0.191 | 0.383 |
| | 27 | 57.8 | 0.020 | 0.042 | 0.060 |
| | 11 | 57.8 | 0.060 | 0.104 | 0.314 |
| Ag ammoniated B960711<br>8-24-8 | 8 | 177 | 0.308 | 0.511 | 1.027 |
| | 24 | 177 | 0.069 | 0.143 | 0.208 |
| | 8 | 177 | 0.254 | 0.438 | 1.323 |
| Ag Blend B960713<br>10-20-10 | 10 | 84.5 | 0.117 | 0.195 | 0.392 |
| | 20 | 84.5 | 0.040 | 0.082 | 0.119 |
| | 10 | 84.5 | 0.097 | 0.167 | 0.505 |
| Ag Blend B960715<br>15-15-15 | 15 | 0.3 | 0.000 | 0.000 | 0.001 |
| | 15 | 0.3 | 0.000 | 0.000 | 0.001 |
| | 15 | 0.3 | 0.000 | 0.000 | 0.001 |
| Ag Blend B980726<br>19-19-19 | 19 | 74.5 | 0.055 | 0.091 | 0.182 |
| | 19 | 74.5 | 0.037 | 0.076 | 0.111 |
| | 19 | 74.5 | 0.045 | 0.078 | 0.234 |
| AG Blend B960820<br>26-9-9 | 26 | 45.7 | 0.024 | 0.041 | 0.082 |
| | 9 | 45.7 | 0.048 | 0.099 | 0.143 |
| | 9 | 45.7 | 0.058 | 0.101 | 0.304 |

## Table H-10. Continued

| Source | %N<br>$\%P_2O_5$<br>$\%K_2O$ | Zn mg/kg | Yearly Zn addition in kg/ha at | | |
|---|---|---|---|---|---|
| | | | lb/A | | |
| | | | 124 N<br>84 $P_2O_5$<br>103 $K_2O$ | 206 N<br>173 $P_2O_5$<br>177 $K_2O$ | 414 N<br>252 $P_2O_5$<br>534 $K_2O$ |
| | | | kg/ha | | |
| | | | 139 N<br>94 $P_2O_5$<br>115 $K_2O$ | 231 N<br>194 $P_2O_5$<br>198 $K_2O$ | 464 N<br>282 $P_2O_5$<br>598 $K_2O$ |
| Ag Blend B960896<br>10-20-20 | 10 | 23.6 | 0.033 | 0.055 | 0.110 |
| | 20 | 23.6 | 0.011 | 0.023 | 0.033 |
| | 20 | 23.6 | 0.014 | 0.023 | 0.071 |
| Ag Blend B960900<br>10-20-20 | 10 | 25.5 | 0.035 | 0.059 | 0.118 |
| | 20 | 25.5 | 0.012 | 0.025 | 0.036 |
| | 20 | 25.5 | 0.015 | 0.025 | 0.076 |
| Ag Blend B960909<br>3-17-40 | 3 | 39.5 | 0.183 | 0.304 | 0.611 |
| | 17 | 39.5 | 0.022 | 0.045 | 0.066 |
| | 40 | 39.5 | 0.011 | 0.020 | 0.059 |
| Ag Blend B960912<br>3-17-40 | 3 | 52.2 | 0.242 | 0.402 | 0.807 |
| | 17 | 52.2 | 0.029 | 0.060 | 0.087 |
| | 40 | 52.2 | 0.015 | 0.026 | 0.078 |
| Ag Blend B960913<br>8-41-12 | 8 | 484 | 0.841 | 1.398 | 2.807 |
| | 41 | 484 | 0.111 | 0.229 | 0.333 |
| | 12 | 484 | 0.464 | 0.799 | 2.412 |
| Ag Blend B961058<br>8-17-34 | 8 | 18.3 | 0.032 | 0.053 | 0.106 |
| | 17 | 18.3 | 0.010 | 0.021 | 0.030 |
| | 34 | 18.3 | 0.006 | 0.011 | 0.032 |
| Ag Blend B961321<br>9-43-10 | 9 | 44.8 | 0.069 | 0.115 | 0.231 |
| | 43 | 44.8 | 0.010 | 0.020 | 0.029 |
| | 10 | 44.8 | 0.052 | 0.089 | 0.268 |

**Table H-11. Summary Statistics for Application of NPK Blends for either N, P, or K Content**

| | | | | Yearly Metal Addition to Soil, kg/ha | | |
|---|---|---|---|---|---|---|
| **Metal** | **Application Rate** | **Nutrient Applied[a]** | **No. of Samples** | **Mean** | **Median** | **Range** |
| Cd | Average | N | 32 | 0.007 | 0.005 | ( 0.001 , 0.022 ) |
| | | P | 32 | 0.003 | 0.001 | ( 0.000 , 0.027 ) |
| | | K | 31 | 0.004 | 0.002 | ( 0.000 , 0.033 ) |
| | High | N | 32 | 0.011 | 0.008 | ( 0.002 , 0.037 ) |
| | | P | 32 | 0.006 | 0.003 | ( 0.001 , 0.055 ) |
| | | K | 31 | 0.007 | 0.004 | ( 0.001 , 0.057 ) |
| | Maximum | N | 32 | 0.022 | 0.016 | ( 0.004 , 0.074 ) |
| | | P | 32 | 0.009 | 0.004 | ( 0.001 , 0.080 ) |
| | | K | 31 | 0.022 | 0.011 | ( 0.002 , 0.171 ) |
| Pb | Average | N | 32 | 0.037 | 0.005 | ( 0.001 , 0.652 ) |
| | | P | 32 | 0.008 | 0.002 | ( 0.000 , 0.099 ) |
| | | K | 31 | 0.040 | 0.002 | ( 0.001 , 0.971 ) |
| | High | N | 32 | 0.061 | 0.009 | ( 0.001 , 1.083 ) |
| | | P | 32 | 0.016 | 0.003 | ( 0.001 , 0.205 ) |
| | | K | 31 | 0.069 | 0.004 | ( 0.001 , 1.671 ) |
| | Maximum | N | 32 | 0.123 | 0.017 | ( 0.003 , 2.176 ) |
| | | P | 32 | 0.023 | 0.005 | ( 0.001 , 0.298 ) |
| | | K | 31 | 0.209 | 0.012 | ( 0.003 , 5.047 ) |
| As | Average | N | 32 | 0.012 | 0.010 | ( 0.000 , 0.049 ) |
| | | P | 32 | 0.004 | 0.003 | ( 0.000 , 0.029 ) |
| | | K | 31 | 0.006 | 0.005 | ( 0.000 , 0.023 ) |
| | High | N | 32 | 0.019 | 0.017 | ( 0.000 , 0.081 ) |
| | | P | 32 | 0.009 | 0.006 | ( 0.000 , 0.059 ) |
| | | K | 31 | 0.011 | 0.008 | ( 0.000 , 0.040 ) |
| | Maximum | N | 32 | 0.039 | 0.034 | ( 0.000 , 0.162 ) |
| | | P | 32 | 0.013 | 0.009 | ( 0.000 , 0.086 ) |
| | | K | 31 | 0.033 | 0.025 | ( 0.000 , 0.120 ) |

**Table H-11. Continued**

| | | | | Yearly Metal Addition to Soil, kg/ha | | |
|---|---|---|---|---|---|---|
| Metal | Application Rate | Nutrient Applied[a] | No. of Samples | Mean | Median | Range |
| Cr | Average | N | 32 | 0.101 | 0.099 | ( 0.018 , 0.312 ) |
| | | P | 32 | 0.041 | 0.023 | ( 0.015 , 0.278 ) |
| | | K | 31 | 0.059 | 0.044 | ( 0.010 , 0.248 ) |
| | High | N | 32 | 0.168 | 0.165 | ( 0.030 , 0.519 ) |
| | | P | 32 | 0.084 | 0.047 | ( 0.031 , 0.574 ) |
| | | K | 31 | 0.101 | 0.075 | ( 0.017 , 0.427 ) |
| | Maximum | N | 32 | 0.337 | 0.331 | ( 0.061 , 1.042 ) |
| | | P | 32 | 0.122 | 0.068 | ( 0.046 , 0.835 ) |
| | | K | 31 | 0.304 | 0.227 | ( 0.051 , 1.290 ) |
| Hg | Average | N | 32 | 0.000 | 0.000 | ( 0.000 , 0.000 ) |
| | | P | 32 | 0.000 | 0.000 | ( 0.000 , 0.000 ) |
| | | K | 31 | 0.000 | 0.000 | ( 0.000 , 0.000 ) |
| | High | N | 32 | 0.000 | 0.000 | ( 0.000 , 0.000 ) |
| | | P | 32 | 0.000 | 0.000 | ( 0.000 , 0.000 ) |
| | | K | 31 | 0.000 | 0.000 | ( 0.000 , 0.000 ) |
| | Maximum | N | 32 | 0.000 | 0.000 | ( 0.000 , 0.001 ) |
| | | P | 32 | 0.000 | 0.000 | ( 0.000 , 0.000 ) |
| | | K | 31 | 0.000 | 0.000 | ( 0.000 , 0.001 ) |
| Ni | Average | N | 32 | 0.024 | 0.021 | ( 0.000 , 0.119 ) |
| | | P | 32 | 0.010 | 0.006 | ( 0.000 , 0.053 ) |
| | | K | 31 | 0.014 | 0.010 | ( 0.000 , 0.067 ) |
| | High | N | 32 | 0.041 | 0.035 | ( 0.000 , 0.198 ) |
| | | P | 32 | 0.020 | 0.012 | ( 0.000 , 0.109 ) |
| | | K | 31 | 0.024 | 0.018 | ( 0.000 , 0.116 ) |
| | Maximum | N | 32 | 0.081 | 0.071 | ( 0.000 , 0.398 ) |
| | | P | 32 | 0.029 | 0.017 | ( 0.000 , 0.158 ) |
| | | K | 31 | 0.073 | 0.054 | ( 0.000 , 0.349 ) |

## Table H-11. Continued

| | | | | Yearly Metal Addition to Soil, kg/ha | | |
|---|---|---|---|---|---|---|
| Metal | Application Rate | Nutrient Applied[a] | No. of Samples | Mean | Median | Range |
| V | Average | N | 32 | 0.142 | 0.097 | ( 0.032 , 0.639 ) |
| | | P | 32 | 0.053 | 0.035 | ( 0.004 , 0.498 ) |
| | | K | 31 | 0.081 | 0.057 | ( 0.009 , 0.299 ) |
| | High | N | 32 | 0.237 | 0.161 | ( 0.053 , 1.063 ) |
| | | P | 32 | 0.108 | 0.072 | ( 0.009 , 1.028 ) |
| | | K | 31 | 0.139 | 0.098 | ( 0.016 , 0.515 ) |
| | Maximum | N | 32 | 0.475 | 0.323 | ( 0.107 , 2.134 ) |
| | | P | 32 | 0.158 | 0.104 | ( 0.013 , 1.495 ) |
| | | K | 31 | 0.421 | 0.297 | ( 0.049 , 1.555 ) |
| Cu | Average | N | 32 | 0.088 | 0.023 | ( 0.000 , 1.080 ) |
| | | P | 32 | 0.020 | 0.007 | ( 0.000 , 0.189 ) |
| | | K | 31 | 0.053 | 0.012 | ( 0.000 , 0.569 ) |
| | High | N | 32 | 0.146 | 0.038 | ( 0.000 , 1.795 ) |
| | | P | 32 | 0.042 | 0.014 | ( 0.000 , 0.391 ) |
| | | K | 31 | 0.090 | 0.020 | ( 0.000 , 0.979 ) |
| | Maximum | N | 32 | 0.292 | 0.076 | ( 0.000 , 3.606 ) |
| | | P | 32 | 0.061 | 0.020 | ( 0.000 , 0.568 ) |
| | | K | 31 | 0.273 | 0.060 | ( 0.000 , 2.957 ) |
| Zn | Average | N | 32 | 0.375 | 0.071 | ( 0.000 , 6.860 ) |
| | | P | 32 | 0.092 | 0.016 | ( 0.000 , 1.044 ) |
| | | K | 31 | 0.430 | 0.035 | ( 0.000 , 10.217 ) |
| | High | N | 32 | 0.624 | 0.119 | ( 0.000 , 11.401 ) |
| | | P | 32 | 0.190 | 0.032 | ( 0.000 , 2.154 ) |
| | | K | 31 | 0.741 | 0.060 | ( 0.000 , 17.590 ) |
| | Maximum | N | 32 | 1.253 | 0.238 | ( 0.000 , 22.901 ) |
| | | P | 32 | 0.276 | 0.047 | ( 0.000 , 3.132 ) |
| | | K | 31 | 2.238 | 0.182 | ( 0.000 , 53.126 ) |

a) Application rates for N, P, and K, see Table 5-1.