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THE NITROGEN STORY (FROM ACCLAMATION TO CONDEMNATION)

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Introduction

Nitrogen is one of the most common and dynamic elements found on earth. It makes up about 78 percent of the air by volume (over 35,000 tons per acre); yet, it is usually considered the single most limiting element in plant and animal nutrition.

Nitrogen and Life

Nitrogen is absolutely essential for life and all organisms must have it to live. It makes up an important part of protein molecules, which are found in protoplasm. Protoplasm is the living material in all plant and animal tissues. However, it was not until the eighteenth century that nitrogen was known to be an essential nutrient element for plant production.

Discovery of Nitrogen

Although nitrogen and nitrogen containing compounds are so vitally important to human existence and sustainability of life on earth, it was not even known to exist until 1772. A Scottish scientist named Rutherford is credited with finding it, but he did not know what he had found. He had discovered that a major portion of air would not dissolve in water and that this portion would extinguish a flame, instead of promoting burning, as did regular air. He called it azote, which meant "no life". It was named nitrogen in 1823 by a scientist named J. A. C. Chapal. He derived the name from the Greek word nitron, which means saltpeter (KNO_3), since it was known to contain nitrogen.

Common Properties and Uses of Nitrogen

All the properties and uses of nitrogen are far too numerous to mention here, but some of the more relevant properties and uses will be reviewed.

Inertness

Pure nitrogen is only very slightly soluble in water and is relatively inert; that is, it does not readily combine with other substances. Many substances would burn violently in our atmosphere if not for the high percent nitrogen. Because of its inertness nitrogen has been used in both gaseous and liquid forms in contact with many other substances. It was the first gas used in filament light bulbs, at atmospheric pressure, to prevent the filaments from burning out. Liquid nitrogen is commonly used as a special coolant because of its availability and inert properties.

Explosives

Although nitrogen is an inactive element and there is difficulty in making it combine with other elements, many nitrogen compounds, once created, are rich in stored energy and very reactive. Practically all nitrogen compounds are unstable and readily form nitrogen gas when they decompose. The ones that tend to decompose rapidly are explosive, and most explosives are nitrogen compounds. A few examples of common explosives are gun powder, trinitro-toluene (TNT), hydrazine, nitroglycerin, ammonium nitrate, and nitrocellulose (gun cotton).

New technologies to prevent terrorist explosives from getting on airlines may benefit agriculture, because they are designed to detect concentrations of nitrogen with no damage to surrounding materials.

Interesting note. Alfred Bernhard Nobel (1833-1896), a famous scientist of Sweden is well known today for founding the Nobel prizes in literature, medicine, peace, physics and chemistry. But, he really became famous for his invention of something else. He found that nitroglycerin, a very shock-sensitive explosive, could be soaked into sawdust and molded into a stick, thus, an explosive satisfactory for farm and roadwork. The invention of dynamite was the source of Nobel's great fortune and fame.

Drugs

Many nitrogen containing chemicals have strong physiological effects on living organisms, and others have pharmacological or medicinal effects on animals. For this reason, many naturally occurring compounds in plants, alkaloids for example, may be strong poisons or drugs. Some common examples include morphine, cocaine, caffeine, and nicotine. Plants that produce high concentrations of these compounds are generally very efficient producers of protein compounds.

Plastics

When a chemical laboratory experiment resulted in a sticky gummy mess, it once meant some experiment had failed. This is not true anymore. Today we are living in a rapidly changing world of polymerization chemistry and plastics.

Nitrocellulose, smokeless gunpowder, was the first real plastic. Put cotton in a mixture of nitric acid and sulfuric acid(to remove water) and you get nitrocellulose. Highly nitrated cellulose is

an explosive, but cellulose at less highly nitrated levels produces lacquers and plastics (celluloid). Alexander Parkes first made nitrocellulose in England in 1855. John Hyatt developed celluloid in the U. S. in 1968. The first motion picture films were made of cellulose nitrate and many films and studios burned before cellulose nitrate was replaced by less flammable cellulose acetate.

Nitrogen containing proteins were used later to produce some plastics. Although these are not common today, there has been renewed interest in research of these plastics in recent years.

Fertilizers

Of course all of us are familiar with the large variety of nitrogen compounds used as sources of nitrogen fertilizer. Although one of the major break throughs in agriculture deals with the advent and use of nitrogen fertilizers, the use of nitrogen fertilizers is being criticized as never before. This will be discussed in more detail in following sections.

Development of Agriculture

Food has and always will be a basic necessity for human beings. Food procurement through hunting and gathering was essential until people learned to cultivate the soil. All sorts of agricultural systems have existed and still exists throughout the world today. The capability of these systems to sustain themselves depends to a large degree on the maintenance of soil productivity. Nitrogen inputs play an important role in this picture.

Good soil fertility is one of those things that a lot of people generally take for granted and think that it will take care of itself. Most people don't realize the importance that nitrogen plays in maintaining good soil fertility. A source of readily available nitrogen is absolutely essential for a sustainable intensive agriculture system. Without intensive agriculture much larger volumes of land would be needed to produce enough food to feed even today's world population.

Early Civilizations

Civilization as we know it began when people learned to cultivate the soil for plant production as previously mentioned. Archeological finds tell us this was about 9,000 to 13,000 years ago in Mesopotamia (now Iraq) along the Tigris and Euphrates rivers. This area was called the "fertile crescent" because of its shape. A sustainable agriculture system was maintained in this area for thousands of years because frequent flooding of these river bottom soils replenished the nutrients removed by crop plants. Since these early civilizations were so dependent on agriculture, as we are today, when agriculture failed, for whatever reason, the civilizations perished.

The middle east has been called a "graveyard of empires" by some scientists because so many civilizations flourished for periods and then completely disappeared. One theory is that these people knew so little about maintaining soil fertility and erosion prevention that they allowed their soil resources to be degraded and depleted to such low nutrient levels that they could no longer support adequate plant production. Even the great city of Babylon failed when its population grew and grew and moved out onto the hilly more erosion prone and less productive soils. Erosion from

these upland soils covered the more productive river bottom soils and eventually destroyed their natural productivity. More wars of this time were fought over food than anything else.

History of Nitrogen Fertilization

How or when nitrogen fertilization actually began is not known, but much of the credit is given to the Greeks because they were known to use manuring at least 900 B.C. It is believed that their observance that certain soils failed to produce satisfactory yields when cropped continuously, led to the addition of animal and plant wastes. Other scholars believe that fertilization was discovered by pure accident, perhaps an animal dying and being left or buried in a field. Regardless of how fertilization was discovered, the age of the Greeks from 800 to 200 B.C. was indeed a Golden Age in agriculture. Their writings, their culture and their agriculture was copied by the Romans, and the philosophy of the Greeks of this period dominated human thinking for more than 2000 years.

Theophrastus (372-287 B.C.) in his writings recommended the abundant manuring of thin soils and suggested that rich soils be manured sparingly. He also endorsed the practice still considered good today--the use of bedding in the stall. He pointed out that this would conserve the urine and bulk and that the humus value of the manure would be increased. Manures were classified according to their richness and it is believed that both manure and sewage from the city of Athens was sold to local farmers as fertilizer for their gardens, vineyards and olive groves around the city.

Manures were the first source of nitrogen used in agriculture, but mineral fertilizers or other soil amendments were not entirely unknown to the Greeks. They realized the value of plant ashes, dug up marl which they applied to some land, and even mixed fertile soil with infertile soil to improve productivity.

The Romans copied the Greeks in almost everything, and after the decline of the Roman empire, there were few major contributions in the development of agriculture for the next 15 centuries.

Modern Developments

The middle of the nineteenth to the beginning of the twentieth century was a time during which much progress was made in the understanding of plant nutrition and crop fertilization. Many persons from several countries, far too numerous to mention here, made major contributions to agricultural science during this time. Much progress has also been made since this time, especially in the United States. Much of our progress in agriculture in the United States can be attributed to the establishment of a system of research and teaching, second to none in the world.

Fertilizer use has expanded tremendously in the United States since World War II, and nitrogen use and management in particular, regardless of source, has proven to be one of the major components of a very productive agriculture system. Nitrogen research, and especially nitrogen behavior and transformations in soils as a basis for achieving more effective use of nitrogen fertilizers, has probably been studied more during the past fifty years than any other single topic in

agriculture. However, nitrogen use and management in agriculture is being criticized today as never before, because many people believe that nitrogen from fertilizers is contributing to significant negative impacts on the environment.

Nitrates and Groundwater

One of the major public health concerns across the United States today is groundwater contamination by nitrates. There is some validity to this concern since 98 percent of our fresh water supply is groundwater and 50 percent of our population drink groundwater. As high as 95 to 98 percent of rural residents in some areas get all their water from groundwater supplies.

No other people in the world can boast the high quality of drinking water that Americans enjoy. But, in rural areas the most prevalent source of contamination is nitrates and it seems to be getting worse. This appears to be the case in Alabama too.

Nitrate Toxicity

Nitrates, as such, are not considered to be a major problem, but nitrates in the human body may be changed to other forms or other compounds which are harmful. Nitrates may be changed by an enzyme, nitrate reductase, to nitrites and then, under normal conditions, to ammonium salts and finally to amino acids or other nitrogenous compounds. Nitrites are the real problem because they react with hemoglobin, to form methemoglobin, thus, reducing the blood's capacity to carry oxygen to all body cells. If the concentration of nitrites is high enough, death results.

Nitrate toxicity is more common in infants, older persons and pregnant women. High levels in water have been known to cause cows to abort fetuses.

Nitrates and Cancer

Once nitrates have been converted to nitrite, there are many other nitrogen compounds that can then interact with it to form compounds called N-nitrosoamines. Certain N-nitrosoamines tested in animals have been shown to be carcinogenic and capable of causing cancer in animals. Epidemiological studies have suggested that exposure to high levels of nitrate and nitrite may be associated with a high incidence of stomach and esophageal cancer, but studies are inconclusive at this time.

The only sure way do determine the patterns of risk to co-exposure of nitrates with other chemicals is to study an entire generation of people who have been exposed to these chemicals over a lifetime. Thus far, no group seems to want to do this.

Public Health Standards

The Public Health Standard for drinking water is 10 mg/l or ppm (parts per million) of nitrate nitrogen (that is, nitrogen in the nitrate form). Concentrations above 3 ppm are generally accepted as indicative of some sort of human-related contamination.

The U.S. Environmental Protection Agency adopted the 10 mg/l as a maximum contaminant level standard in 1982.

Sources of Nitrate Contamination

The four major sources of groundwater nitrate contamination are **on-site septic systems, livestock and poultry operations, land disposal of municipal and industrial wastes** and **nitrogen fertilizers**.

How Common is Nitrate Contamination?

A 1982 survey by EPA indicated that 2.7 percent of 603,000 rural wells tested across the country had nitrate above the standard. A 1985 U.S. Geological Survey study found that 6 percent of the nation's rural wells exceeded the standard. In some predominantly agricultural counties in several states, 25 percent or more of the shallow wells, and 80 percent of the shallow dug wells, tested above the standard. For wells included in these particular surveys from Alabama, very few tested above the 10 ppm standard, but over 7 percent tested above the 3 ppm level.

Nitrate contamination of groundwater does not appear to be a major problem in Alabama, at least not as of yet, although there is some concern. Recent well-water monitoring in the Alabama Sand Mountain area of the Cumberlain Plateau suggests that nitrate levels may be increasing rather fast in this area. Over 30 percent of selected rural wells monitored in certain counties in 1987-88 had nitrates above the 10 mg/l level. Both human and animal wastes are believed to be the problems within this area. More surveys in this area of the state as well as other areas will be conducted within the near future.

Nitrogen Fertilizer Future

Total inputs of nitrogen for crop production are not expected to decrease within the foreseeable future. In fact, overall nitrogen needs should increase, but environmental restrictions may lead to more and more of these needs being met from sources other than commercial mineral fertilizers. Things are happening right now that may impact nitrogen use and management as well as sources of nitrogen used for fertilizer.

Following is a list of some things to expect in the future.

1. Expect more emphasis on environmentally safe use and management of nitrogen fertilizers (**research and education**).
2. Expect more environmental restrictions (**laws, regulations, paper work**).
3. Expect more competition from organic N sources.
    a. Animal wastes (livestock and poultry)
    b. Municipal wastes
    c. Plant sources
    d. Household garbage maybe