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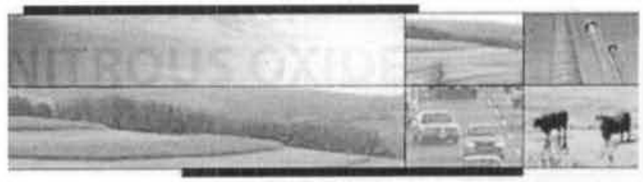
Sources and Emissions



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Where Does Nitrous Oxide Come From?

Nitrous oxide (N_2O) is produced by both natural and human-related sources. Primary human-related sources of N_2O are agricultural soil management, animal manure management, sewage treatment, mobile and stationary combustion of fossil fuel, adipic acid production, and nitric acid production. Nitrous oxide is also produced naturally from a wide variety of biological sources in soil and water, particularly microbial action in wet tropical forests.

Nitrous oxide emission levels from a source can vary significantly from one country or region to another, depending on many factors such as industrial and agricultural production characteristics, combustion technologies, waste management practices, and climate. For example, heavy utilization of synthetic nitrogen fertilizers in crop production typically results in significantly more N_2O emissions from agricultural soils than that occurring from less intensive, low-tillage techniques. Also, the presence or absence of control devices on combustion sources, such as catalytic converters on automobiles, can have a significant affect on the level of N_2O emissions from these types of sources.

Emission inventories are prepared to determine the contribution of emissions from different sources. The following sections present information from inventories of U.S. human-related and natural sources of N_2O globaly. For more information on international emission of N_2O from human-related sources, visit the International Analysis section of this site.

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U.S. Human-related Sources

Table 1 shows the level of emissions from individual sources for the years 1990 and 1997 to 2003.

Table 1 U.S. Nitrous Oxide Emissions by Source ($TgCO_2$ Equivalents)

Source Category	1990	1997	1998	1999	2000	2001	2002	2003
Agricultural Soil Management	253.0	252.0	267.7	243.4	263.9	257.1	252.6	253.5
Mobile Sources	43.7	55.2	55.3	54.6	53.2	49.0	45.6	42.1

Manure Management	16.3	17.3	17.4	17.4	17.8	18.0	17.9	17.5
Human Sewage	13.0	14.7	15.0	15.4	15.6	15.6	15.7	15.9
Nitric Acid	17.8	21.2	20.9	20.1	19.6	15.9	17.2	15.8
Stationary Sources	12.3	13.5	13.4	13.5	14.0	13.5	13.5	13.8
Remaining Settlements	5.5	6.1	6.1	6.2	6.0	5.8	6.0	6.0
Adipic Acid	15.2	10.3	6.0	5.5	6.0	4.9	5.9	6.0
N_2O Product Usage	4.3	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Waste Combustion	0.4	0.4	0.3	0.3	0.4	0.4	0.5	0.5
Agricultural Residue Burning	0.4	0.4	0.5	0.4	0.5	0.5	0.4	0.4
Remaining Forest Land	0.1	0.3	0.4	0.5	0.4	0.4	0.4	0.4
Total for U.S.	**382.0**	**396.2**	**407.8**	**382.1**	**402.2**	**385.9**	**380.5**	**376.7**

Source: US Emissions Inventory 2005: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003

The principal human-related sources of N_2O are described below. For each source, a link is provided to the report entitled "US Emissions Inventory 2006: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004," prepared by EPA, which provides detailed information on the characterization and quantity of national emissions from each source. This report, hereafter referred to as the "U.S. inventory report," provides the latest descriptions and emissions associated with each source category and is part of the United States' official submittal to the United Nations Framework Convention on Climate Change (UNFCCC). The U.S. inventory report also describes the procedures used to quantify national emissions, as well as a description of trends in emissions since 1990.

Agricultural soil management. N_2O is produced naturally in soils through the microbial processes of denitrification and nitrification. These natural emissions of N_2O can be increased by a variety of agricultural practices and activities, including the use of synthetic and organic fertilizers, production of nitrogen-fixing crops, cultivation of high organic content soils, and the application of livestock manure to croplands and pasture. All of these practices directly add additional nitrogen to soils, which can then be converted to N_2O. Indirect additions of nitrogen to soils can also result in N_2O emissions. Indirect additions include those process by which applied fertilizer or manure nitrogen volatilizes into ammonia and oxides of nitrogen and then is ultimately re-deposited onto the soil in the form of particulate ammonium, nitric acid, and oxides of nitrogen. Surface run-off and leaching of applied nitrogen into ground water and surface waters can also result in indirect additions of nitrogen to the soil. The U.S. inventory report provides a detailed description on N_2O emissions from agricultural soil management and how they are estimated (see the Chapter entitled "Agriculture").

Mobile and stationary sources of fossil fuel combustion. N_2O is a product of the reaction that occurs between nitrogen and oxygen during fossil fuel combustion. The volume emitted varies with the fuel type, technology, or pollution control device used, as well as maintenance and operating practices. For example, catalytic converters can promote the formation of N_2O, although the latest technical modifications to converters are addressing this problem. The U.S. inventory report provides a detailed description on N_2O emissions from fuel combustion sources and how they are estimated (see the chapter entitled "Energy").

Nitric acid production. Nitric acid is an inorganic compound used primarily as a feedstock for synthetic commercial fertilizer. It is also a major component in the production of adipic acid and explosives. Virtually all of the nitric acid produced in the United States is manufactured by the catalytic oxidation of ammonia in which N_2O is formed as a by-product and is released from reactor vents into the atmosphere. The U.S. inventory report provides a detailed description on N_2O emissions from nitric acid production and how they are estimated (see the Chapter entitled "Industrial Processes").

Livestock manure management. Nitrous oxide is produced as part of the nitrogen cycle through the nitrification and denitrification of the organic nitrogen in livestock manure and urine. The production of N_2O from livestock manure depends on the composition of the manure and urine, the type of bacteria involved in the process, and the amount of oxygen and liquid in the manure system. Nitrous oxide emissions are most likely to occur in dry manure handling systems that have aerobic (in the presence of oxygen) conditions, but that also contain pockets of anaerobic (in the absence of oxygen) conditions due to saturation. It should be noted that emissions from livestock manure and urine deposited on pasture, range, or paddock lands, as well as emissions from manure and urine that is spread onto fields, are accounted for under the source category of "Agricultural Soil Management". The U.S. inventory report provides a detailed description on N_2O emissions from livestock manure management and how they are estimated (see the Chapter entitled "Agriculture").

Human sewage. Domestic human sewage is usually mixed with other household wastewater, which includes shower drains, sink drains, washing machine effluent, etc. and transported by a collection system to either an on-site (e.g., a septic system) or centralized wastewater treatment plant. Nitrous oxide (N_2O) may be generated during both nitrification and denitrification of the nitrogen present, usually in the form of urea, ammonia, and proteins. These compounds are converted to nitrate via nitrification, an aerobic (in the presence of oxygen) process converting ammonia-nitrogen into nitrate (NO_3). Denitrification occurs under anaerobic conditions (in the absence of oxygen), and involves the biological conversion of nitrate into dinitrogen gas (N_2). N_2O can be an intermediate product of both these processes. The U.S. inventory report provides a detailed description on N_2O emissions from human sewage and how they are estimated (see the Chapter entitled "Waste").

Adipic acid production. Although only responsible for about 1% of the total nitrous oxide emissions in the U.S., adipic acid production is an important category from an individual plant perspective and because of the efforts that have been made to reduce emissions from those plants. N_2O is generated as a by-product during the production of adipic acid which is used in the production of nylon and as a flavor enhancer for some foods. This white crystalline solid is used in the manufacture of synthetic fibers, coatings, plastics, urethane foams, elastomers, and synthetic lubricants. The U.S. inventory report provides a detailed description on N_2O emissions from adipic acid production and how they are estimated (see the chapter entitled "Industrial Processes").

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Natural Sources

Natural emissions of N_2O primarily result from bacterial breakdown of nitrogen in soils and in the earth's oceans. Globally, tropical soils (primarily wet forest soils, but also savannas) are estimated to produce 6.3 Tg of N_2O annually and oceans are thought to add around 4.7 Tg of N_2O annually to the atmosphere (IPCC, 2001(c) EXIT Disclaimer). Together, these two sources account for over 70% of the natural sources. Similar microbial processes in temperate region soils produce smaller quantities of N_2O. In some ocean areas, large areas of surface water can become oxygen depleted, allowing active denitrification in open water. Large amounts of oceanic nitrous oxide can also arise from denitrification in marine sediments, particularly in nutrient rich areas such as those of estuaries.

It is important in studies of N_2O emissions to account for the various interactions between natural processes and human influences in the nitrogen cycle, since human impacts can significantly enhance the natural processes that lead to N_2O formation. For example, the nitrogen nutrient loading in water bodies due to fertilization and run-off to streams can enhance N_2O emissions from these natural sources. Human-related ammonia emissions have also been shown to cause N_2O emissions in the atmosphere through ammonia oxidation.

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