Annual Pollution Report

2000 Air Emissions and Water Discharges

Minnesota Pollution Control Agency
April 2002

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Summary

The Minnesota Pollution Control Agency (MPCA) is required by Minnesota Statutes, Chapter 116.011 to submit to the Legislature an annual report of the volume of pollution emitted or discharged to the state's air and water resources. In addition to gross amounts, the MPCA must report the annual percentage increase or decrease of pollutants for the most recent year for which data are available. The report must also demonstrate the magnitude of the various sources of air and water pollution. The basis of the MPCA's 2002 Annual Pollution Report is the U. S. Environmental Protection Agency's Air Emissions Inventory for 2000 and the water discharge monitoring reports, which are part of EPA's Permit Compliance Tracking System, also for the year 2000.

Annual emissions and discharge estimates are one important component of tracking progress on air and water pollution, and for tracking performance and relative contributions of pollution sources. The MPCA also regularly prepares reports on the physical, chemical and biological conditions measured in the environment, and on pollutants of special concern to human health and the environment. These reports and others are available on the Internet and are referenced throughout this document for readers who would like additional context and information.

The MPCA is continually seeking to improve its reporting of environmental data and information, and welcomes comments and suggestions from readers for future reports of this nature.

Air Emissions

The United States Environmental Protection Agency (EPA) estimates annual emissions of major air pollutants for every state in order to assess historic trends. The major air pollutants summarized in this report include carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOCs), particulate matter (PM_{10} and $PM_{2.5}$) and ammonia (NH_3). The most recent emissions data for the major air pollutants is from 2000.

Global climate change is a growing concern in Minnesota. Therefore, 2000 emissions of the principal greenhouse gas, carbon dioxide (CO_2), have been included in this year's report. The statewide emissions were calculated using a variety of fuel use data sources.

The Minnesota Air Toxics Emission Inventory estimates emissions of air toxics including compounds such as lead, benzene, formaldehyde and mercury. There may be some overlap between the Minnesota Air Toxics Emission Inventory and the EPA emission estimates for VOCs because many air toxics are also VOCs. Air toxics emissions inventories are not generated for every year. The most recent complete inventory of air toxic emissions is from 1997. The 1999 air toxics inventory will be available in spring of 2003.

Table 1 lists the total statewide emissions of the major air pollutants from 1996 to 2000. The percent change from 1999 to 2000 is given in the final column. It is possible to look at emission trends between these years. However, it is important not to place undue emphasis on a yearly change. Trends should be viewed over several years of data. In addition, emission estimates fluctuate as a result of changes and improvements in the inventory.

An increase may result because new sources were added to the inventory, rather than as a result of actual increased emissions in Minnesota. The EPA releases a complete inventory every three years (e.g., 1996

and 1999). Therefore, the 2000 emissions reported are projected numbers based on available 1999 information, economic growth activity and historical trends.

Table 1: Minnesota Air Pollution Emissions Estimates, 1996-2000 (thousand short tons)

Pollutant	1996	1997	1998	1999	2000	1999 to 2000 % Change
Carbon monoxide (CO)	1,794	1,790	1,851	1,828	2,105	+15.0%
Sulfur dioxide (SO_2)	157	164	159	165	190	+15.0%
Oxides of nitrogen (NO_x)	490	510	499	488	533	+9.2%
Volatile organic compounds (VOCs)	441	439	410	395	458	+16.0%
Particulate matter (PM_{10})	828	850	940	847	894	+5.5%
Particulate matter ($PM_{2.5}$)	191	193	206	191	211	+10.0%
Ammonia (NH_3)	188	192	195	199	196	-1.5%
Total*	3,898	3,945	4,054	3,922	4,376	+12.0%

*$PM_{2.5}$ is already included in PM_{10} and so is not included in the total. $PM_{2.5}$ emissions represent only primary formation; secondary formation, which is the major contributor, is not included.

There may be differences in the total emission figures for a given year discussed in this report versus previous emission reports the MPCA has published. This is because the data are continually being updated in the EPA's air emissions inventory. In addition, it should be noted that despite the importance of the secondary formation of fine particulates, estimated air emissions data in this report are only based on direct releases from sources into the atmosphere. Secondary formation occurs when emissions of volatile gases combine and form fine particulates. These particles are not directly emitted but are formed downwind of the emission source.

All of the pollutants except ammonia showed an increase from 1999 to 2000. Ammonia essentially remained constant. Overall, all of the pollutants have increased slightly from 1996 levels, with some fluctuation up and down through the years.

The total emissions of CO_2 in 2000 were 109 million short tons. This represents a 5.6 percent increase from 1999. The 1997 emissions of air toxics are given in the body of the report.

Water Discharges

Owners or operators of any disposal system or point source are required by Minnesota Statutes, Chapter 115.03(7) to maintain records and make reports of discharges to waters of the state. These self-monitoring reports submitted to MPCA are commonly referred to as Discharge Monitoring Reports. These data, in addition to those contained in Effluent Discharge Mass Loading Reports, which can be generated from EPA's Permit Compliance Tracking System (maintained by MPCA data specialists), are the basis for the point source discharge summary given in Table 2. These figures represent the combined loading from 58 municipal and 27 industrial discharges (85 major facilities discharging more than one million gallons per day to waters of the state). These major facilities represent approximately 70% of the total volume of discharge to waters of the state from point sources. The remaining 30% comes from many smaller municipal and industrial facilities. Although discharges from these facilities are small, they can have significant impacts on individual lake and stream segments.

Table 2: Minnesota Water Pollution Discharge Estimates from Major Point Sources, 1996-2000 (thousand kilograms)

Pollutant	1996	1997	1998	1999	2000	1999 to 2000 % Change
Total suspended solids	11,274	10,076	8,000	6,069	5,119	- 15.7%
Biological oxygen demand (BOD)	8,311	6,743	5,397	4,264	3,471	- 18.6%
Phosphorus	1,425	1,171	1,652	1,405	1,441	+ 2.5%
Ammonia (NH_3)	1,560	1,709	1,415	1,219	1,283	+ 5.0%
Nitrate (NO_3)	4,336	4,123	4,703	4,701	4,684	-0.4%
Total	26,906	23,822	21,167	17,658	15,998	- 9.4%

In general, major point source discharges to waters of the state as represented by the five pollutants in Table 2 show a downward trend over the five-year reporting period. Phosphorus and nitrate showed a very slight upward trend from 1996 to 2000. Of particular significance is that the total volume of pollutants discharged from 1996 to 2000 was cut by about 40 percent, from nearly 27 million kilograms to just under 16 million kilograms. Most of this decrease can be attributed to steady decreases in the two high-volume pollutants, total suspended solids and biological oxygen demand. Both discharges were more than cut in half from 1996-2000 and decreased 15.7 and 18.6 percent respectively from 1999-2000. These decreases probably reflect increased treatment plant efficiency as well as the effects of reducing waste stream volume at the source over the five years.

The overall trend in discharge of ammonia was down about 20 percent from 1996 to 2000, although it showed a 5 percent increase from 1999-2000. Part of this increase may be explained by the fact that since 1999 more permittees are being required to submit their ammonia discharge data. Nitrate discharges have been relatively stable over the five-year period, trending very slightly downward from 1999 to 2000 (0.4 percent). Phosphorus has shown more year-to-year variability than nitrate over the five-year period although, like nitrate, the overall trend from 1996-2000 was up very slightly. Unlike nitrate, phosphorus discharges increased slightly from 1999 to 2000. The MPCA is currently reviewing its phosphorus discharge standards to waters of the state and the outcome of this process may affect phosphorus discharges allowed from point sources in the future.

However, point source contributions of nitrate and phosphorus to waters of the state are still small compared to nonpoint contributions of these pollutants from sources such as agricultural and urban runoff. Point sources are most significant during periods of low precipitation and stream flow while nonpoint sources are most significant during periods of high precipitation and stream flow. The MPCA is investigating better ways to measure the effects of nonpoint pollution in Minnesota’s lakes, rivers and ground water, but this type of monitoring is expensive and often requires a more complex monitoring network than measuring volume and quality of discharge from pipes.

Air Pollutant Emissions Overview

Thousands of chemicals are emitted into the air. Many of these are air pollutants that can directly or indirectly affect human health, reduce visibility, cause property damage and harm the environment. For this reason, the EPA and the MPCA attempt to reduce the amount of air pollutants released into the air. In order to understand how much pollution is released and to track the success of reduction strategies, these agencies estimate the emissions of certain air pollutants released in Minnesota.

Criteria Pollutants

The 1970 Clean Air Act identified six major air pollutants that were present in high concentrations throughout the United States called "criteria pollutants." These air pollutants are particulate matter (PM_{10}), sulfur dioxide (SO_2), nitrogen dioxide (NO_x), ozone (O_3), carbon monoxide (CO) and lead (Pb). Fine particulate matter ($PM_{2.5}$) was later added as an additional criteria pollutant. The National Emissions Trends (NET) database inventories emissions of five criteria pollutants (PM_{10}, $PM_{2.5}$, SO_2, NO_x, and CO). Ozone is not directly emitted, so a group of ozone precursors called volatile organic compounds (VOCs) is included instead. Lead is inventoried with the hazardous air pollutants.

Greenhouse Gases

Another group of air pollutants has risen in importance. Although greenhouse gases do not necessarily directly harm human health, their increase in concentration can lead to global climate change. Global climate change poses risks to human health and to ecosystems. Important economic resources such as agriculture, forestry, fisheries, and water resources also may be affected. The principal greenhouse gas is carbon dioxide (CO_2). MPCA tracks the emissions of CO_2 in Minnesota.

Air Toxics

Many other chemicals are released in smaller amounts than the criteria pollutants, but are still toxic. EPA refers to chemicals that cause serious health and environmental hazards as hazardous air pollutants or air toxics. Air toxics include chemicals such as benzene, formaldehyde, acrolein, mercury and polycyclic aromatic hydrocarbons (PAHs). EPA tracks emissions of these chemicals in the National Toxics Inventory (NTI) database. Minnesota values come from Minnesota Air Toxics Emission Inventory which includes 109 chemicals: 16 PAHs, 80 non-metal compounds (excluding PAHs), and 13 metal compounds.

This report is limited to a summary and discussion of emissions of various air pollutants in Minnesota. However, the MPCA has prepared several other reports that discuss air pollution trends and emissions in more detail. Please reference the following reports for more information regarding air pollution.

Air Quality in Minnesota: Problems and Approaches—2001 Legislative Report
http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html

Minnesota Environment 2000
http://www.pca.state.mn.us/about/pubs/mnereport/index.html

MPCA Staff Paper on Air Toxics—November 1999
http://www.pca.state.mn.us/air/airtoxics.html#paper

Criteria Air Pollutant Emissions

EPA prepares estimates of annual national emissions of criteria pollutants for every state to assess historic trends in emissions. This emissions inventory, the National Emissions Trends (NET) database, includes five criteria pollutants (PM_{10}, $PM_{2.5}$, SO_2, NO_x, and CO). Ozone is not directly emitted, so a group of ozone precursors called volatile organic compounds (VOCs) is included instead. Ammonia is also inventoried in the NET database because of its importance in particle formation. Lead is inventoried with the air toxics.

The NET database is released every three years (e.g., 1996 and 1999). EPA calculates aggregate emissions for each year between the inventory releases based on economic growth activity. Therefore, 2000 emissions reported are projected based on available 1999 information and historical trends. Each pollutant's emissions are estimated for many source categories, which collectively account for all manmade emissions. Air pollutant emissions in this report are discussed by pollutant based on the following three classes of pollutant sources as defined in the Clean Air Act:

- Point source - a stationary source of emissions, such as an electric power plant, that can be identified by name and location. A "major" source emits a threshold amount (or more) of at least one criteria pollutant, and must be inventoried and reported.
- Area source - a small point source such as a home or commercial building, or a diffuse stationary source, such as wildfires or agricultural tilling. These sources do not individually produce sufficient emissions to qualify as point sources. For example, a single dry cleaner typically will not qualify as a point source, but collectively the emissions from many dry cleaning facilities may be significant.
- Mobile source - any kind of vehicle or equipment with a gasoline or diesel engine. Mobile sources are broken up into two categories; highway sources which include gasoline and diesel cars and trucks and off-highway sources which include non-highway vehicles such as lawnmowers, construction equipment, snowmobiles, aircraft, marine vessels, railroads, etc.

This report presents trend data from 1996-2000 when available. The emission trends are the net effect of many factors, including changes in the nation's economy and in industrial activity, technology, consumption of fuels, traffic, and other activities that cause air pollution. The trends also reflect changes in emissions as a result of air pollution regulations and emission controls. In addition, the emissions reported are estimates. Changes in the way emissions are calculated may also affect trends, even if there was no real increase or decrease in emissions.

The reader may note differences in the total emission figures for a given year discussed in this report versus previous MPCA emission reports. This is because the data are continually being updated in the NET database. Furthermore, despite the importance of the secondary formation of some pollutants (e.g. $PM_{2.5}$), estimated air emissions data in this report are only based on direct releases from sources into the atmosphere. Secondary formation of pollutants is not included in the estimates.

Find more information on the NET database in the following EPA web site:
http://www.epa.gov/air/data/netdb.html

See the EPA AIR*Data* web site to download criteria pollutant emissions data:
http://www.epa.gov/air/data/index.html

Find more information on criteria air pollutants in the following EPA web site:
http://www.epa.gov/air/urbanair/6poll.html

Carbon Monoxide

Carbon monoxide (CO) is a colorless and odorless toxic gas formed in high concentrations when carbon in fuels is not burned completely.

CO enters the bloodstream and reduces the delivery of oxygen to the body's organs and tissues. The health threat from CO is most serious for those who suffer from cardiovascular disease. At higher concentrations it also affects healthy individuals. Exposure to elevated CO levels is associated with impairment of visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks. Prolonged exposure to high levels can lead to death.

At concentrations commonly found in the ambient air, CO does not appear to have adverse effects on plants, wildlife or materials. However, CO is oxidized to form carbon dioxide (CO_2) a contributor to global warming.

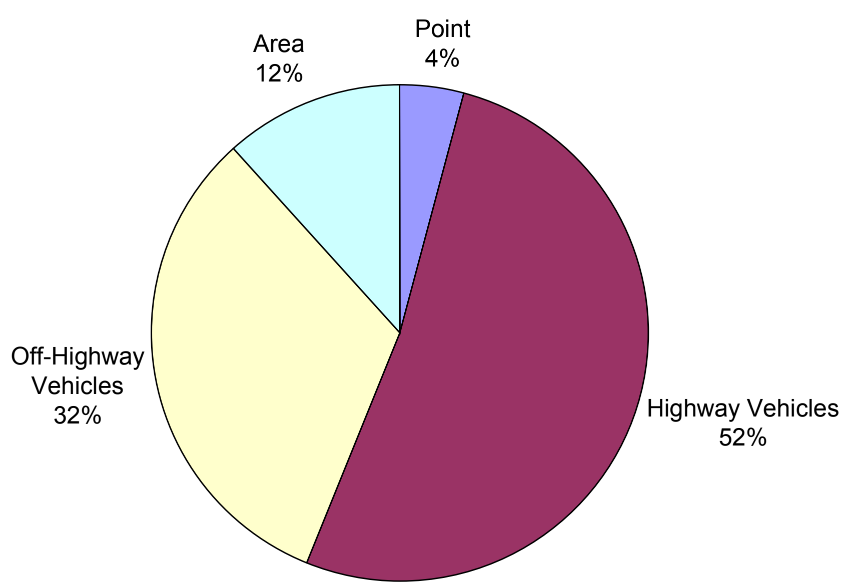
Emissions Data and Sources

The EPA estimate for statewide emissions of CO in 2000 is 2,104,632 tons.

The figure below shows sources of 2000 CO emissions. The majority of CO emissions come from the transportation sector, which consists of highway and off-highway vehicles. Highway vehicles contribute 52 percent of total statewide CO emissions, while off-highway vehicles and engines contribute 32 percent of total CO emissions. Off-highway emissions come primarily from gasoline consumption by lawn and garden, industrial and recreational engines.

The remaining 16 percent of emissions come from point and area sources. Area source emissions are primarily from residential wood burning, waste disposal through open burning and other combustion

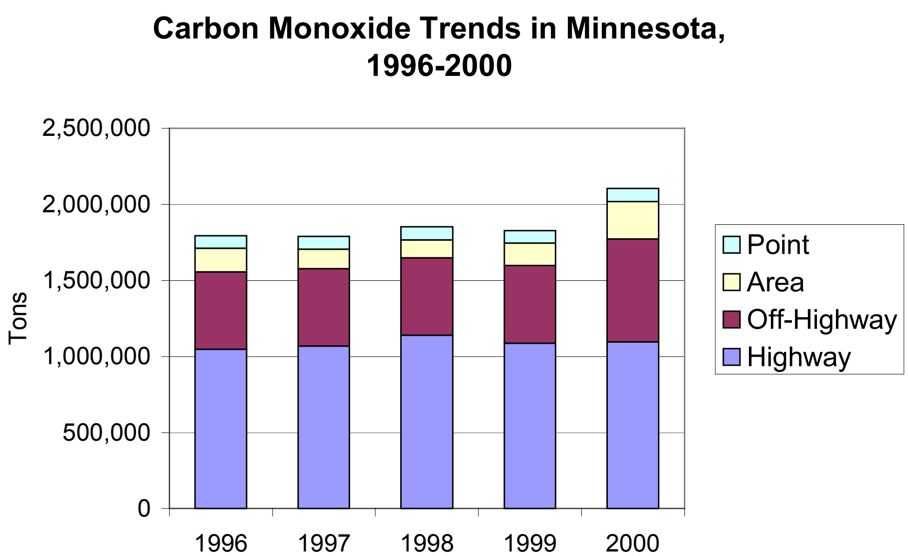
Sources of Carbon Monoxide Emissions in Minnesota, 2000



sources such as wildfires. Point sources include electric utilities and other industries that contribute to CO emissions through fuel combustion. Petroleum refineries are the primary industrial point source that contributes to CO emissions.

Trends

Nationally, CO emissions have decreased 18 percent over the last 20 years. However, in Minnesota from 1996-2000, CO emissions have generally remained constant except for the estimated 2000 emissions, which represent a 15 percent increase from 1999 values. The EPA inventory attributes this increase to an increase in residential wood burning, non-highway gasoline engine emissions and miscellaneous combustion including wildfires. It is unlikely that actual emissions increased this much over one year, based on trends from years past.



References/Web Links

For more information on carbon monoxide, see the following web sites:

http://www.epa.gov/air/urbanair/co/index.html

http://www.epa.gov/airtrends/

http://www.pca.state.mn.us/air/emissions/co.html

Nitrogen Oxides

Nitrogen oxides (NO_x) is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. The two primary constituents are nitric oxide (NO) and nitrogen dioxide (NO_2). NO is a colorless, odorless gas that is readily oxidized in the atmosphere to NO_2. NO_2 exists as a brown gas that gives photochemical smog its yellowish-brown color. NO_x is reported because NO and NO_2 continuously cycle between the two species. NO_x form when fuel is burned at high temperatures. NO is the principal oxide of nitrogen produced in combustion processes.

NO_x contributes to a wide range of human health effects. NO_2 can irritate the lungs and lower resistance to respiratory infection (such as influenza). However, more importantly, NO_x are a major precursor both to ozone and to particulate matter (PM). As discussed in the ozone and PM sections of this report, exposure to both PM and ozone is associated with serious adverse health effects.

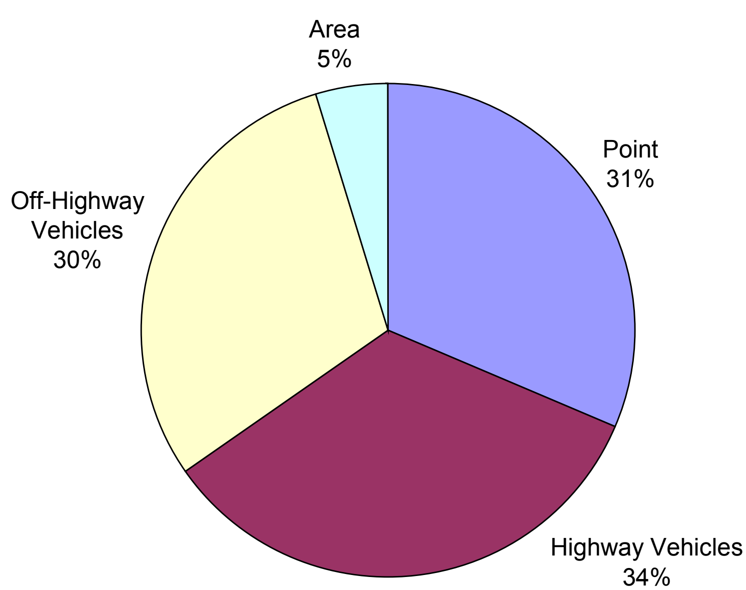
High NO_x concentrations also cause serious environmental impacts. Deposition of nitrogen can lead to fertilization, eutrophication, or acidification of terrestrial, wetland and aquatic systems. This can result in changes in species number and composition such as the reduction of fish and shellfish populations. In addition, nitrous oxide (N_2O), another component of NO_x, is a greenhouse gas that contributes to global warming.

Emissions Data and Sources

The EPA estimate for statewide emissions of NO_x in 2000 is 532,853 tons.

The figure below shows sources of 2000 NO_x emissions. The majority of NO_x emissions come from the transportation sector, which consists of highway and off-highway vehicles. Highway vehicles contribute 34 percent of total statewide NO_x emissions, while off-highway vehicles and engines contribute 30 percent of total NO_x emissions. Gasoline and diesel engines contribute the majority of emissions from the transportation sector.

Sources of Nitrogen Oxide Emissions in Minnesota, 2000

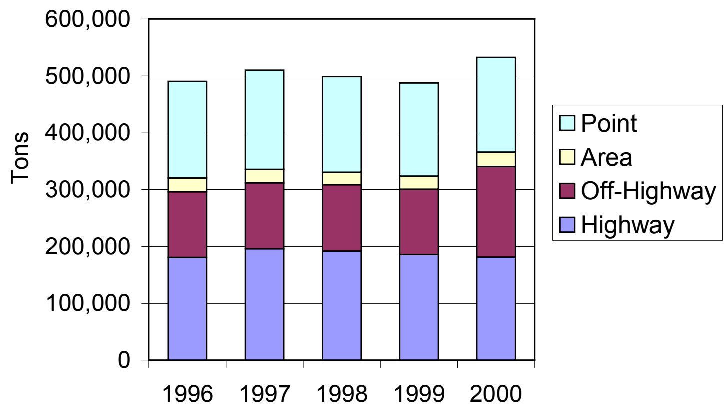


Thirty-one percent of NO_x emissions come from point sources as electric utilities and industrial facilities emit NO_x during coal and gas combustion. Area sources are responsible for the remaining 5 percent of NO_x emissions. Residential and small industrial combustion makes up the majority of area source emissions.

Trends

Nationally, NO_x emissions have increased 4 percent over the last 20 years. In Minnesota, from 1996-2000, NO_x emissions have generally remained constant while the estimated 2000 emissions represent a 9 percent increase from 1999 values. The increase in 2000 estimated emissions is primarily a result of increased off-highway emissions including a ten-fold increase in marine vessel emissions and a doubling of emissions from railroads. Increases from these source categories are surprising and it is likely that they result from a methodology change or error in the EPA inventory. There was also an increase in residential combustion under area sources.

Nitrogen Oxide Emission Trends in Minnesota, 1996-2000



References/Web Links

For more information on nitrogen oxides, see the following web sites:

http://www.epa.gov/air/urbanair/nox/index.html

http://www.epa.gov/airtrends/

http://www.pca.state.mn.us/air/emissions/no2.html

Volatile Organic Compounds

Volatile organic compounds (VOCs) are compounds containing the elements carbon and hydrogen that exist in the atmosphere primarily as gases because of their low vapor pressure. VOCs are defined in federal rules as chemicals that participate in forming ozone. Therefore, only gaseous hydrocarbons that are photochemically reactive and participate in the chemical and physical atmospheric reactions that form ozone and other photochemical oxidants are considered VOCs.

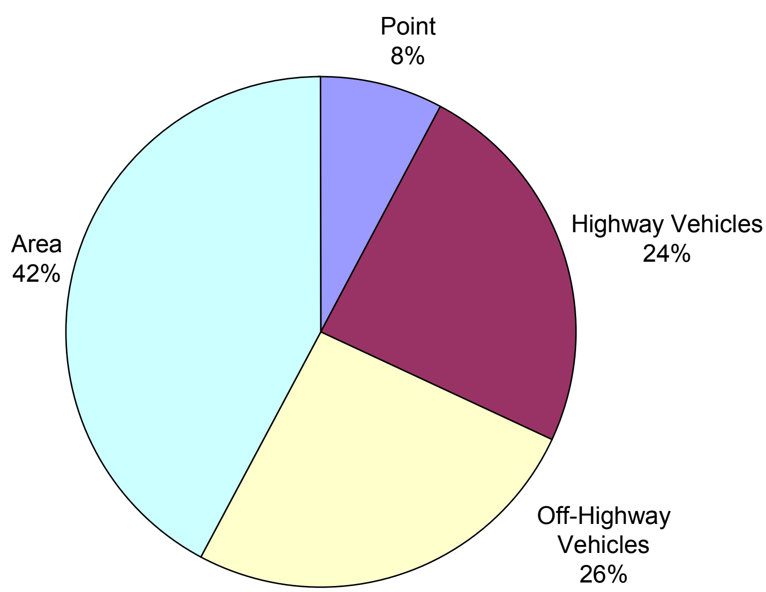
Many VOCs are also air toxics and can have harmful effects on human health and the environment. However, VOCs are regulated as a criteria pollutant because they are precursors to ozone. See the sections on ozone and air toxics for related human health and environmental effects.

Emissions Data and Sources

The EPA estimate for statewide emissions of VOCs in 2000 is 458,306 tons.

VOCs are emitted from a variety of sources, including industrial sources, motor vehicles, consumer products and natural sources such as lightning and biological processes in soil. The figure below shows manmade Minnesota sources of VOCs in 2000. Half of the emissions come from the transportation sector, which consists of highway and off-highway vehicles. Twenty-four percent of emissions come from highway vehicles and 26 percent come from off-highway vehicles.

Sources of Volatile Organic Compounds in Minnesota, 2000

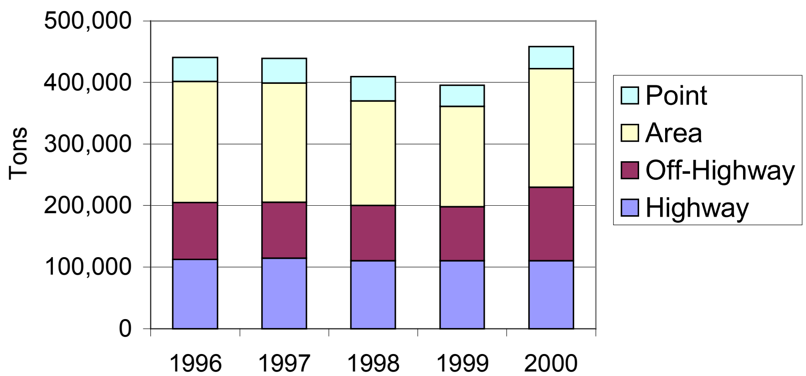


Area sources contribute 42 percent of VOC emissions, primarily from solvent utilization, residential wood combustion, and storage and transport of fuels and chemicals. The final 8 percent of emissions come from point source combustion, solvent utilization and storage and transport of fuels and chemicals.

Trends

Nationally, VOC emissions have decreased 32 percent over the last 20 years. In Minnesota, VOC emissions were slightly higher in 1996, 1997 and 2000 and slightly lower in 1998 and 1999. These differences may not be statistically significant. The estimated 2000 emissions represent a 16 percent increase from 1999 values. According to the EPA inventory, the increase is primarily a result of increased residential wood combustion, emissions from off-highway gasoline engines and miscellaneous combustion such as wildfires.

Volatile Organic Compounds Emission Trends in Minnesota, 1996-2000



References/Web Links

For more information on volatile organic compounds, see the following web sites:

http://www.epa.gov/airtrends/

http://www.pca.state.mn.us/air/emissions/voc.html

Sulfur Dioxide

Sulfur dioxide (SO_2) belongs to the family of sulfur oxide gases. It is a colorless gas that can be detected by taste and odor at concentrations as low as 0.3 ppm. Sulfur oxide gases are formed when fuel containing sulfur (mainly coal and oil) is burned and during metal smelting and other industrial processes.

SO_2 reacts with other chemicals in the air to form tiny sulfate particles. In fact, sulfate aerosols make up the largest single component of fine particulate matter. It is difficult to distinguish between health effects due to SO_2 exposure and those due to fine particulate exposure. The major health effects of concern associated with exposures to high concentrations of SO_2, sulfate aerosols and fine particulates include impaired breathing, respiratory illness, alterations in the lung's defenses, aggravation of existing respiratory and cardiovascular disease, and mortality. Children, asthmatics and the elderly may be particularly sensitive.

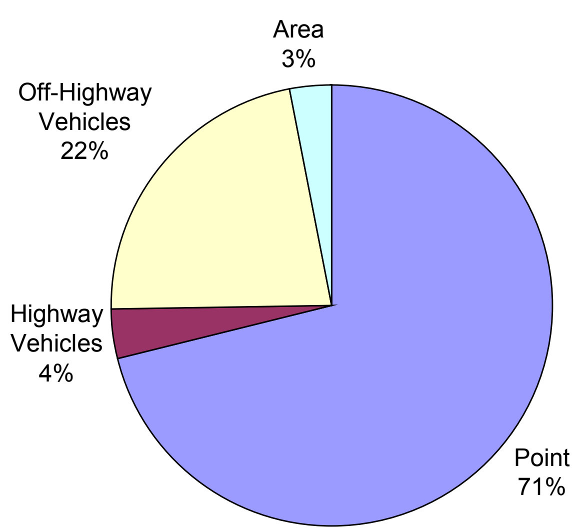
SO_2 also causes significant environmental damage. SO_2 reacts with other substances in the air to form acids, which fall to earth as rain, fog, snow, or dry particles. Acid rain damages forests and crops, changes the makeup of soil, and makes lakes and streams acidic and unsuitable for fish. Continued exposure changes the number and variety of plants and animals in an ecosystem. In addition, SO_2 accelerates the decay of buildings and monuments and is a major cause of reduced visibility due to haze in Minnesota.

Emissions Data and Sources

The EPA estimate for statewide emissions of SO_2 in 2000 is 189,636 tons.

The figure below shows sources of 2000 SO_2 emissions. Over 70 percent of SO_2 emissions come from point sources. Electric utilities and industrial facilities burning coal emit the majority (>85 percent) of SO_2 attributed to point sources.

Sources of Sulfur Dioxide Emissions in Minnesota, 2000



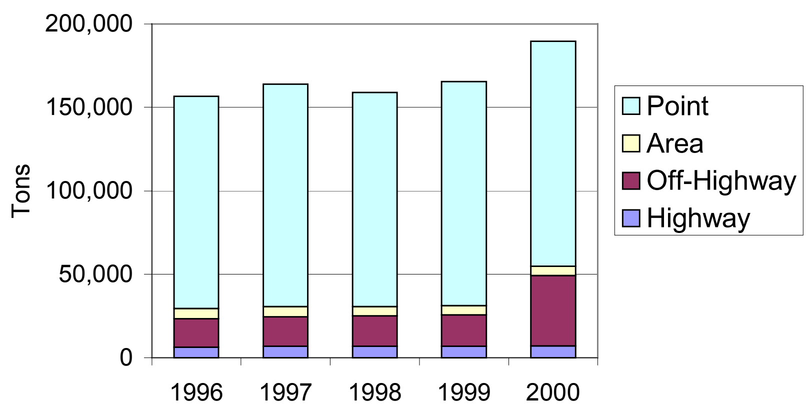
Off-highway vehicles and engines emit 22 percent of SO_2. Off-highway emissions come primarily from non-road diesel engines and marine vessels. Highway vehicles contribute 4 percent of the emissions. These emissions are divided between gasoline-powered cars, trucks and motorcycles and diesel vehicles.

The remaining three percent of area emissions of SO_2 result from fuel combustion by small industrial and commercial facilities and residences.

Trends

Nationally, SO_2 emissions have decreased 31 percent over the last 20 years. Nationally and in Minnesota emissions have remained essentially level in recent years. The estimated Minnesota 2000 emissions represent a 15 percent increase from 1999 values. The increase is primarily a result of an increase in off-highway emissions from marine vessels. Estimated marine vessel emission increased from 225 tons in 1999 to 23,807 tons in 2000. Increases from this source category are surprising and likely due to a methodology change or error in the EPA inventory.

Sulfur Dioxide Emission Trends in Minnesota, 1996-2000



References/Web Links

For more information on sulfur dioxide, see the following web sites:

http://www.epa.gov/oar/urbanair/so2/index.html

http://www.epa.gov/airtrends/

http://www.pca.state.mn.us/air/emissions/so2.html

Ammonia

Ammonia (NH_3) is a colorless gas with a very sharp odor. It dissolves easily in water and evaporates quickly. Ammonia reacts with sulfates and nitrates in the presence of water to create ammonium sulfate and ammonium nitrate, both of which are fine particles. Therefore, ammonia is an important precursor in $PM_{2.5}$ formation.

Breathing low concentrations of ammonia may cause coughing and nose and throat irritation. However, ammonia in ambient air is a greater concern due to its role as a precursor to $PM_{2.5}$ formation than from direct health effects. See the section on $PM_{2.5}$ for related human health and environmental effects.

Emissions Data and Sources

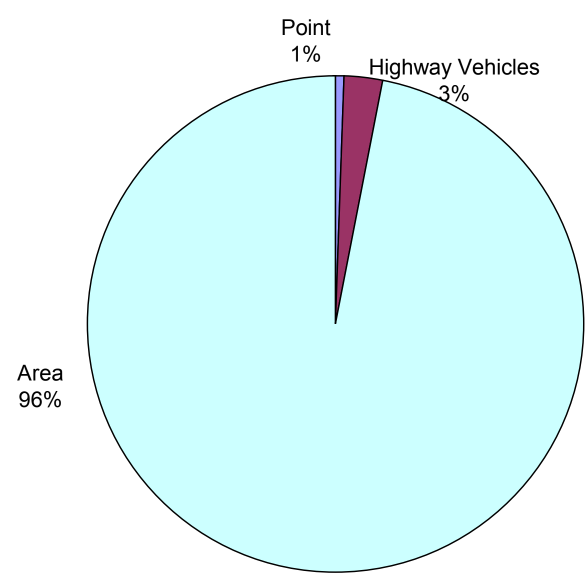
The EPA estimate for statewide emissions of NH_3 in 2000 is 195,729 tons.

The figure below shows sources of 2000 NH_3 emissions in Minnesota. The majority of NH_3 emissions (96 percent) come from area sources. According to the EPA inventory, agriculture and forestry contribute almost all of the NH_3 from area sources. Most of the ammonia emitted is generated from livestock waste management and fertilizer production.

Highway vehicles are responsible for 3 percent of ammonia emissions through the combustion of fuel. Ammonia is not emitted from the fuel combustion process itself, but from the control technology applied to control nitrogen oxide (NO_x) emissions. These methods reduce NO_x by injecting urea or ammonia into the exhaust gas to react with the nitrogen oxides. If the reaction is not complete, a portion of the ammonia may exit the system in the effluent.

The remaining 1 percent of NH_3 comes from the petroleum industry and the manufacture of agricultural chemicals such as fertilizers.

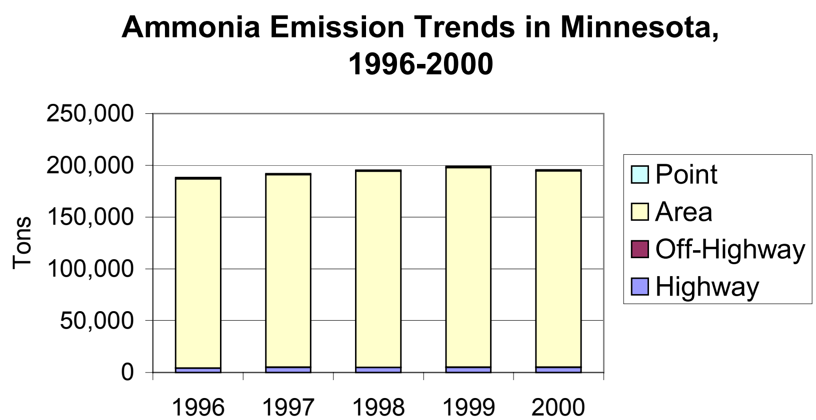
Sources of Ammonia Emissions in Minnesota, 2000



Currently, the United States Department of Agriculture and EPA are working to refine the NH_3 inventory for all source categories, including some natural sources that are not in the current inventory.

Trends

From 1996-2000 in Minnesota, NH_3 emission estimates have generally remained constant. The estimated 2000 emissions represent a 1.5 percent decrease from 1999 values. This decrease may not be statistically significant.



References/Web Links

For more information on ammonia, see the following web sites:

http://www.atsdr.cdc.gov/tfacts126.html

http://www.epa.gov/airtrends/

Particulate Matter

Particulate matter is the general term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. Some particles are seen as soot or smoke. Others are so small that they can only be detected with an electron microscope. Particles less than or equal to 2.5 micrometers (μm) in diameter, or $PM_{2.5}$, are known as "fine" particles. Those larger than 2.5 μm but less than or equal to 10 μm are known as "coarse" particles. PM_{10} refers to all particles less than or equal to 10 μm in diameter.

PM_{10}

Coarse particles are generally emitted from sources such as vehicles traveling on unpaved roads, materials handling, and crushing and grinding operations, and windblown dust. Coarse particles can settle rapidly from the atmosphere within hours, and their spatial impact is typically limited because they tend to fall out of the air in the downwind area near their emissions point.

Both coarse and fine particles can be inhaled into the lungs. These particles then accumulate in the respiratory system and are associated with numerous adverse health effects. Exposure to coarse particles is primarily associated with the aggravation of respiratory conditions such as asthma.

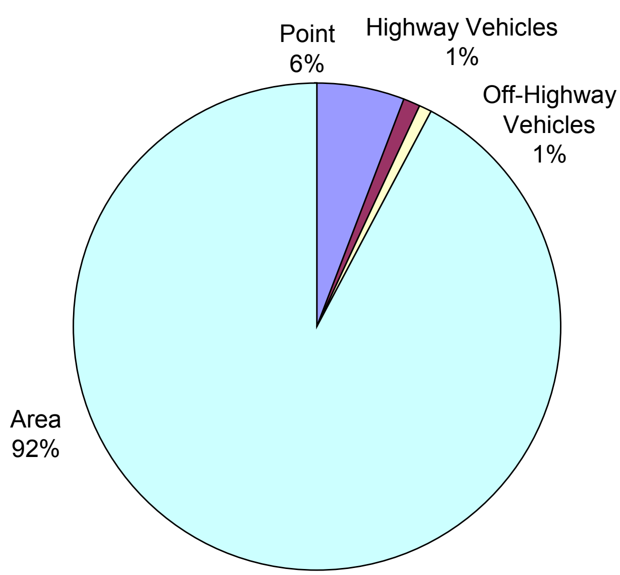
Particulate matter also causes adverse impacts to the environment. When particles containing nitrogen and sulfur deposit onto land or water bodies, they may affect nutrient balances and acidity, resulting in the depletion of nutrients in the soil, damage to sensitive forests and farm crops, and diversity changes in ecosystems. Particulate matter also causes soiling and erosion damage to materials and buildings.

Emissions Data and Sources

The EPA estimate for statewide direct emissions of PM_{10} in 2000 is 894,093 tons.

The figure below shows estimated sources of 2000 PM_{10} direct emissions. Emissions of secondarily formed PM_{10} are not accounted for in these emission graphs. Area sources contribute 92 percent of PM_{10}

Sources of PM_{10} Emissions in Minnesota, 2000



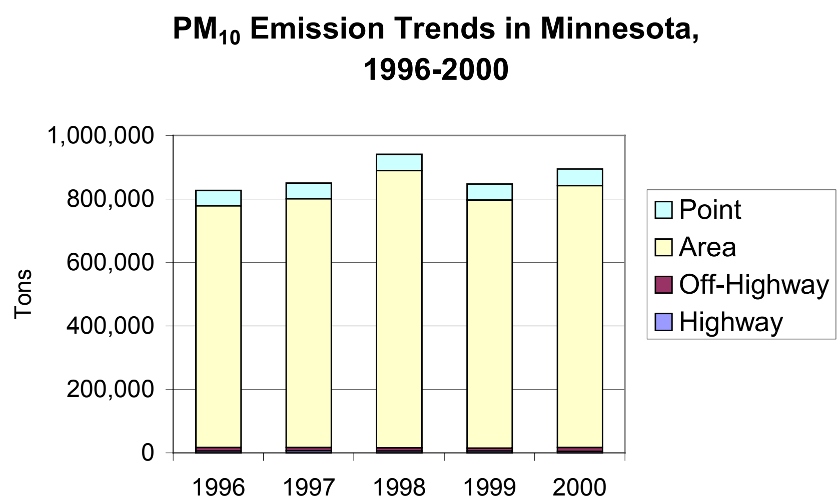
emissions. The area sources consist of fugitive dust (63 percent) and agriculture and forestry (33 percent) according to the EPA inventory. The remainder of the area source contribution is from combustion. Fugitive dust sources include unpaved roads, paved roads, construction and other sources.

Industrial sources including metal processing, storage and transport, electric utilities, and other industrial processing account for 6 percent of PM_{10} emissions. Metal processing accounts for 45 percent of the industrial portion of PM_{10}. Highway and off-highway sources make up about 2 percent of total PM_{10}.

Fugitive dust sources tend to be located away from people and tend to be coarser particles, which are of less concern from a human health perspective. Particles emitted from non-fugitive dust sources such as cars and wood stoves are smaller, more toxic and more often released in populated areas.

Trends

Nationally, manmade direct PM_{10} emissions have decreased 47 percent over the last 20 years. In Minnesota direct emissions have oscillated up and down from 1996-2000. The estimated Minnesota 2000 emissions represent a 5.5 percent increase from 1999 values. The increase is primarily a result of increased residential wood burning, agricultural and forestry, fugitive dust, and an increase in miscellaneous combustion including wildfires.



References/Web Links

For more information on PM_{10}, see the following web sites:

http://www.epa.gov/oar/urbanair/pm/index.html

http://www.epa.gov/airtrends/

http://www.pca.state.mn.us/air/emissions/pm10.html

$PM_{2.5}$

Fine particles are both directly emitted during fuel combustion (from motor vehicles, power generation, industrial processes, residential fireplaces and wood stoves) and formed secondarily in the atmosphere from gases such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOCs). Fine particles tend to remain suspended for long times and travel farther than coarse particles. Therefore, they are likely to be more uniformly dispersed at urban and regional scales than coarse particles.

Both coarse and fine particles can be inhaled into the lung. These particles then accumulate in the respiratory system and are associated with numerous adverse health effects. Fine particles are associated with decreased lung function, increased hospital admissions and emergency room visits, increased respiratory symptoms and disease, and premature death. Studies indicate that fine particles may also affect the cardiovascular system and contribute to lung cancer.

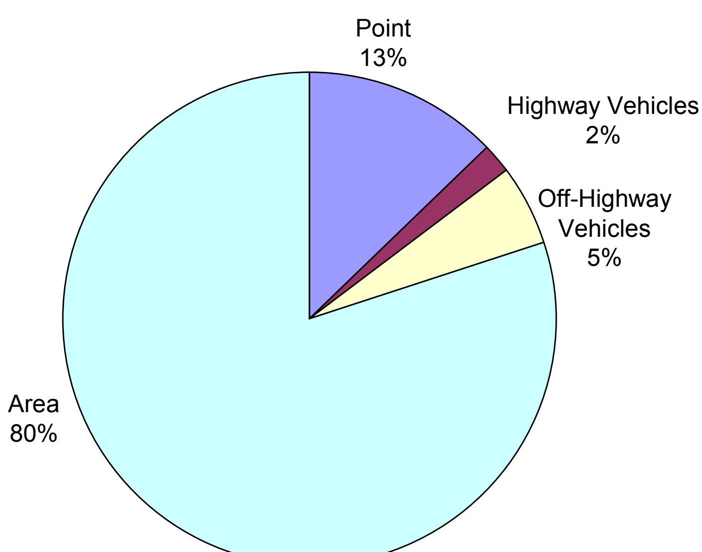
Particulate matter also causes adverse impacts to the environment. Fine particulates are the major cause of reduced visibility in parts of the United States. In addition, when particles containing nitrogen and sulfur deposit onto land or water bodies, they may affect nutrient balances and acidity, resulting in the depletion of nutrients in the soil, damage to sensitive forests and farm crops, and diversity changes in ecosystems. Particulate matter also causes soiling and erosion damage to materials and buildings.

Emissions Data and Sources

The EPA estimate for statewide direct emissions of $PM_{2.5}$ in 2000 is 211,389 tons. However, this number only takes into account direct, manmade emissions of $PM_{2.5}$. Secondarily formed particles are not directly emitted, but are formed downwind of the emissions source. EPA is working to improve the $PM_{2.5}$ emissions inventory since $PM_{2.5}$ is predominantly comprised of secondary particles and directly emitted carbonaceous particles. The EPA emissions inventory shows $PM_{2.5}$ emission sources mirroring PM_{10} to a great extent. In fact, $PM_{2.5}$ and PM_{10} sources are markedly different because most crustal material particles are larger than 2.5 μm diameter while almost all of the secondary particles and directly emitted carbonaceous particles are smaller than 2.5 μm.

The figure below shows only directly emitted, manmade $PM_{2.5}$ emissions. According to the EPA emissions inventory, 80 percent of direct $PM_{2.5}$ emissions come from area sources such as fugitive dust (50 percent), agriculture/forestry (32 percent) and combustion (17 percent).

Sources of Direct $PM_{2.5}$ Emissions in Minnesota, 2000



Industrial sources such as metals processing, storage and transport, electric utilities, fuel combustion and other industrial processes make up 13 percent of $PM_{2.5}$ emissions. Highway and off-highway emissions make up only 7 percent of $PM_{2.5}$ emissions.

Much of $PM_{2.5}$ is the result of secondary formation. These sources are not represented in the figure provided. The principal types of secondary particles are ammonium sulfate and ammonium nitrate, formed in the air from gaseous emissions of SO_2 and NO_x reacting with ammonia. Some secondary particles are also formed from VOCs. Therefore, for a complete understanding of $PM_{2.5}$ emissions, one should also consider the emissions of SO_2, NO_x, NH_3 and VOCs. See the sections on these other pollutants for a further understanding of the sources contributing to $PM_{2.5.}$

Overall, fuel combustion is a significant source of $PM_{2.5}$, while fugitive dust sources do not play a particularly important role.

Trends

Nationally, manmade direct $PM_{2.5}$ emissions have decreased 5 percent over the last 10 years. The estimated Minnesota 2000 emissions (191,198 tons) represent a 10 percent increase from 1999 values (211,389 tons). Since the current 2000 emission estimates for $PM_{2.5}$ are very incomplete, it would be misleading to attempt to present a trend chart.

References/Web Links

For more information on $PM_{2.5}$, see the following web sites:

http://www.epa.gov/oar/urbanair/pm/index.html

http://www.epa.gov/airtrends/

http://www.epa.gov/ncea/dieslexh.htm

http://www.pca.state.mn.us/air/emissions/pm10.html

Ozone

Ozone is an odorless, colorless gas composed of three atoms of oxygen. Naturally occurring ozone in the upper atmosphere helps protect the earth's surface from ultraviolet radiation. However, at elevated concentrations, ground-level ozone can irritate the respiratory system, reduce lung function, aggravate and potentially cause asthma, and cause other lung effects. Children, active adults, and people with respiratory diseases are particularly sensitive to ozone.

Ozone is an important criteria pollutant. In late June 2001, the Air Quality Index (AQI) for the Twin Cities reached some of its highest levels since the Clean Air Act took effect in the 1970s. On four days the AQI reached a level considered unhealthy for sensitive groups. These high AQI readings were primarily a result of elevated ground-level ozone concentrations.

Emissions of ozone are not reported because ozone is not normally emitted directly into the air. Instead, it is created when "ozone precursors" such as nitrogen dioxide (NO_2) and volatile organic compounds (VOCs) react in a hot stagnant atmosphere. Since heat and sunlight are needed for ozone to be produced, elevated levels of ozone in Minnesota are normally seen on very hot summer afternoons.

Ozone precursors come from a variety of sources. NO_2 can form when fuels are burned at high temperatures. The major NO_2 sources are combustion processes from automobiles and power plants. VOCs are emitted from a variety of sources, including industrial sources, motor vehicles, consumer products and natural sources such as lightning and biological processes in soil. See the NO_x and VOC sections of this report for more information regarding 2000 emissions of ozone precursors.

References/Web Links

For more information on ozone, see the following web sites:

http://www.epa.gov/air/urbanair/ozone/index.html

http://www.epa.gov/airtrends/

http://bopp.pca.state.mn.us/aqi/

Lead

Lead (Pb) is a metal found naturally in the environment as well as in manufactured products. In the past, the major sources of lead emissions were motor vehicles and industrial sources. Since lead in gasoline was phased out, metals processing (lead and other metals smelters) and aircraft using leaded fuel are the major source of lead emissions to the air today.

Lead causes damage to organs such as the kidneys and liver and may lead to high blood pressure and increased heart disease. In addition, exposure to lead may contribute to osteoporosis and reproductive disorders. Most importantly, lead exposure causes brain and nerve damage to fetuses and young children, resulting in seizures, behavioral disorders, memory problems, mood changes, learning deficits and lowered IQ.

Elevated lead levels are also detrimental to animals and to the environment. Wild and domestic animals experience the same kind of effects as people exposed to lead. Elevated levels of lead in the water can cause reproductive damage in some aquatic life and cause blood and neurological changes in fish.

Emissions Data and Sources

Annual lead emission data is not available through the NET database. However, the MPCA includes lead in the Minnesota Air Toxics Emission Inventory. The 1997 emissions inventory is the most recent complete inventory available. The inventory does not include forest fires or prescribed burning. According to the inventory, 163,025 lbs (82 tons) of lead was emitted in Minnesota in 1997. Of that, 96 percent was from point sources. Mobile sources contributed 4 percent of lead emissions and area sources contributed less than one percent of lead emissions. The area source contribution would be somewhat higher if prescribed burning and forest fires were included in the inventory. A table containing the lead emission values is included on page 25 in the air toxics section of this report.

Trends

In Minnesota, lead in the air has dropped significantly. Between 1984 and 1994 average lead concentrations decreased 87% from .53 micrograms per cubic meter ($\mu g/m^3$) to .06 $\mu g/m^3$. The national ambient air quality standard is 1.5 $\mu g/m^3$.

References/Web Links

http://www.epa.gov/air/urbanair/lead/index.html

http://www.pca.state.mn.us/air/lead.html#tips

http://www.pca.state.mn.us/air/toxics.html

http://www.commerce.state.mn.us/pages/Energy/Policy/06-Appendix%20A%20.pdf

Carbon Dioxide

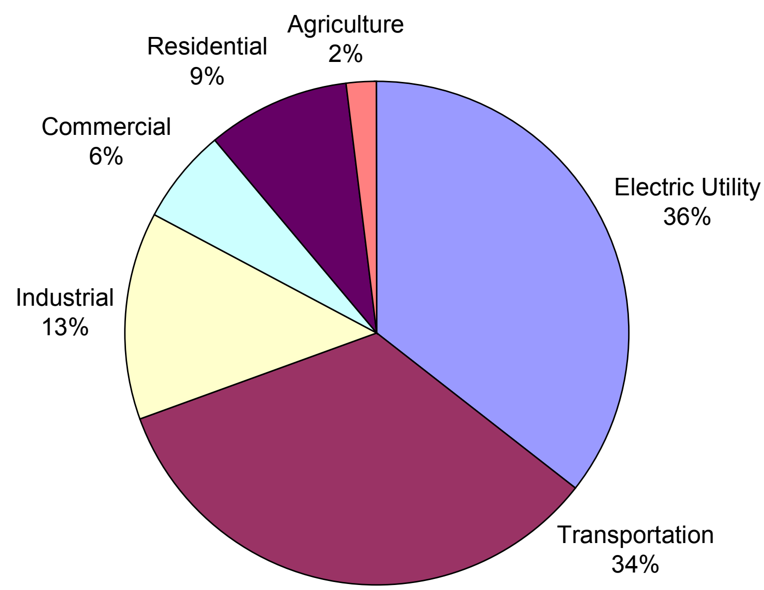
Carbon dioxide is a gas that is primarily formed from the combustion of fossil fuels such as oil, gas, and coal. It is a concern because it is the major greenhouse gas that contributes to accelerated warming of the earth's atmosphere. The earth's greenhouse effect is a natural phenomenon that helps regulate the temperature of our planet. Many greenhouse gases occur naturally, but fossil fuel burning and other human activities are adding gases to the natural mix at an unprecedented rate.

Emissions Data and Sources

The estimate for statewide emissions of carbon dioxide in 2000 is 109 million short tons.

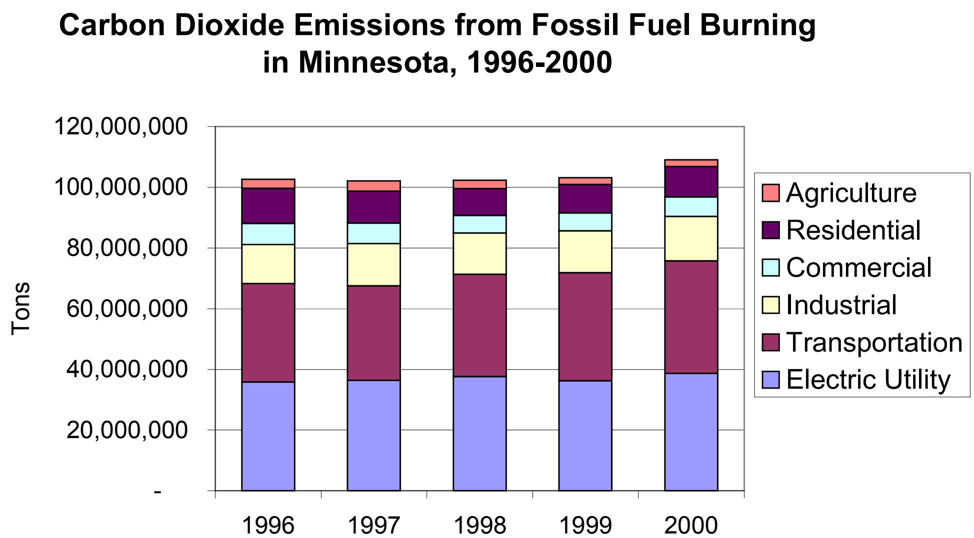
The pie chart below shows the breakdown of carbon dioxide emissions from fossil fuel burning by sector. The majority of the carbon dioxide emissions come from the electric utility (36%) and transportation (34%) sectors. The remaining 30 percent of the emissions come from fossil fuel combustion in the industrial, commercial, residential and agriculture sectors.

Sources of Carbon Dioxide Emissions from Fossil Fuel Burning in Minnesota, 2000



Trends

Over the five years from 1996-2000, carbon dioxide emissions from fossil fuel burning in Minnesota rose an average of 1.2 percent per year. These increases reflect a continuing increase in the electric utility and transportation sectors. From 1999 to 2000, carbon dioxide emissions increased 5.6 percent.



Source

The statewide emissions estimates for carbon dioxide were calculated in March, 2002 by Peter Ciborowski, MPCA senior pollution control specialist, using a variety of fuel use data sources.

Air Toxics

Through modeling and MPCA air toxics monitoring, several chemicals besides criteria pollutants have been identified at concentrations of potential concern in Minnesota air. These chemicals include compounds such as benzene, formaldehyde, acrolein, and polycyclic aromatic hydrocarbons (PAHs). Chemicals of potential concern in Minnesota are identified in the 1999 Staff Paper on Air Toxics, the 2001 Legislative Report--Air Quality in Minnesota: Problems and Approaches, and in the EPA's soon to be released National Air Toxics Assessment (NATA).

EPA refers to chemicals that cause serious health and environmental hazards as hazardous air pollutants or air toxics. EPA defines air toxics as pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects.

EPA tracks emissions of these chemicals in the National Toxics Inventory (NTI) Database. Minnesota values come from Minnesota Air Toxics Emission Inventory which includes 109 chemicals: 16 PAHs, 80 non-metal compounds (excluding PAHs), and 13 metal compounds. Twenty out of the 109 pollutants are not in the 1990 Clean Air Act Amendment Hazardous Air Pollutant list. The emissions inventory includes emissions from three principal source categories: point, area, and mobile sources.

- Point source - a stationary source of emissions, such as an electric power plant, that can be identified by name and location. A "major" source emits a threshold amount (or more) of at least one criteria pollutant, and must be inventoried and reported.
- Area source - a small point source such as a home or commercial building, or a diffuse stationary source, such as wildfires or agricultural tilling. These sources do not individually produce sufficient emissions to qualify as point sources. For example, a single dry cleaner typically will not qualify as a point source, but collectively the emissions from many dry cleaning facilities may be significant.
- Mobile source - any kind of vehicle or equipment with a gasoline or diesel engine. Mobile sources are broken up into two categories; highway sources which include gasoline and diesel cars and trucks and off-highway sources which include non-highway vehicles such as lawnmowers, construction equipment, snowmobiles, aircraft, marine vessels, railroads, etc.

Table 3 provides 1997 Minnesota emissions of air toxics. Emissions inventory data from 1999 will be available in the spring of 2003. These air toxics are a subset of the Minnesota Air Toxics Emissions Inventory. The table gives total statewide emissions of each chemical, along with the percent from point, area, highway, and off-highway sources. The emissions do not include forest fires or prescribed burning.

For more information on the Minnesota Air Toxics Emission Inventory, see the following web site:

http://www.pca.state.mn.us/air/toxics.html

For more information on air toxics, see the following web sites:

http://www.epa.gov/ttn/atw/index.html

http://www.pca.state.mn.us/air/airtoxics.html

http://www.pca.state.mn.us/hot/legislature/reports/2001/airquality.html

http://www.pca.state.mn.us/air/mercury.html

Table 3: 1997 Minnesota Air Toxics Emissions Inventory Statewide Summary

	Total (tons/yr)	Point	Area	Highway	Off-highway
Acenaphthene	7.2		100%		
Acenaphthylene	145		100%		
Acetaldehyde	1970	5%		44%	51%
Acrolein	170	27%		46%	27%
Acrylonitrile	4.1	1%	99%		
Anthracene	10		100%		
Antimony	1.7	80%	20%		
Arsenic	11	99%	1%		
Atrazine	249		100%		
Benz(a)anthracene	14		99%		1%
Benzo(ghi)perylene	3.9		91%	2%	7%
Benzene	7807	1%	22%	55%	21%
Benzo(a)pyrene	4.4	30%	68%	1%	2%
Benzo(b)fluoranthene	4.4		97%	1%	2%
Benzo(k)fluoranthene	1.5		93%	2%	5%
Beryllium	0.28	92%	8%		
Butadiene-1,3	692	1%		68%	31%
Cadmium	2.0	93%	7%		
Carbon tetrachloride	4.9	17%	83%		
Chloroform	29	74%	26%		
Chromium	13	92%	1%	2%	5%
Chromium VI	0.55	92%	8%		
Chrysene	9.1		94%	4%	1%
Cobalt	1.3	68%	32%		
Copper	31	44%	1%	55%	
Dibenz(a,h)anthracene	2.9		99%		1%
Dibromoethane-1,2	0.45	2%	98%		
Dibutyl phthalate	0.90	37%	63%		
Dichloroethane-1,2	1.0	33%	67%		
Diethylhexyl phthalate (DEHP)	8.4	100%	0.001%		
Ethylbenzene	2623	5%	9%	48%	38%
Ethylene oxide	51		100%		
Fluoranthene	14		99%		1%
Fluorene	17		100%		
Formaldehyde	4389	9%	1%	42%	48%
Glycol ethers	1199	35%	65%		
Hexachlorobenzene	0.0001		100%		
Indeno(1,2,3-cd) pyrene	14		100%		
Lead	82	96%		4%	
Manganese	118	99%			1%
Mercury	1.8	85%	4%	3%	9%
Methylene diphenyl diisocyanate (MDI)	0.14	100%			
Methylene chloride	460	37%	63%		

Table 3 continued: 1997 Minnesota Air Toxics Emissions Inventory Statewide Summary

	Total (tons/yr)	Point	Area	Highway	Off-highway
Naphthalene	719	2%	71%	26%	1%
Nickel	17	96%	1%	1%	2%
Phenanthrene	66		100%		
Phenol	78	95%	1%		4%
Polychlorinated biphenyls (PCBs)	0.0005	92%	8%		
Polychlorinated dibenzodioxins (PCDDs)	0.002	4%	96%		
Polychlorinated dibenzofurans (PCDFs)	0.01	3%	97%		
Pyrene	17		99%	0.5%	0.5%
Styrene	2337	64%		33%	3%
Tetrachloroethylene	393	19%	81%		
Tetrachlorodibenzo-p-dioxin-2,3,7,8 (TCDD)	0.00001	20%	80%		
Tetrachlorodibenzo-p-furan-2,3,7,8 (TCDF)	0.0003	15%	85%		
Toluene	20786	6%	33%	42%	19%
Toluene-2,4 diisocyanate (TDI)	0.003	100%			
Trichloroethane-1,1,1	965	5%	95%		
Trichloroethylene	283	85%	15%		
Trifluralin	26		100%		
Vinyl chloride	7.4	2%	98%		
Xylene, m	2527		3%	97%	
Xylene, o	1616	4%	12%	84%	
Xylene, p	24		100%		
Xylenes (isomers and mixtures)	14295	8%	30%	34%	28%

Water Pollutant Discharges Overview

Minnesota's rivers, streams and lakes provide great natural beauty, and supply the water necessary for recreation, industry, agriculture and aquatic life. The MPCA is the state agency responsible for protecting Minnesota's water quality. The major goal of the MPCA's water-quality program is to protect and improve Minnesota's rivers, lakes, wetlands and ground water so that they support healthy aquatic communities and designated public uses such as fishing, swimming and drinking water. The key strategies for accomplishing this goal include regulating point-source discharges, controlling nonpoint sources of pollution, and assessing water quality to provide information and data in order to make appropriate environmental management decisions.

Point sources consist mainly of municipal and industrial wastewater discharges. Point sources are most significant during periods of low precipitation and stream flow. Nonpoint sources include runoff from agricultural fields, feedlots, urban areas, and on-site sewage treatment systems. Nonpoint sources are most significant during periods of high precipitation and stream flow.

Minnesota has been successful in controlling the end-of-pipe discharges from wastewater treatment plants and industries to our state's waters. But at the same time, the challenges posed by nonpoint sources of pollution, for example, runoff from cities and agricultural areas, are increasing in proportion with changing land uses and expanding population and development.

In order to solve the problem of water pollution, the federal Clean Water Act requires states to adopt water quality standards to protect the nation's waters. These standards define how much of a pollutant can be in a surface and/or ground water while still allowing it to meet its designated uses, such as for drinking water, fishing, swimming, irrigation or industrial purposes.

For each pollutant that causes a water body to fail to meet state water quality standards, the federal Clean Water Act requires the MPCA to conduct a Total Maximum Daily Load (TMDL) study. A TMDL study identifies both point and nonpoint sources of each pollutant that fails to meet water quality standards. Rivers and streams may have several TMDLs, each one determining the limit for a different pollutant. Many of Minnesota's water resources cannot currently meet their designated uses because of pollution problems from a combination of point and nonpoint sources.

Major Water Discharge Parameters and Trends

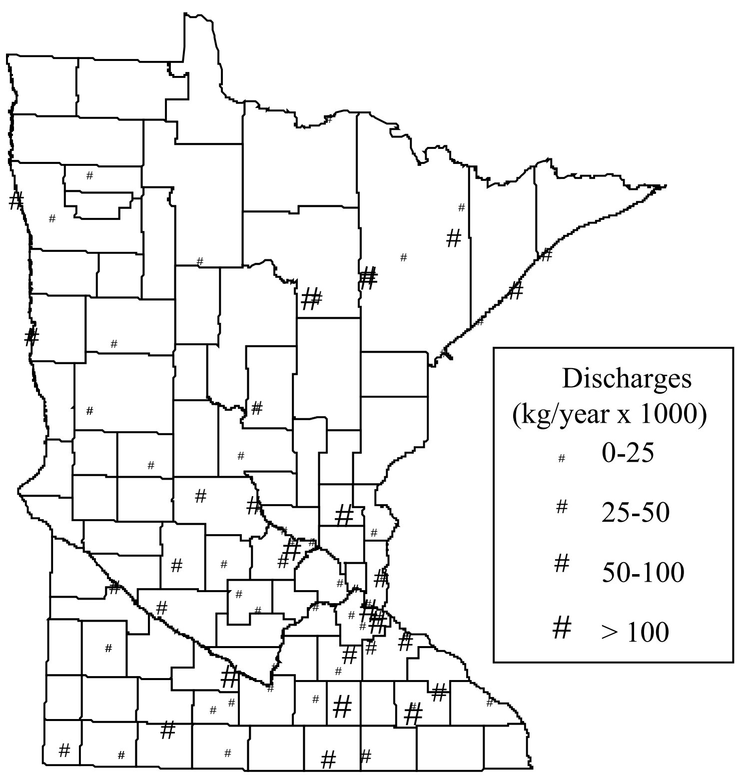
This report presents the following water pollutants that are released by major facilities (point sources) into Minnesota's waters: total suspended solids (TSS), biochemical oxygen demand (BOD), total phosphorus (TP), nitrate (NO_3) and ammonia (NH_3). The MPCA continues to investigate ways to effectively measure and report water pollution from nonpoint sources. A summary table of the data from 1996-2000 and an analysis of trends for these pollutants is shown on page 3 of this report.

Total Suspended Solids

Total suspended solids (TSS) is a measure of the material suspended in water or wastewater. Total suspended solids cause interference with light penetration, buildup of sediment and potential degradation of aquatic habitat. Suspended solids also carry nutrients that cause algae blooms that are harmful to fish and other aquatic organisms.

Based on results of Discharge Monitoring Reports for 85 major treatment facilities, the estimated discharge of total suspended solids (TSS) to waters of the state for the year 2000 was 5,119,000 kilograms. Total suspended solids were more than cut in half from 1996-2000. The state map below shows the 2000 total suspended solids discharges to surface waters by major point sources of water pollutants.

Total Suspended Solids Discharges from Major Point Sources, 2000

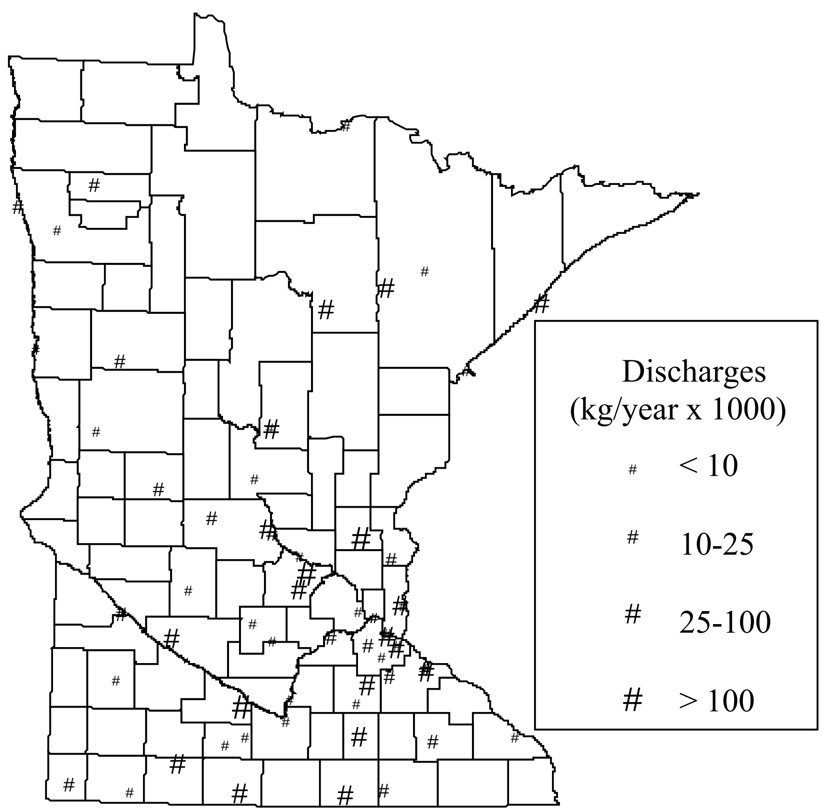


Biological Oxygen Demand and Carbonaceous Biological Oxygen Demand

When organic wastes are introduced into water, they require oxygen to break down. High concentrations of organic materials characterize untreated domestic wastes and many industrial wastes. The amount of oxygen required for decomposition of organic wastes by microorganisms is known as biological oxygen demand (BOD). The carbonaceous biological oxygen demand (CBOD) is the amount of oxygen required for microorganisms to decompose waste carbonaceous materials. Both BOD and CBOD are indicators of the strength of waste effluent and the effectiveness of treatment. A high demand for oxygen (the higher the number for BOD or CBOD) causes reduction in the concentration of dissolved oxygen in the receiving waters. Depletion of oxygen deteriorates water quality and impacts aquatic life, including fish and other organisms. Since their effects on receiving waters are similar, discharge data for BOD and CBOD have been combined in this report.

Based on results of Discharge Monitoring Reports for 85 major treatment facilities, the estimated discharge of the combined total of Biological Oxygen Demand (BOD) and Carbonaceous Biological Oxygen Demand (CBOD) to waters of the state for the year 2000 was 3,471,000 kilograms. As with total suspended solids, combined discharges of BOD and CBOD were more than cut in half between 1996-2000. The state map below shows the 2000 BOD discharges to surface waters by major point sources of water pollutants. Distribution of discharges for CBOD is similar.

Biological Oxygen Demand Discharges from Major Point Sources, 2000

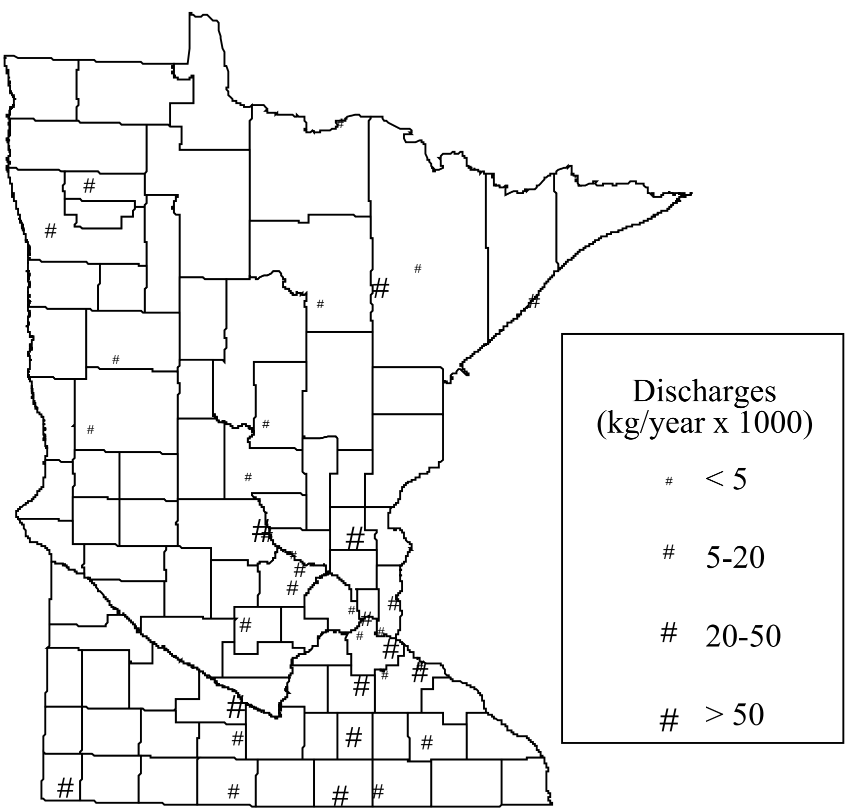


Total Phosphorus

Total phosphorus (TP) is the primary pollutant associated with the eutrophication of surface water from anthropogenic sources (sources that result from human activities). Excess phosphorus causes algae blooms and reduced water transparency, making water unsuitable for swimming and other activities. Phosphorus is released from both point and nonpoint sources of pollution. Minnesota has had point source effluent limitations for phosphorus since the early 1970s. According to Minn. Rule 7050.0211 subp. 1, "Where the discharge of effluent is directly to or affects a lake or reservoir, phosphorus removal to one milligram per liter shall be required. In addition, removal of nutrients from all wastes shall be provided to the fullest practicable extent whenever sources of nutrients are considered to be actually or potentially detrimental to the preservation or enhancement of designated waters."

Based on results of Discharge Monitoring Reports for 85 major treatment facilities, the estimated discharge of total phosphorus (TP) to waters of the state for the year 2000 was 1,441,000 kilograms. Phosphorus has shown some year-to-year variability from 1996-2000 with a slight increase overall. The state map below shows the 2000 total phosphorus discharges to surface waters by major point sources of water pollutants.

Total Phosphorus Discharges from Major Point Sources, 2000

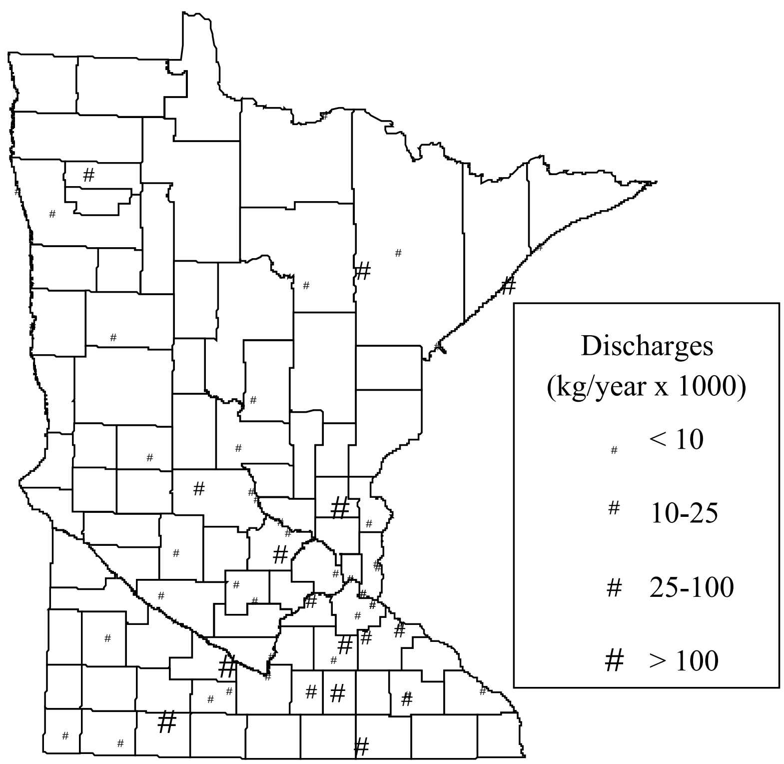


Nitrogen

Nitrogen, generally occurring as nitrate (NO_3) or ammonia (NH_3), is present in a wide variety of effluents including sewage (wastewater treatment plants and on-site sewage facilities), food processing wastes, mining effluents, landfill leachate, and agricultural and urban runoff. Nitrate and/or ammonia concentrations in most of these sources are monitored under permit requirements. Nitrogen as ammonia can be toxic to aquatic life and nitrogen in the form of nitrate is a significant problem in ground water supplies. Nonpoint sources of nitrogen from agricultural and urban runoff are a significant source of loading to waters of the state, although very little of this contribution is captured through Discharge Monitoring Reports required by permit.

Based on results of Discharge Monitoring Reports for 85 major treatment facilities, the estimated discharge of the combined total of nitrogen in the form of ammonia (NH_3) and nitrate (NO_3) was 5,967,000 kilograms. Of this total, 1,283,000 kilograms was in the form of ammonia and 4,684,000 kilograms was in the form of nitrate. The overall trend in discharge of ammonia was down about 20% from 1996-2000 while nitrate discharges have been relatively stable over the same five-year period. The state map below shows the 2000 ammonia discharges to surface waters by major point sources of water pollutants.

Ammonia Discharges from Major Point Sources, 2000



Emerging Contaminants of Concern

Organic Wastewater Chemicals

As we enter the 21st century, there have been increasing concerns about potential contamination of water resources that could result inadvertently during the production, use and disposal of the thousands of chemicals modern society has come to rely on in industry, agriculture, medical treatment and common household use. A common path for these chemicals to enter the environment is through wastewater from sewage treatment plants or on-site sewage treatment systems. Collectively, these chemicals are referred to as organic wastewater chemicals (OWCs). OWCs include human and veterinary drugs, antibiotics, hormones, detergents, disinfectants, plasticizers, fire retardants, pesticides and the breakdown products of these organic compounds as they degrade in the environment.

As our knowledge of the environmental occurrence and toxicological behavior of OWCs has grown, concern has increased about the potential adverse environmental and human health effects their presence in our water supplies may cause. For many OWCs, we have an incomplete understanding of their toxicological significance in the environment, particularly the effects of long-term, low-level exposure. The potential for OWCs to interact synergistically or antagonistically further complicates the issue. Until very recently, laboratory analytical methods did not exist to detect low levels of OWCs in water or wastewater. Rapid progress is being made to develop these methods and studies are now underway to assess the magnitude and impact of the effects of low levels of OWCs in the environment.

For an overview of the issue of OWCs in the environment, see:

http://toxics.usgs.gov/regional/emc.html

Endocrine-Disrupting Chemicals

One particularly troublesome category of OWCs includes endocrine-disrupting chemicals, or endocrine disruptors for short. Endocrine disruptors are chemicals present in the environment that, by virtue of their ability to interact with the endocrine system in humans and wildlife, cause a variety of adverse health effects. These effects have been identified primarily in species exposed to relatively high concentrations of manmade chemicals such as organochlorine pesticides, polychlorinated biphenyls (PCBs) and dioxins, as well as synthetic and plant-derived estrogens. Species that live and reproduce in and near water such as fish and amphibians are especially at risk.

There is increasing evidence that similar effects are occurring in the general human population from exposures to ambient environmental concentrations of these chemicals. For example, some studies have shown declines in the quantity and quality of sperm produced by human males in recent decades. Increases in incidences of certain cancers (breast, testes, prostate) have reportedly been linked to endocrine disruption. Because the endocrine system is critical to normal growth, development and reproduction, even small disturbances in endocrine function may have profound and lasting effects.

The most critical time of exposure is during sensitive prenatal periods. In addition to causing birth defects, small changes in endocrine function may have delayed consequences that become evident later in adult life or even in future generations. The potential for synergistic effects from multiple contaminants exists, but for the most part has not been researched. The seriousness of the endocrine disruptor issue and the many uncertainties associated with it have led to an increasing research effort, especially in the last 10 years.

For further information on this issue nationally see:

http://www.epa.gov/endocrine/

At the local level, MPCA conducted two surveys of a variety of emerging contaminants in surface water, biota, ground water and waste streams in 2001. Fish and sediments from six large rivers in the state (Mississippi, Minnesota, Red, Rainy, St. Croix and St. Louis Rivers) are being tested for polybrominated diphenyl ethers (PBDEs). PBDEs are widely used as flame retardants on clothing, carpeting and upholstery. They are persistent in the environment and accumulate in the food chain. The fish and sediment samples were collected below the largest wastewater treatment plant (WWTP) discharge on each river. Sludge from two WWTPs are being tested for PBDEs as will several landfill leachates and landfill sludges.

In cooperation with the U. S. Geological Survey and the Minnesota Department of Health, the MPCA also conducted a study of the occurrence of pharmaceutical compounds, hormones, human and livestock antibiotics and household and industrial-use compounds in surface water below WWTP discharges, wastewater effluents, landfill leachates and ground water potentially impacted by individual sewage treatment systems, urban land use and feedlots. The surface waters targeted in this study were the large rivers of the state and six small streams with relatively high contributions from WWTP effluents (low dilution streams). A project report is expected to be released in late 2002.

Antibiotics and Antibiotic-Resistant Bacteria

Antibiotics and related pharmaceuticals are a large class of OWCs increasingly being discovered in both surface and ground water. For example, sulfoamide and tetracycline antimicrobials have been recently documented in surface and ground water by USGS. The results of this work are described in:

http://toxics.usgs.gov/regional/Lindsey_AC_2001.pdf

A related problem, the increased prevalence of antibiotic resistance, is an outcome of evolution and society's increased reliance on antibiotics. Whenever antibiotics are used, there is selective pressure for resistance to occur. Any population of organisms, bacteria included, includes variants with unusual traits, such as the ability to withstand an antibiotic's attack on a microbe. When we take an antibiotic to treat symptoms of a disease, the drug kills defenseless bacteria, leaving behind ("selecting") those remaining that can resist it. The survivors then multiply until they become the dominant microorganism.

Antibiotic resistance results from gene action when bacteria acquire genes conferring resistance by such mechanisms as spontaneous mutation of DNA (genetic material) or microbial transformation. The antibiotic does not cause the resistance, but allows it to happen where an already existing variant can flourish. Once resistance is established, it builds upon itself as more organisms develop resistance to more drugs. In recent years, there have been a number of examples of increasing drug resistance in humans and other animals including a resurgence in tuberculosis and cases of penicillin-resistant pneumonia.

Nonpoint Source Pollution

As discussed above, Minnesota has made significant progress in cleaning up point sources of water pollution as measured by discharges of major pollutants in municipal and industrial wastewater. A indicator of this success is shown by the fact that the 85 major treatment facilities discharging more than one million gallons per day have cut their total volume of discharge to waters of the state by about 40 percent from 1996 to 2000.

It is the nonpoint sources of pollution from rainfall or snow melt moving over or through the ground carrying natural and human-made pollutants into lakes, rivers, wetlands and ground water that now pose the greater challenge for cleanup. Both point and nonpoint sources of pollution must be controlled to reach the Clean Water Act goal of fishable, swimmable waters in the State. Too much phosphorus and nitrogen continue to reach our lakes, rivers and shallow ground water aquifers, carried in soil erosion and runoff from roads, yards, farms and septic systems.

Many of the stresses from nonpoint source pollution that affect our surface and ground water resources are the result of choices that individuals make every day, such as lawn care, watercraft operation and waste disposal. The daily decisions that homeowners, developers, farmers and businesses make regarding land use are crucial to protecting water resources from the effects of nonpoint source pollution. Once a water resource declines in quality, recovery is costly and can take many years. Clearly, prevention is the key when it comes to nonpoint source pollution. What happens to Minnesota's water resources in the next 10 years will help determine the quality of those resources for the next 100 years.

The effects of solely nonpoint source pollution on a water resource are often difficult and expensive to measure. The best long-term data about Minnesota streams comes from measuring six key pollutants at 80 stream locations over the past 40 years. These locations are chosen to not be unduly influenced by the effects of point source pollution although the results certainly reflect the contribution of all discharges upstream of the monitoring point. The results agree well with those shown by point source discharges from Discharge Monitoring Reports in that significant reductions in ammonia, biochemical oxygen demand, phosphorus, total suspended solids and fecal coliform bacteria have been observed. Only nitrogen (as NO_3) which is generally associated with nonpoint sources of pollution has increased over the same period, a result that is also reflected in the discharge monitoring reports as shown in Table 2. Ground water data collected from 1992-1996 show that in aquifers that are sensitive to nitrate contamination, 60 percent of the wells monitored had nitrate levels above one part per million (ppm). Of these, 18 percent contained nitrates above the state drinking water standard of 10 ppm. Again, much of this is likely due to effects of land use practices at the surface and the effects of nonpoint source pollution.

For a further discussion of the effects of nonpoint source pollution on Minnesota's water resources see:

http://www.pca.state.mn.us/about/pubs/mnereport/

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