Annual Pollution Report

to the Legislature

April 2005

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Foreword

The Annual Pollution Report statute requires the Minnesota Pollution Control Agency (MPCA) to estimate to the best of its ability the total amounts of air and water pollution emitted in the state during the most recent calendar year for which data are available. The statute further directs the MPCA to estimate the percentage increase or decrease over the previous calendar year, and to estimate the relative contributions of the various sources of these emissions and discharges to the environment.

The MPCA has prepared this report since 1996. It has evolved to include new kinds of information, such as discharges of toxic air pollutants, greenhouse gas emissions, and emerging contaminants of concern as these kinds of data have become available. The following observations of some strengths and shortcomings of the current reporting process are presented for interested parties to help determine if and how the report should be changed.

Strengths

- The Annual Pollution Report is the only MPCA report that specifically asks for an accounting of emissions and discharges. Such inventories are inherently important, as understanding emission amounts and sources is fundamental in protecting the environment and human health.

- The report attempts to track trends year to year, which is valuable if data are reliable.

- The report covers both air and water pollutants in one document, instead of separate reports, reminding readers of the potential for cross-media impacts.

- The report shows relative contributions of various pollution sources to the total.

Minn. Statutes 116.011 Annual pollution report.

A goal of the pollution control agency is to reduce the amount of pollution that is emitted in the state. By April 1 of each year, the pollution control agency shall report the best estimate of the agency of the total volume of water and air pollution that was emitted in the state in the previous calendar year for which data are available. The agency shall report its findings for both water and air pollution:

(1) in gross amounts, including the percentage increase or decrease over the previous calendar year; and

(2) in a manner which will demonstrate the magnitude of the various sources of water and air pollution.

HIST: 1995 c 247 art 1 s 36; 2001 c 187 s 3

Shortcomings

- Aggregating data into total volumes lacks the important context of relative risk. Pollutants emitted in smaller volumes can have a greater impact than some emitted in tremendously larger volumes. The volume figures also do not convey whether such emissions and discharges are acceptable or unacceptable from a risk perspective.

- The most current pollutant emissions and discharge data is usually at least two years behind real time, sometimes more, depending on the type of pollutants. Air emission estimates are frequently revised as industrial output models and factors used to estimate emissions are refined. Year-to-year comparisons are not always reliable, as methodologies for estimating emissions are still evolving.

- There is currently no reliable way to quantify the volumes of water pollutants released by nonpoint sources in the form of polluted runoff, such as city streets, construction sites and farm fields. This is a major gap in inventorying pollutants discharged, for a category highly culpable for water quality impairments.

As with the 2004 report, this year's report presents some of the information differently. For example:

- Air pollution estimates for point source emissions are based on the Minnesota emission inventory.

- Nonpoint source water pollutant estimates are being highlighted in basin-loading studies, which attempt to quantify the amounts of specific pollutants entering a given watershed from specific sources, both point and nonpoint. While this falls short of being able to quantify nonpoint source discharges statewide, it represents an important first step to better understanding the relative contributions of point and nonpoint sources to specific watersheds, which in turn can guide local and state officials in planning for water quality improvements.

The examples noted above are presented to help the reader get a sense for the dilemmas the MPCA faces in attempting to deliver accurate, timely and useful information about what is discharged into Minnesota's air and water.

The MPCA has significantly expanded and improved public access to environmental data available electronically through its Environmental Data Access Initiative, funded by the Legislature. Water quality data and air quality data from all over the state are now easily available at this link: http://www.pca.state.mn.us/data/eda/index.cfm

As this system continues to grow and evolve, the MPCA will evaluate new reporting formats for presenting annual pollution data. The agency welcomes suggestions from interested parties for upgrading the current reporting process to better meet the purpose envisioned in the statute.

Introduction and 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 2005 Annual Pollution Report is the 1999 and 2002 Minnesota Criteria Pollutant Emission Inventories, the 1999 Air Toxics Emission Inventory and the 2003 Water Quality National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Reports, which are part of the U.S. Environmental Protection Agency's (EPA) Permit Compliance System.

Annual emission 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.

Air Emissions

The MPCA reports data from its own Minnesota Criteria Pollutant Emission Inventory, using data generated in the state, for more accurate results. Prior to the 2004 report, EPA data was used. 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 lead. These are known as the criteria pollutants. The most recent emissions data available from large facilities for these pollutants are from 2002.

About Emission Inventories

Completing air pollutant emission inventories is a time-intensive process. For example, to develop the Criteria Pollutant Emission Inventory for the year 2002, facilities with MPCA permits had until April 1, 2003 to submit their 2002 emissions estimates to the MPCA. Agency staff then compiled these emission estimates into a draft Criteria Pollutant Emission Inventory, which was sent back to the facilities for review in December 2003. Facilities completed their review by February 1, 2004. MPCA staff then reviewed the changes and completed the inventory for 2002 in March 2004.

The Minnesota Air Toxics Emission Inventory is completed once every three years to coincide with the three-year cycle of the U.S. EPA's National Emission Inventory. MPCA staff develop emissions estimates for the Air Toxics Emission Inventory based upon the completed Criteria Pollutant Emission Inventory, the assistance of permittees, and statistical information from other state and federal agencies.

Global climate change is a continuing concern worldwide. Therefore, Minnesota emissions of the principal greenhouse gas, carbon dioxide (CO_2), are included for 2002. 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 benzene and formaldehyde. There may be some overlap between the Minnesota Air Toxics Emission Inventory and the estimates for VOCs because many air toxics are also VOCs. The most recent complete inventory of air toxics emissions is from 1999.

The MPCA releases a complete emission inventory including criteria pollutants and air toxics every three years. Emissions of criteria pollutants from large facilities are estimated every year. Therefore, the 2002 emissions include 2002 criteria emissions from large facilities. The 1999-2002 numbers all include 1999 data from smaller area and mobile sources. Updated 2002 emissions from area and mobile sources will be available in mid-2005. The air toxics emission inventory will also be updated at that time.

Table 1 lists the total statewide emissions of the major air pollutants from 1999 to 2002. The percent change from 2001 to 2002 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.

Table 1: Minnesota Air Pollution Emission Estimates, 1999-2002
(thousand tons)*

Pollutant	1999	2000	2001	2002	2001-2002 % Change
Carbon monoxide (CO)	2503	2505	2503	2508	+0.2%
Sulfur dioxide (SO_2)	154	156	150	157	+4.6%
Oxides of nitrogen (NO_x)	478	482	466	478	+2.6%
Volatile organic compounds (VOCs)	396	395	393	393	0.0%
Particulate matter (PM_{10})**	858	862	850	852	+0.2%
Total	4389	4400	4362	4388	+0.6%

*1999 mobile and area emission estimates are used in all years. Differences between years are attributable to changes in point source emissions.
**PM_{10} emissions represent only primary formation; secondary formation is not included.

There may be differences in the total emission figures for a given year discussed in this report versus emission reports that the MPCA has published prior to 2004 because MPCA data is being used instead of EPA data. Differences in methodology exist between the two inventories. In addition, data may be updated in MPCA's emission inventory due to corrections or changes in methodology.

It should also be noted that despite the importance of the secondary formation of particulate matter, 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. Although EPA-approved models to predict the secondary formation of fine particulates do not currently exist, work is underway to develop these models. Direct emissions of fine particulate matter ($PM_{2.5}$) are included for the first time this year in the Minnesota Criteria Pollutant Emission Inventory.

All pollutants either remained unchanged or showed a slight increase from 2001 to 2002. All of the increase was attributable to point sources, since only 1999 emissions are available for area and mobile sources. The increase in SO_2 was the result of higher emissions from utilities. The small increase in NO_x resulted from longer hours of operations at taconite facilities. The total emissions of CO_2 in 2002 were 112 million short tons. This represents a 5.6 percent increase from 2001. The 1999 air toxics emissions 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 any discharges to waters of the state. These self-monitoring reports submitted to MPCA are commonly referred to as Discharge Monitoring Reports (DMRs). 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 (Table 2) for the last five years for which data are available, ending in 2003. The 2003 figures represent the combined loading from 60 municipal and 26 industrial discharges (86 major facilities discharging more than one million gallons per day to waters of the state). These major facilities represent approximately 85% of the total volume of discharge to waters of the state from point sources. The remaining 15% comes from many smaller municipal and industrial facilities. Although discharges from these facilities are small, they can have significant impacts on individual lakes and stream segments.

Table 2: Minnesota Water Pollution Discharge Estimates from Major Point Sources, 1999-2003 (thousand kilograms)

Pollutant	1999	2000	2001	2002	2003	2002 to 2003 % Change
Total suspended solids	6,069	5,119	8,552	8,852	8,266	-6.6%
Biochemical oxygen demand (BOD)	4,264	3,471	4,920	5,828	6,789	+14.2%
Phosphorus	1,405	1,441	1,374	1,289	1,546	+16.6%
Ammonia (NH_3)	1,219	1,283	1,023	1,127	1,521	+25.9%
Nitrate (NO_3)	4,701	4,684	4,276	4,234	3,576	-15.5%
Total	17,658	15,998	20,145	21,330	21,698	+1.7%

In 2003, two municipal facilities at Rosemount (operated by the Metropolitan Waste Control Commission) and at Lake City were added to the majors DMR database. These facilities added 278 million and 236 million gallons of flow and 16,674 and 6,499 kilograms of total suspended solids (TSS) respectively to the statewide database. Of the remaining 84 major facilities, 35 showed an increase in TSS loading over 2002, 46 showed a decrease in TSS loading over 2002, and three facilities reported insufficient data to allow a determination to be made. The 6.6% decrease in discharge of TSS to waters of the state (Table 2) represents a return to the year-to-year downward trend noted from 1997-2000 before the flood year of 2001 (when the Mississippi River was above flood stage for over a month during the spring) and 2002 (a record wet year in many areas, with frequent high-intensity rainfall events). In 2003, spring snowmelt, runoff and precipitation returned to a more "normal" pattern, and this is likely reflected in the overall decrease in TSS, despite increases in biochemical oxygen demand (BOD), phosphorus (P) and ammonia (NH_3) for the statewide database.

Although BOD, P and NH_3 showed increases from 2002 to 2003, the overall trend towards a lower rate of increase in the five discharge parameters is encouraging. The overall increase of 1.7% from 21,330 thousand kilograms (2002) to 21,698 thousand kilograms (2003) is the smallest increase in the statewide total discharge since a 9.4% decrease occurred between 1999 and 2000. The increase in BOD, P and NH_3 could be the result of increased loadings due to population growth, economic expansion and the addition of two major municipal treatment facilities to the 2003 statewide database.
Although statewide P discharges returned to a level not seen since before 1999, nitrate (NO_3) discharges continued a downward trend that began in 1999. Nitrate showed a 15.5% decline in 2003 over 2002. Statewide, NO_3 discharges have declined 31% since peaking at 4,701 thousand kilograms in 1999. This is encouraging, since NO_3 continues to be a major contributor to the problem of hypoxia in the Gulf of Mexico.

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 agriculture and urban runoff. Point sources tend to have the greatest impact on receiving waters during periods of low precipitation and stream flow, while nonpoint sources are most significant during periods of high precipitation and stream flow. However, it is difficult to measure directly the effects of nonpoint pollution on Minnesota's lakes, rivers and ground water. Best estimates suggest that approximately 86% of water pollution in Minnesota can be attributed to nonpoint sources, while about 14% comes from point sources.

The MPCA continues to investigate better ways to assess and measure nonpoint pollution, but nonpoint source monitoring is expensive and often requires a more complex, labor-intensive (and therefore more costly) monitoring network than measuring volume and quality of discharge from pipes. The MPCA continues to conduct loading studies for a number of watersheds in the state. The 2004 Annual Pollution Report included results of one such study on the Crow River basin in central Minnesota. This year we report on a study of watershed improvements in the city of Minneapolis chain of lakes by tracking phosphorus concentrations, a key indicator of nonpoint pollution. We also summarize a current MPCA initiative to assess the effect of use of road salt and other deicing chemicals on waters of the state.

Chapter 1: 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 these reasons, the MPCA attempts 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, the MPCA estimates 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 oxides (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 Minnesota Criteria Pollutant Emission Inventory estimates emissions of five criteria pollutants (PM_{10}, SO_2, NO_x, CO and Pb). Ozone is not directly emitted, so a group of ozone precursors called volatile organic compounds (VOCs) is included instead. $PM_{2.5}$ was calculated for the first time for the 2002 emissions inventory; however, only point sources are available for this report. To provide some additional details about ozone and $PM_{2.5}$, the Criteria Pollutant Emissions section contains information about ozone, sources of fine particulates in Minnesota and a summary of the MPCA's Air Quality Index (AQI) data for 2004.

Greenhouse Gases

Although greenhouse gases do not necessarily directly harm human health, their increase in concentration can lead to global climate change. The principal greenhouse gas emitted is carbon dioxide (CO_2). MPCA tracks CO_2 emissions in Minnesota.

Air Toxics

Many other chemicals are released in smaller amounts than the criteria pollutants, but are still toxic. The 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 organic matter. Minnesota data come from the 1999 Minnesota Air Toxics Emission Inventory. The 2002 Air Toxics Emission Inventory should be complete in June 2005.

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: Progress and Priorities—2005 Report to the Legislative
http://www.pca.state.mn.us/publications/reports/lr-airqualityreport-2005.html

Air Quality in Minnesota: Into the Future—2003 Report to the Legislative
http://www.pca.state.mn.us/publications/reports/lr-airqualityreport-2003.html

Air Toxics Monitoring in the Twin Cities Metropolitan Area Preliminary Report
http://www.pca.state.mn.us/hot/legislature/reports/2003/lr-airtoxmonitoring-1sy03.pdf

Criteria Air Pollutant Emissions

Minnesota's Emission Inventory Rule requires all facilities in Minnesota that have an air emissions permit to submit an annual emission inventory report to the Minnesota Pollution Control Agency (MPCA). The report quantifies emissions of the regulated pollutants listed below:

- carbon monoxide (CO)
- nitrogen oxides (NO_x)
- lead (Pb)
- particulate matter less than 10 microns in diameter (PM_{10})
- sulfur dioxides (SO_2)
- volatile organic compounds (VOC)

The emission inventory is used to track the actual pollutant emissions of each facility and to determine the type and quantity of pollutants being emitted into the atmosphere. Ozone is a criteria pollutant that is not directly emitted, so a group of ozone precursors called volatile organic compounds (VOCs) is included instead. The data is then used to calculate an annual emission fee for each facility. Starting with the 2002 inventory, MPCA has also begun estimating $PM_{2.5}$ emissions from PM_{10} emissions using an EPA model.

The Minnesota Criteria Pollutant Emission Inventory estimates emissions from these large facilities every year in order to fulfill the Minnesota rule. In addition, every three years, the MPCA estimates emissions from two other principal source categories: area sources and mobile sources. Overall, the Minnesota Criteria Pollution Emission Inventory includes emissions from three principal source categories.

1. **Point Sources**: Typically large, stationary sources with relatively high emissions, such as electric power plants and refineries. A "major" source emits a threshold amount (or more) of at least one criteria pollutant, and must be inventoried and reported.
2. **Area Sources**: Typically stationary sources, but generally smaller sources of emissions than point sources. Examples include dry cleaners, gasoline service stations and residential wood combustion. Area sources may also include 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 gas station typically will not qualify as a point source, but collectively the emissions from many gas stations may be significant.
3. **Mobile Sources**: Mobile sources are broken up into two categories; on-road vehicles and non-road sources. On-road vehicles include vehicles operated on highways, streets and roads. Non-road sources are off-road vehicles and portable equipment powered by internal combustion engines. Lawn and garden equipment, construction equipment, aircraft and locomotives are examples of non-road sources.

The most current criteria pollutant emission inventory for the State of Minnesota is available for all three principal source categories in 1999 and for point sources for 2002. When 2002 summary data is given, it includes area and mobile data from 1999 and point source data from 2002. This report presents trend data for point sources from 1998-2002.

With each new inventory, improvements are made in terms of pollutants covered, source categories included, and the accuracy of emission estimates. Therefore, changes in the way emissions are calculated may 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 emission reports the MPCA has published because MPCA data is used starting with the 2004 report. Prior to 2004, EPA emissions data was used. Differences in methodology exist between the two inventories. Data may be also updated in past emission inventories due to corrections or changes in methodology.

In addition, despite the importance of secondary formation for some pollutants (e.g. PM_{10}), 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, because there is currently no reliable way to estimate their quantity. However, models to predict secondary formation of particulates are under development.

Find more information on the Minnesota Criteria Pollutant Emission Inventory:
http://www.pca.state.mn.us/air/criteria-emissioninventory.html

See the MPCA Environmental Data Access web site to download MPCA emission estimates:
http://www.pca.state.mn.us/data/edaAir/index.cfm

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

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

Air Quality Index (AQI)

The Air Quality Index (AQI) was developed by the EPA to provide a simple, uniform way to report daily air quality conditions.

In Minnesota, four criteria pollutants are used to calculate the AQI: ground-level ozone, sulfur dioxide, carbon monoxide and fine particles ($PM_{2.5}$). The AQI is currently calculated for the Brainerd area, Duluth, Ely, Rochester, St. Cloud, and the Twin Cities area. The Brainerd area includes the Mille Lacs monitoring site and a new monitoring location in Baxter. All pollutants are not monitored at each location.

The AQI translates each pollutant measurement to a common index, with an index of 100 set to reflect where health effects might be expected in sensitive populations. The pollutant with the highest index value is used to determine the overall AQI. The table below shows the different AQI categories along with the corresponding index range.

AQI Color Legend:

Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300

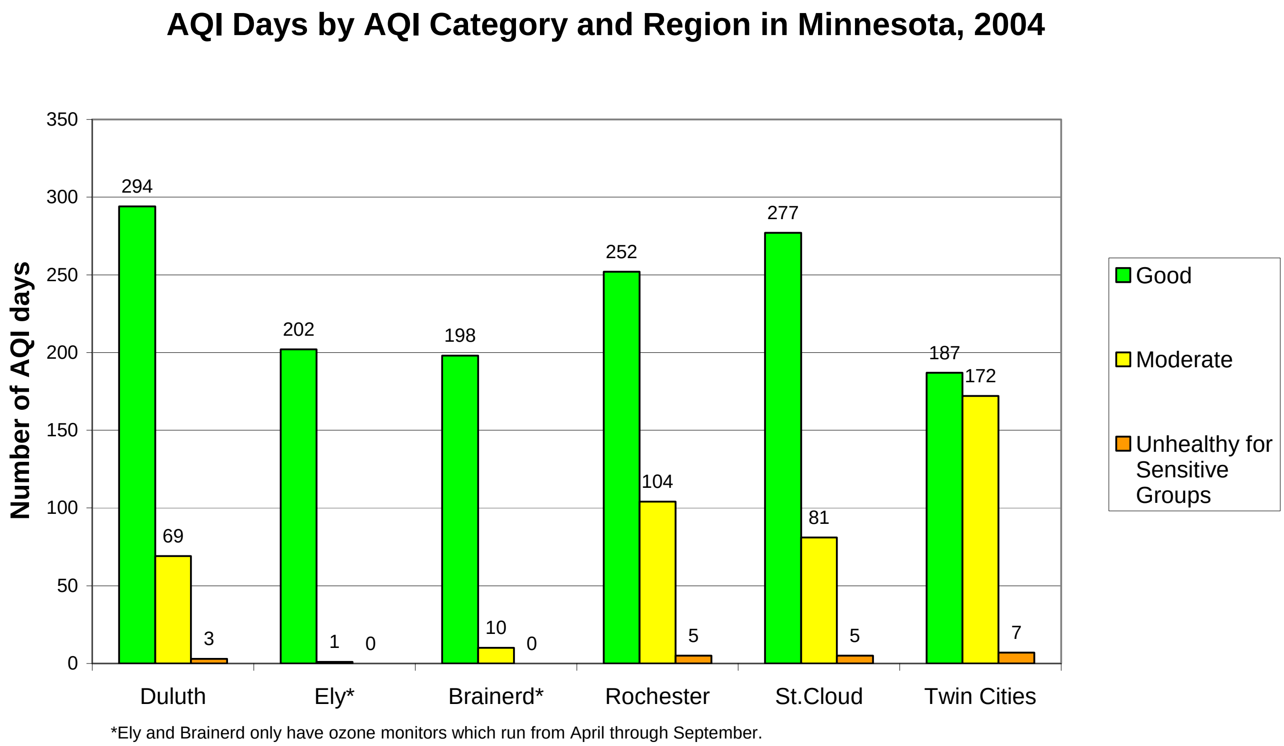
The AQI in Minnesota cities rarely reaches the Unhealthy range; however, many citizens are affected by air quality in the Unhealthy for Sensitive Groups category.

The chart on the next page displays the number of Good, Moderate, and Unhealthy for Sensitive Groups days in Minnesota in 2004. Days are categorized by the highest AQI level calculated at anytime during that day. The EPA may report different AQI summary totals for Minnesota because the MPCA and EPA use different methods to calculate the AQI.

The Twin Cities had 187 Good air quality days, 172 Moderate air quality days and 7 days that were considered Unhealthy for Sensitive Groups.

Since not all pollutants are monitored at each location, some regions do not show a total of 366 (2004 was a leap year) days being reported for the year. For instance, the Ely and Brainerd locations were only monitored for ozone in 2004. Ozone is only a problem in warm weather and is monitored from April through September. Monitors may also be shut down for maintenance for short periods of time.

High AQI days in Minnesota are usually the result of elevated levels of ozone and $PM_{2.5}$. Ely and Brainerd have fewer Moderate and Unhealthy for Sensitive Group days than the other locations, in part, because these sites did have $PM_{2.5}$ monitors. The Twin Cities area likely has the highest number of Moderate and Unhealthy for Sensitive Group days because it has a higher population and more sources of ozone and $PM_{2.5}$ than the other regions.



References/Web Links

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

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

http://www.epa.gov/airnow/

http://www.epa.gov/airnow/aqibroch/

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.

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, which are briefly described in the following sections.

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

$PM_{2.5}$

Fine particles can be inhaled deeply into the lung. These particles then accumulate in the respiratory system and are linked with a number of serious health effects such as increased cardiovascular and respiratory hospital admissions and deaths. Studies indicate that peaks in $PM_{2.5}$ may aggravate respiratory conditions such as asthma and chronic bronchitis.

For seven days in 2004, levels of fine particulate matter were high enough in the Twin Cities area to lead to air alerts for people in sensitive groups. These groups include people with respiratory or heart disease, the elderly and children. $PM_{2.5}$ was also responsible for the majority of Moderate air quality days. The number of Moderate days is significant because recent evidence suggests some people may suffer health effects in the Moderate air quality range.

Emissions Data and Sources

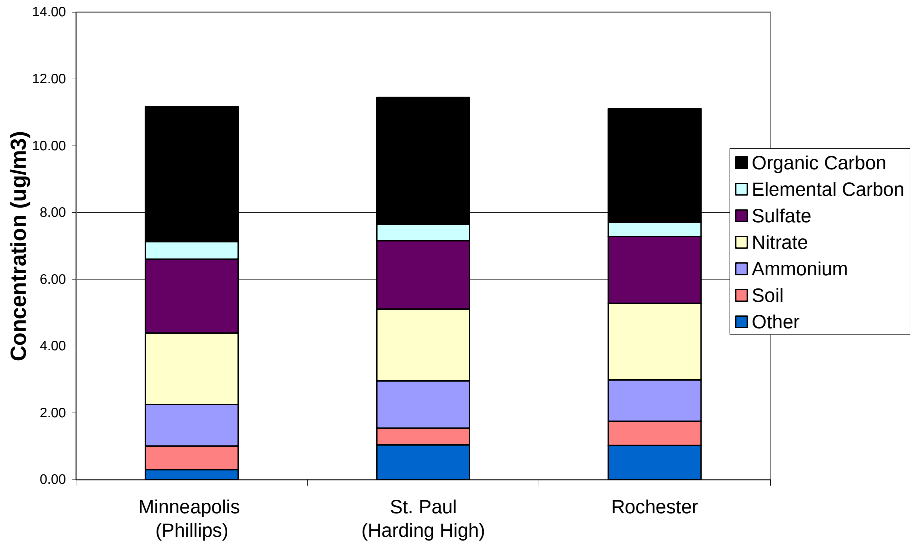
Fine particles can be directly released during combustion processes, for example, when coal, gasoline, diesel, other fossil fuels and wood are burned. Many particles are also formed secondarily in the atmosphere from chemical reactions involving gaseous pollutants such as nitrogen oxides, sulfur oxides, some volatile organic compounds and ammonia. Major sources of fine particles are cars, trucks, buses, diesel construction equipment, coal-fired power plants, biomass (wood, vegetation, etc.) burning and agriculture.

Because they are tiny and light, fine particles can be carried by the wind for hundreds of miles, making exposure to these pollutants a regional problem. Unlike ozone, which is typically elevated in the hot summer months, fine particles can be a problem throughout the year.

The MPCA began estimating direct sources of $PM_{2.5}$ emissions in the 2002 Minnesota Criteria Pollutant Emissions inventory. Currently only point source emissions are completed. In addition, secondarily formed particles which are not directly emitted, but are formed downwind of the emissions source are not included because they cannot be accurately quantified at this time. Work is underway to develop models to predict secondary formation. This is significant because secondary particles are a major component of the mass of ambient $PM_{2.5}$.

While complete emissions data is not available, the MPCA has three fine particle monitors in St. Paul, Minneapolis and Rochester, which help determine the source of particles in urban areas. The figure on the next page shows the results of a preliminary analysis of the major $PM_{2.5}$ components from these monitors.

$PM_{2.5}$ Composition at Three Minnesota Sites, 2003



The concentrations of the major fractions of $PM_{2.5}$ are very similar across the three monitors. The largest fraction is organic carbon, followed by sulfate and nitrate. Getting a sense of the composition of fine particles in Minnesota can help to pinpoint the sources of these particles.

Organic carbon particles: These can be either primary particles or can be formed secondarily from the reaction of some volatile organic compounds. They can result from human activities (fossil fuel consumption, prescribed fires, cooking) or biogenic activities (vegetative material, biogenic gases, naturally occurring forest fires). Scientists are unsure at this point whether the majority of organic carbon particles are of primary or secondary origin. See the VOC section of this report for Minnesota's 2002 VOC emissions associated with human activities.

Fine sulfate particles: These result from the oxidation of sulfur dioxide, forming sulfuric acid, which can then react with ammonia. Most sulfur dioxide emissions result from human sources including coal-fired power plants and other industrial sources such as smelters, industrial boilers and oil refineries. See the SO_2 section of this report for Minnesota's 2002 SO_2 emissions.

Nitrate particles: These particles form from the oxidation of nitrogen oxides. Nitrogen oxide gases are released from virtually all combustion activities, especially those involving cars, trucks, buses, off-road sources (e.g., construction equipment, lawn mowers and boats), coal-fired power plants and other industrial sources. See the NO_x section of this report for Minnesota's 2002 NO_x emissions.

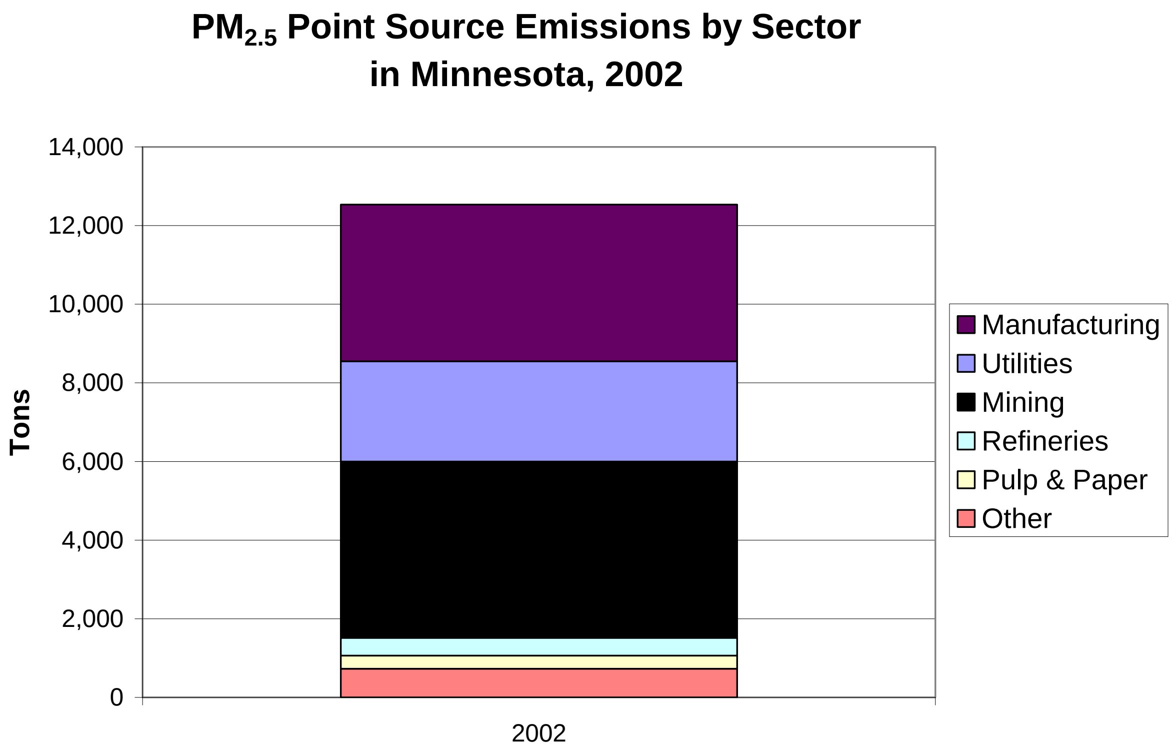
Elemental carbon particles: These particles are commonly called soot. They are smaller than most particles and tend to absorb rather than scatter light. These particles are emitted into the air from virtually all combustion activity, but are especially prevalent in diesel exhaust and smoke from the burning of wood and wastes.

Ammonia: Most of the ammonia emitted in Minnesota is generated from livestock waste management and fertilizer production and use.

Soil: This fraction consists of primary particles that are eroded from the landscape.

Trends

The MPCA estimated direct point sources of $PM_{2.5}$ emissions for the first time in 2002. A total of 12,532 tons of direct $PM_{2.5}$ was emitted from point sources in 2002. These sources constitute only a small percentage of the total $PM_{2.5}$ emitted from area and mobile sources and secondarily formed in the atmosphere from other compounds. The majority of $PM_{2.5}$ emissions came from the manufacturing, utilities and mining sectors. The emissions inventory tends to be dominated by larger particles which tend to have more mass. Particles between 1 and 2.5 µm in diameter may come from mechanical breakdown; however, smaller particles below 1 µm are generally considered to pose a greater risk to human health. These particles tend to be emitted from combustion sources. Therefore, the sources that dominate mass based emission inventories may not be the sources that pose the greatest risk to human health.



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/airnow/aqguidepart.html

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

PM_{10}

Exposure to PM_{10} particles is primarily associated with the aggravation of respiratory conditions such as asthma. PM_{10} has also been linked to cardiovascular mortality and related health effects, but many studies indicate a stronger association between $PM_{2.5}$ and these health effects.

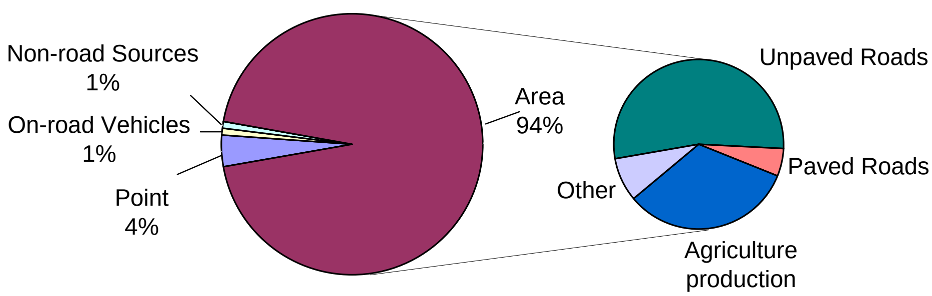
Coarse particles are generally emitted from sources such as vehicles traveling on unpaved roads, materials handling, and crushing and grinding operations, and windblown dust. Coarse particles can settle rapidly from the atmosphere within hours, and their spatial impact is typically limited (compared to $PM_{2.5}$) because they tend to fall out of the air in the downwind area near their emissions point.

Emissions Data and Sources

The MPCA estimate for statewide direct emissions of PM_{10} in 2002 is 851,946 tons.

The figure below shows estimated sources of 2002 PM_{10} direct emissions.

Sources of PM_{10} Emissions in Minnesota, 2002



Emissions of naturally occurring and secondarily formed PM_{10} are not accounted for in these pie charts and graphs. Area sources contribute 94 percent of PM_{10} emissions. The majority of area source emissions come from dust from unpaved roads (54 percent) and agriculture production (33 percent). Fugitive dust from paved roads and construction and combustion sources make up the remainder of the area source contribution.

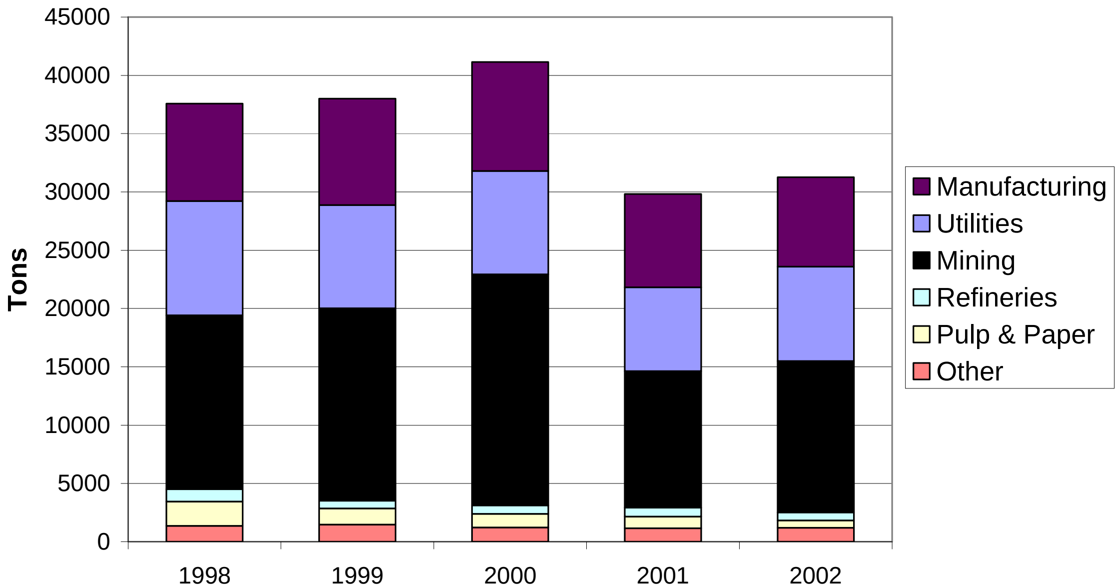
Point sources account for 4 percent of PM_{10} emissions. These emissions come from the mining, manufacturing and utility sectors. On-road vehicles and non-road mobile sources make up about 2 percent of total PM_{10}.

Although most of the mass of PM_{10} emissions come from fugitive dust sources, these 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 combustion sources such as cars, wood stoves, and industrial and commercial combustion are generally smaller, more toxic and more often released in populated areas.

Trends

Point sources contribute 4 percent to the total state PM_{10} emissions. Emissions from the mining sector decreased significantly in 2001. This decrease in mining emissions of PM_{10} was due primarily to the closing of LTV Steel Company. Emissions increased slightly in 2002 in the utilities and mining sectors.

PM_{10} Point Source Emission Trends by Sector in Minnesota, 1998-2002



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/

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.

Emissions Data and Sources

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 oxides (NO_x) 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_x can form when fuels are burned at high temperatures. The major NO_x sources are combustion processes from automobiles and power plants. VOCs are emitted from a variety of sources, including industrial sources, motor vehicles and consumer products. NO_x and VOCs are also emitted by naturally occurring sources such as soil and vegetation. See the NO_x and VOC sections of this report for more information regarding 2002 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/ozone.html

http://www.pca.state.mn.us/air/ozonestudy.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). 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 these pollutants is associated with serious adverse health effects.

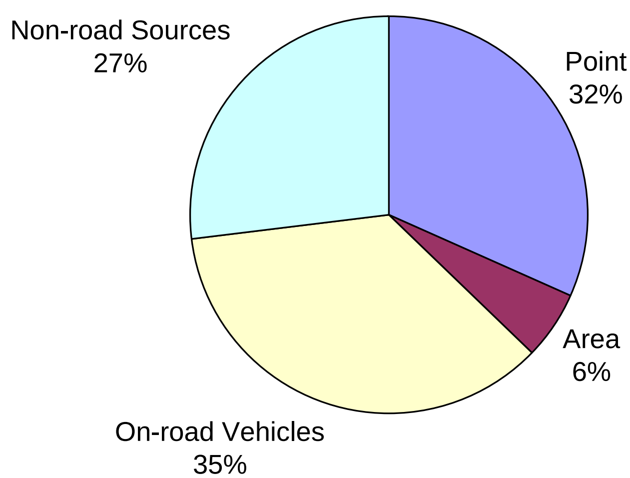
High NO_x concentrations also have environmental impacts. Deposition of nitrogen can lead to fertilization, eutrophication, or acidification of terrestrial, wetland and aquatic systems. This can result in changes in species number and composition such as the reduction of fish and shellfish populations. 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 MPCA estimate for statewide emissions of NO_x in 2002 is 478,341 tons.

The figure below shows sources of 2002 NO_x emissions.

Sources of Nitrogen Oxide Emissions in Minnesota, 2002

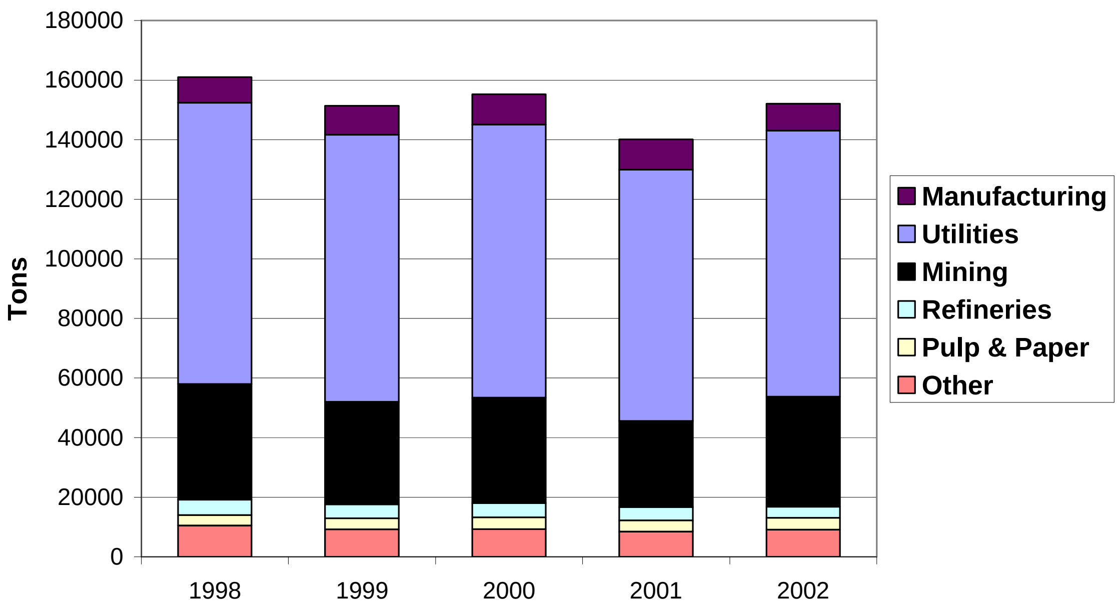


The majority of NO_x emissions come from the transportation sector, which consists of on-road vehicles and non-road sources. On-road vehicles contribute 35 percent of total statewide NO_x emissions, while non-road sources contribute 27 percent of total NO_x emissions. Gasoline engines contribute the majority of emissions from the transportation sector. Thirty-two percent of NO_x emissions come from point sources, primarily from the utility and mining sectors. Area sources are responsible for the remaining 6 percent of NO_x emissions. Residential and small industrial and commercial combustion makes up the majority of area source emissions.

Trends

Point sources contribute 32 percent of the NO_x emissions in the state. In Minnesota, NO_x emission estimates from point sources have stayed relatively constant since 1998 with some fluctuation between years. All categories have increased their NO_X emissions since 2001 except for manufacturing and refineries. Mining and utilities saw the greatest increase. Mining NO_x emissions increased in 2002 because taconite plants had higher hours of operation for baking taconite pellets in kilns. The kilns burn natural gas, resulting in NO_x emissions.

Nitrogen Oxide Point Source Emission Trends by Sector in Minnesota, 1998-2002



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/econ-emissions.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.

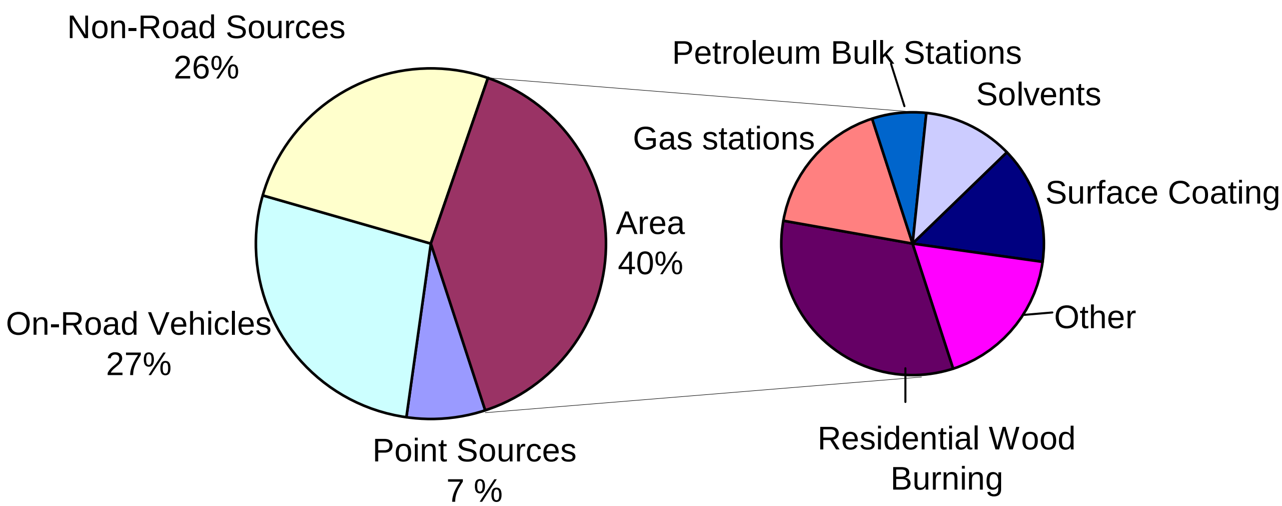
Many VOCs are also air toxics and can have harmful effects on human health and the environment. However, VOCs are regulated as a criteria pollutant because they are precursors to ozone. See the sections on ozone and air toxics for related human health and environmental effects.

Emissions Data and Sources

The MPCA estimate for statewide emissions of VOCs in 2002 is 392,772 tons.

VOCs are emitted from a variety of sources: including industrial sources, motor vehicles, consumer products and natural sources such as soils and vegetation. The figure below shows only manmade Minnesota sources of VOCs in 2002.

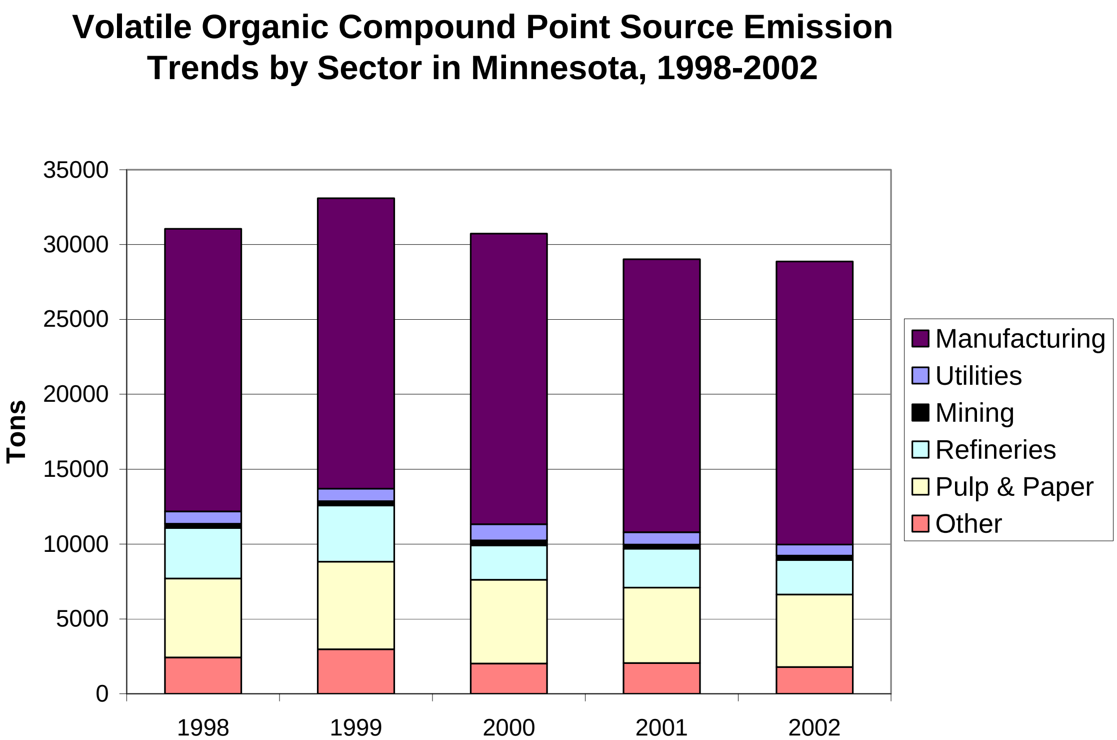
Sources of Volatile Organic Compounds in Minnesota, 2002



Over half of the emissions come from the transportation sector, which consists of on-road vehicles and non-road sources. Twenty-seven percent of emissions come from on-road vehicles and 26 percent come from non-road sources. Non-road sources include recreational equipment, pleasure boats, and lawn and garden equipment as well as other agricultural and commercial equipment. Area sources contribute 40 percent of VOC emissions, primarily from residential wood burning, gasoline service stations, commercial and consumer solvent usage, and petroleum bulk stations and terminals. The final 7 percent of emissions come from point sources such as the manufacturing sector, pulp and paper operations, and refineries.

Trends

Point sources contribute 7 percent of the VOC emissions in the state. VOC point source emission estimates have gradually decreased in Minnesota since 1999. All categories except mining and manufacturing have decreased from 2001 levels.



References/Web Links

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

http://www.epa.gov/airtrends/econ-emissions.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 impaired visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks. Prolonged exposure to high levels can lead to death.

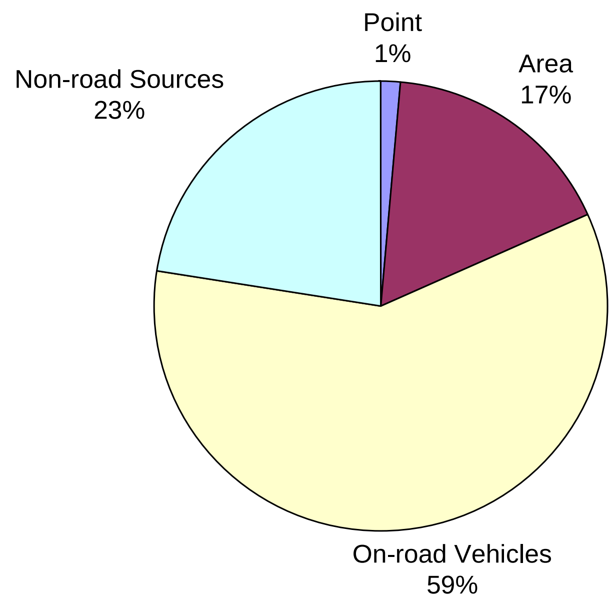
At concentrations commonly found in the ambient air, CO does not appear to have adverse effects on plants, wildlife or materials. However, CO is oxidized to form carbon dioxide (CO_2), a contributor to global warming.

Emissions Data and Sources

The MPCA estimate for statewide emissions of CO in 2002 is 2,508,057 tons.

The figure below shows sources of 2002 CO emissions.

Sources of Carbon Monoxide Emissions in Minnesota, 2002



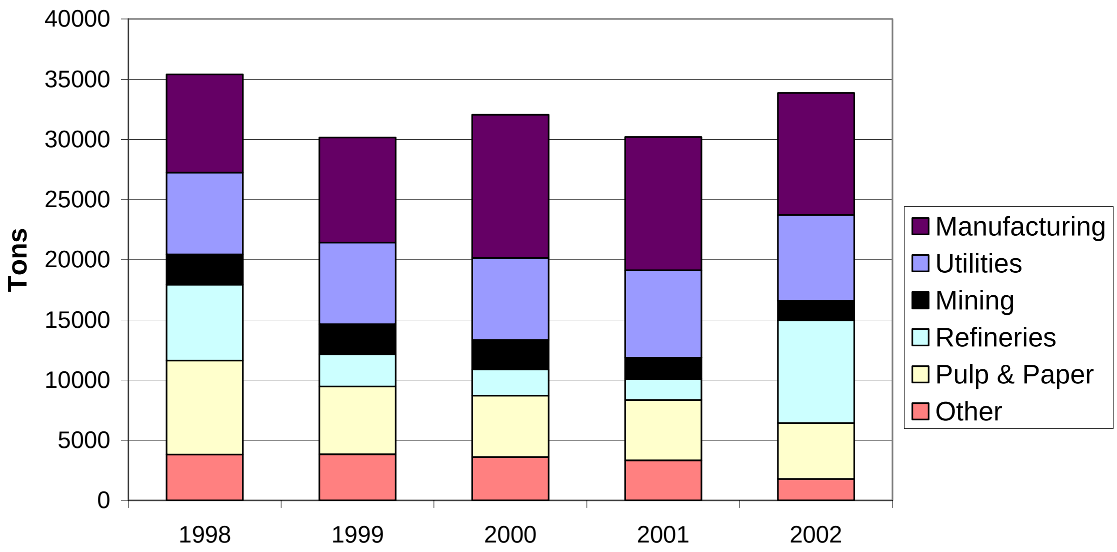
The majority of CO emissions come from the transportation sector, which consists of on-road vehicles and non-road sources. On-road vehicles contribute 59 percent of total statewide CO emissions, while non-road sources contribute 23 percent of total CO emissions. Non-road emissions come primarily from gasoline consumption by lawn and garden, recreational and commercial equipment.

The remaining 18 percent of emissions come from point and area sources. Area source emissions are primarily from prescribed burning, residential wood burning, forest fires and waste disposal through open burning. Major point source contributors to CO emissions are from the manufacturing and utility sectors.

Trends

Point sources contribute only 1 percent to the total Minnesota CO emissions. Emissions from point sources have shown some fluctuation since 1998. 2002 point source emissions decreased from 2001 levels in all categories except refineries which increased substantially. The increase was primarily from Marathon Ashland refinery. Normally, the refinery runs the FCC catalyst regenerator in full burn mode, meaning in excess oxygen. In 2002, it ran in both full and partial burn mode. Higher emission factors are used for partial burn regenerator mode resulting in higher estimated emissions of CO.

Carbon Monoxide Point Source Emission Trends by Sector in Minnesota, 1998-2002



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/econ-emissions.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.

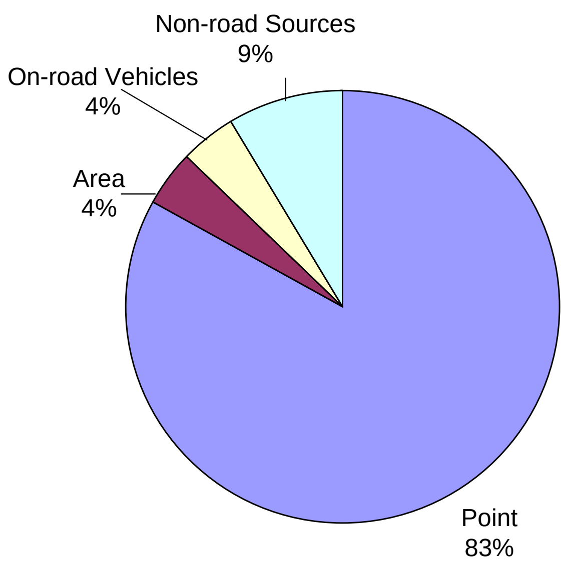
SO_2 also causes significant environmental damage. SO_2 reacts with other substances in the air to form acids, which fall to earth as rain, fog, snow, or dry particles. Acid rain damages forests and crops, changes the makeup of soil, and makes lakes and streams acidic and unsuitable for fish. Continued 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 MPCA estimate for statewide emissions of SO_2 in 2002 is 157,086 tons.

The figure below shows sources of 2002 SO_2 emissions.

Sources of Sulfur Dioxide Emissions in Minnesota, 2002



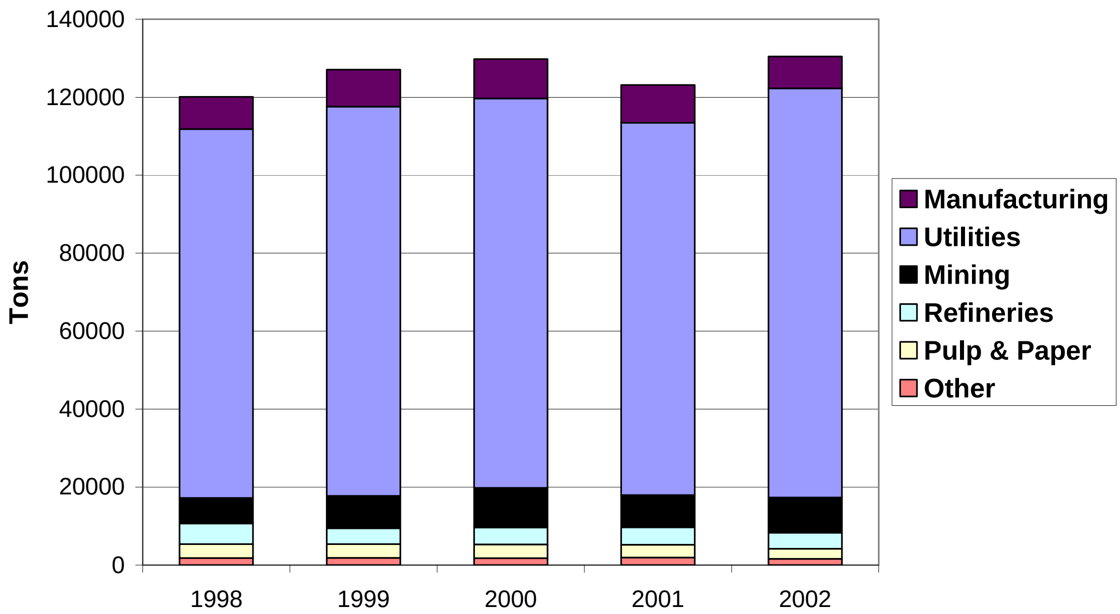
More than 80 percent of SO_2 emissions come from point sources. Electric utilities and industrial facilities burning coal emit the majority of SO_2 attributed to point sources. Non-road sources emit 9 percent of SO_2. Non-road source emissions come primarily from agricultural equipment, marine vessels, trains and construction and mining equipment. On-road vehicles contribute 4 percent of the emissions. These emissions are divided between gasoline-powered cars, trucks and motorcycles, and diesel vehicles.

The remaining 4 percent of area emissions of SO_2 result from fuel combustion by small industrial and commercial facilities and residences.

Trends

Point sources contribute 83 percent to the total state SO_2 emissions. Emissions from point sources have remained relatively constant with some fluctuation since 1997. Coal-burning utilities are the greatest emitters of SO_2. Estimated emissions have decreased from all categories except utilities and mining since 2001. The utilities and mining sectors had increased SO_2 emissions in 2002.

Sulfur Dioxide Point Source Emission Trends by Sector in Minnesota, 1998-2002



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/econ-emissions.html

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 became the primary sources of lead emissions.

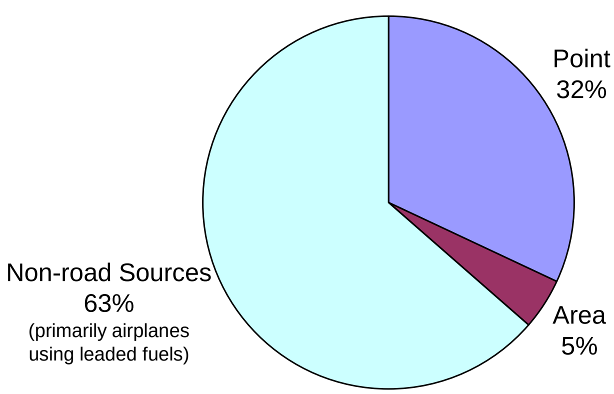
Lead causes damage to organs such as the kidneys and liver and may lead to high blood pressure and increased heart disease. In addition, exposure to lead may contribute to osteoporosis and reproductive disorders. Most importantly, lead exposure causes brain and nerve damage to fetuses and young children, 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

The MPCA estimate for statewide emissions of lead in 2002 is 82 tons. The total mass of lead emitted is much less than the other criteria pollutants. However, it takes only a small amount of lead to cause serious and permanent health problems. Therefore, even relatively low lead emissions are a concern. The figure below shows sources of 2002 lead emissions.

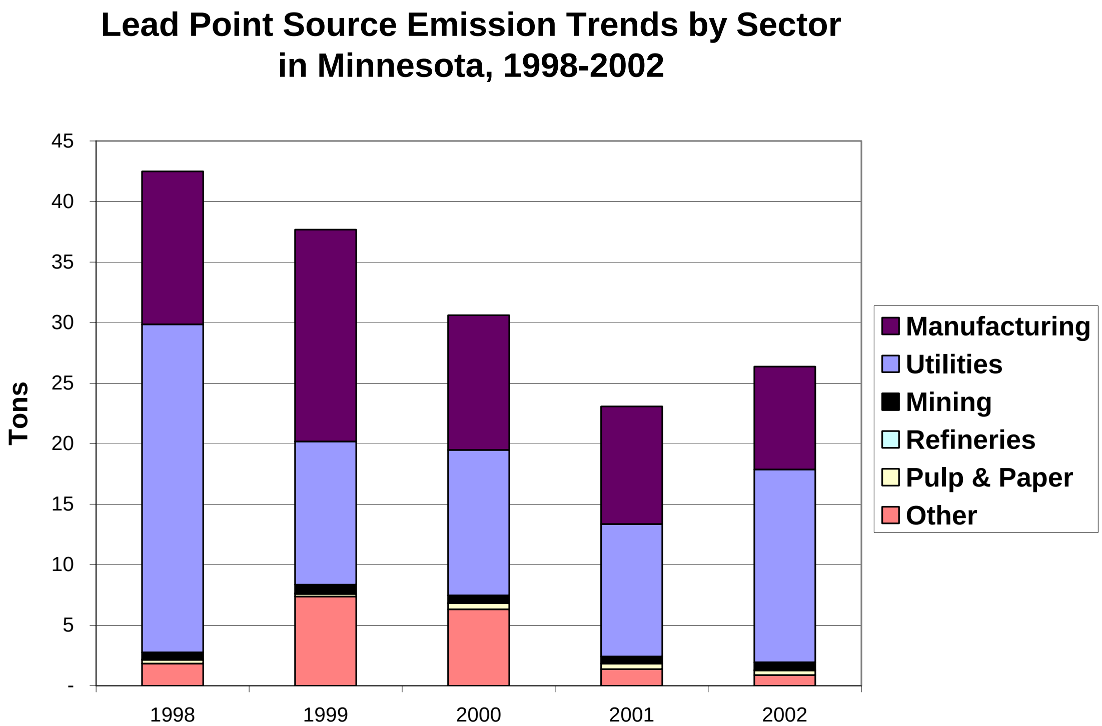
Sources of Lead Emissions in Minnesota, 2002



Non-road sources (primarily airplanes using leaded fuels) contribute 63 percent of Minnesota's lead emissions. Point sources such as utilities and metal processing (including lead and other metal smelters) add an additional 32 percent of lead to the environment. Area sources contribute the final 5 percent of lead emissions. Area source lead emissions result from prescribed burning, auto body refinishing and forest fires.

Trends

Point sources contribute 32 percent to the total state lead emissions. In Minnesota, estimated lead emissions from point sources have increased slightly since 2001. Most of the increase was from utilities.



References/Web Links

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

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

http://www.health.state.mn.us/divs/eh/lead/index.html

Carbon Dioxide

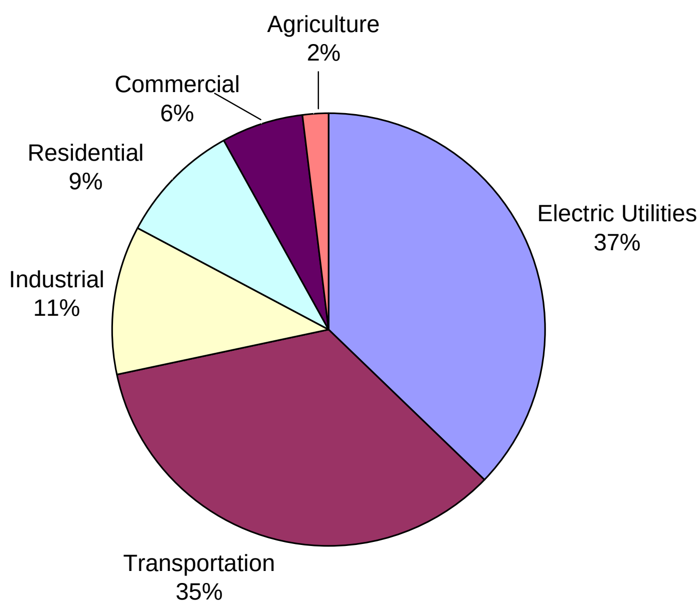
Carbon dioxide is a gas that is primarily formed from the combustion of fossil fuels such as oil, gas, and coal. It is the major greenhouse gas that can contribute to warming of the earth's atmosphere. The earth's greenhouse effect is a natural phenomenon that helps regulate the temperature of our planet.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

Emissions Data and Sources

The estimate for statewide emissions of carbon dioxide in 2002 is 112 million short tons.

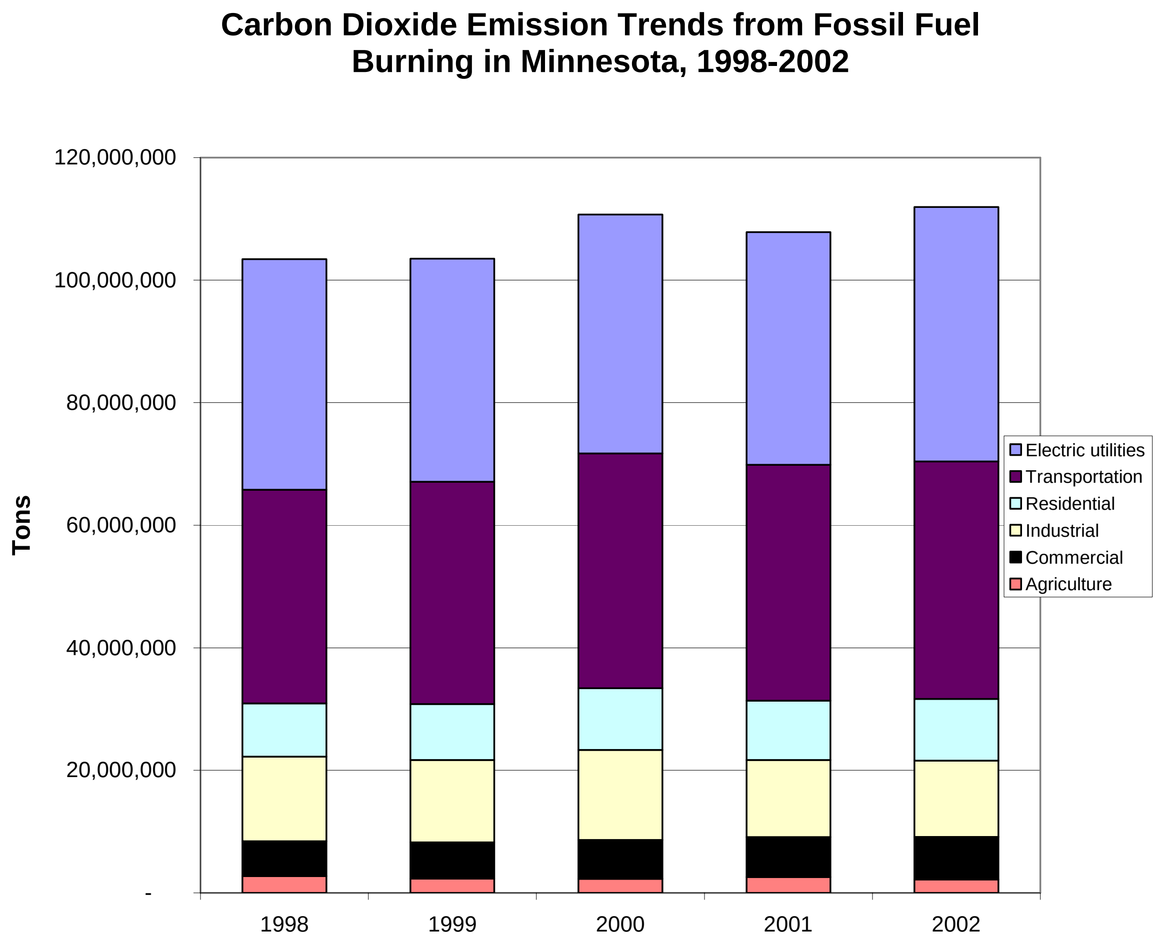
The pie chart below shows the breakdown of carbon dioxide emissions from fossil fuel burning by sector. The majority of the carbon dioxide emissions come from the electric utility (37%) and transportation (35 %) sectors. The remaining 28 percent of the emissions come from fossil fuel combustion in the industrial, commercial, residential and agriculture sectors.

Sources of Carbon Dioxide Emissions from Fossil Fuel Burning in Minnesota, 2002



Trends

Carbon dioxide emissions from fossil fuel burning in Minnesota increased slightly 5.6 percent from 1999 to 2000. From 2000 to 2001, carbon dioxide emissions decreased 2.6 percent. The Taconite Harbor facility was taken off-line in 2001, which accounts for some of the reduction from 2000 to 2001 in the industrial category. Economic recession in 2001 also likely contributed to some of the decrease. Emissions rose 5.6% from 2001-2002.

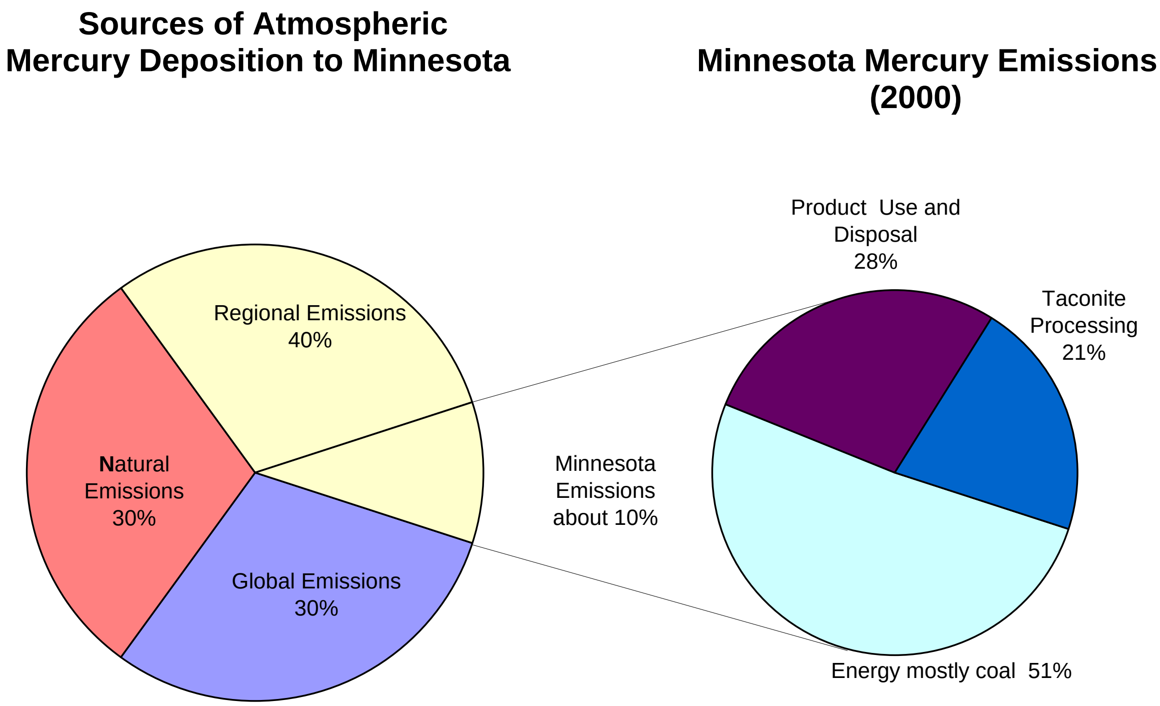


Mercury

Mercury contamination of fish is a well-documented problem in Minnesota. The Minnesota Department of Health advises people to restrict their consumption of sport fish due to mercury on virtually every lake tested. Nearly all — more than 99 percent — of the mercury in Minnesota lakes and rivers comes from the atmosphere. Consequently, the data presented here only include releases to the atmosphere.

Emissions Data and Sources

Mercury emitted to the atmosphere due to human activities is divided by the MPCA into three categories: (1) Emissions incidental to energy production, (2) emissions due to the use and disposal of mercury in products, and (3) emissions due to taconite processing. Although emissions from fossil fuel combustion and the processing of metal ores are both the result of the incidental release of trace contaminants of natural geological materials, we have placed them in separate categories (energy production and taconite processing, respectively).



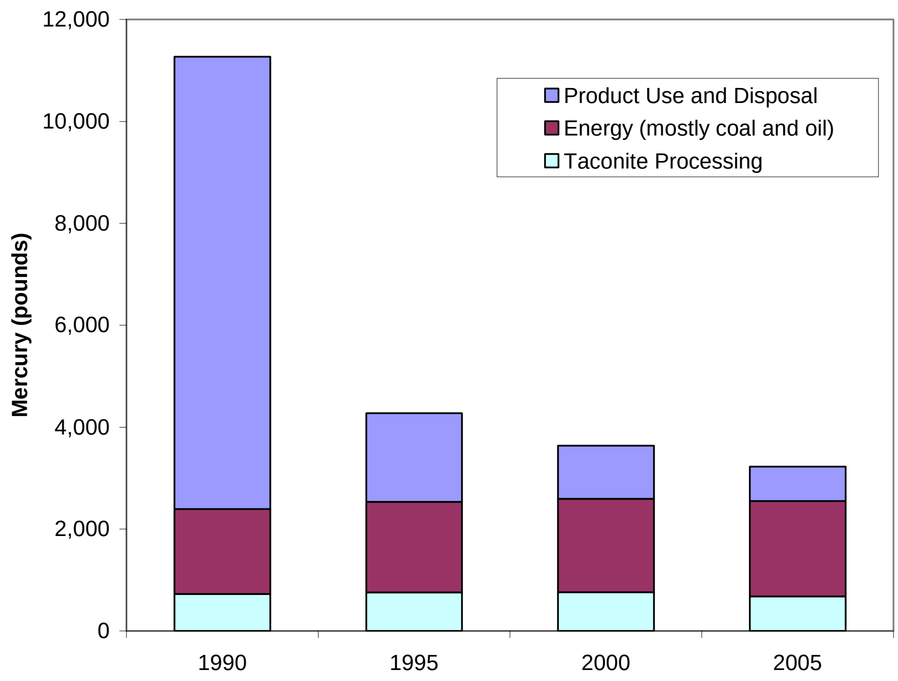
Because mercury vapor can be transported long distances by the atmosphere, most of Minnesota's emissions are deposited in other states and countries, and Minnesota receives their emissions. Minnesota emits about as much mercury as the state receives, and about 90% of Minnesota's emissions are carried by the wind out of state. MPCA staff estimates that only about 10% of mercury deposition in rural Minnesota is the result of emissions originating within the state.

MPCA staff estimates that the remaining 90% of the deposition is due to three roughly equal sources: 30% from human-generated sources in the rest of North America, 30% from human sources in the rest of the world, and 30% naturally cycling mercury.

Trends

MPCA staff estimates that total mercury emissions in Minnesota declined significantly from 1990 to 2000. In 1990, emissions are estimated to have been about 11,300 pounds. By 2000, mostly due to discontinued use of mercury in products and mandated controls on incineration of solid waste, emissions were about 3,600 pounds, a 68% reduction from 1990 levels.

Trends in Minnesota Mercury Emissions from Human Activities



Sediment core studies from lakes in Minnesota and elsewhere show slight declines in atmospheric deposition relative to a peak in the 1970s and 1980s. There is some evidence that concentrations of mercury in fish have also declined, but not to the point of eliminating concerns about fish consumption. MPCA staff estimates that in order for Minnesota to significantly reduce concerns about mercury in fish, human-caused emission sources in and out of the state would need to reduce by about 90% from 1990 levels, or about 75% from 2000 levels.

References/Web Links

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

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

http://www.epa.gov/mercury/

Air Toxics

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.

One of the goals in the MPCA's ongoing clean air strategic plan is to meet all environmental and human health benchmarks for toxic air pollutants. Of the 45 gaseous air toxics measured by the MPCA that have health benchmarks, two have recently had concentrations above their health benchmarks in Minnesota: benzene and formaldehyde.

The Minnesota Air Toxics Emission Inventory estimates emissions of air toxics. Air toxic emission inventories are generally compiled every three years. The most recent inventory for Minnesota is from 1999. The inventory includes three principal source categories: point, area, and mobile sources.

1. **Point Sources**: Typically large, stationary sources with relatively high emissions, such as electric power plants and refineries.
2. **Area Sources**: Typically stationary sources, but generally smaller sources of emissions than point sources. Examples include dry cleaners, gasoline service stations and residential wood combustion. Area sources may also include 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 gasoline station typically will not qualify as a point source, but collectively the emissions from many gas stations may be significant.
3. **Mobile Sources**: Mobile sources are broken up into two categories; on-road vehicles and non-road sources. On-road vehicles include vehicles operated on highways, streets and roads. Non-road sources are off-road vehicles and portable equipment powered by internal combustion engines. Lawn and garden equipment, construction equipment, aircraft and locomotives are examples of non-road sources.

MPCA staff compiled the emissions estimates for the point and area sources in the 1999 inventory. The results for mobile sources were obtained from EPA's 1999 National Emission Inventory Version 3 for Hazardous Air Pollutants.

Table 3 provides a summary of air toxics emissions from principal source categories taken from the 1999 Minnesota Air Toxics Emission Inventory. The table gives total statewide emissions of each chemical, along with the percent from point, area, highway, and off-highway sources. The inventory includes 156 chemicals: 17 polycyclic organic matters (POMs), 126 non-metal compounds (excluding POMs), and 13 metal compounds.

Table 3: 1999 Minnesota Air Toxics Emissions Inventory Statewide Summary

Pollutant	Total (short tons)	Point (%)	Area (%)	On-road Vehicles (%)	Non-road Sources (%)
Polycyclic Organic Matter (POMs)					
Acenaphthene	41	90%	6%	1%	2%
Acenaphthylene	59		93%	4%	3%
Anthracene	8.9	2%	88%	6%	4%
Benz[a]Anthracene	11	1%	96%	2%	1%
Benzo[a]Pyrene	2.4		92%	4%	4%
Benzo[b]Fluoranthene	1.7		90%	6%	4%
Benzo[g,h,i,]Perylene	5.7		91%	3%	6%
Benzo[k]Fluoranthene	2.8		94%	4%	2%
Chrysene	8.4		98%	1%	1%
Dibenzo[a,h]Anthracene	0.003	11%	5%	1%	84%
Fluoranthene	13	2%	86%	5%	8%
Fluorene	9.0	1%	70%	11%	18%
Indeno[1,2,3-c,d]Pyrene	3.0		95%	2%	3%
Naphthalene	468	12%	70%	14%	4%
Phenanthrene	30	1%	83%	5%	10%
Pyrene	16	1%	87%	5%	7%
Other POM not included above	171	8%	92%		
POM Total	850	12%	74%	9%	4%
Metal Compounds					
Antimony Compounds	1.4	85%	15%		
Arsenic Compounds	9.2	92%		4%	3%
Beryllium Compounds	0.21	85%	8%		7%
Cadmium Compounds	10	10%	89%		
Chromium Compounds	15	94%	5%	1%	
Chromium (VI)	0.28	55%	4%	36%	4%
Cobalt Compounds	2.7	91%	9%		
Copper Compounds	16	95%	5%		
Lead Compounds	55	72%	7%		22%
Manganese Compounds	107	97%	3%		
Mercury Compounds	2.6	68%	5%	18%	9%
Nickel Compounds	30	79%	17%	1%	3%
Selenium Compounds	2.0	95%	4%		
Metal Compound Total	250	85%	9%	1%	5%

Table 3: 1999 Minnesota Air Toxics Emissions Inventory Statewide Summary

Pollutant	Total (short tons)	Point (%)	Area (%)	On-road Vehicles (%)	Non-road Sources (%)
Non-Metal Compounds (Excluding POMs)					
1,1,2,2-Tetrachloroethane	0.6	6%	94%		
1,1,2-Trichloroethane	0.05	100%			
1,2,4-Trichlorobenzene	3.7	100%			
1,2,4-Trimethylbenzene	78	88%	12%		
1,3,5-Trimethylbenzene	0.16	100%			
1,3-Butadiene	946		35%	41%	23%
1,3-Dichloropropene	382		100%		
1,4-Dichlorobenzene	186		100%		
2,2,4-Trimethylpentane	8315		2%	39%	59%
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	0.000005	27%	73%		
2,3,7,8-Tetrachlorodibenzofuran	0.0002	6%	94%		
2,4-D (2,4-Dichlorophenoxyacetic Acid)(Including Salts	84		100%		
2,4-Dinitrophenol	0.07	100%			
2,4-Dinitrotoluene	0.003	100%			
2,4-Toluene Diisocyanate	2.5	99%	1%		
2-Chloroacetophenone	0.07	100%			
2-Nitropropane	0.005		100%		
4,4'-Methylenedianiline	0.08	100%			
4,4'-Methylenediphenyl Diisocyanate (MDI)	32	99%	1%		
4-Nitrophenol	0.21	100%			
Acetaldehyde	2308	3%	30%	41%	25%
Acetamide	0.0003		100%		
Acetone	828	19%	81%		
Acetonitrile	6.1	100%			
Acetophenone	0.8	22%	78%		
Acrolein	508	2%	70%	14%	14%
Acrylamide	0.12	100%			
Acrylic Acid	6.9	100%			
Acrylonitrile	2.7	38%	62%		
Aldehydes	445	6%	94%		
Allyl Chloride	0.004	100%			
Aniline	0.0006	100%			
Atrazine	90		100%		
Benzaldehyde	0.7	100%			
Benzene	7035	1%	27%	46%	26%
Benzyl Chloride	6.0	100%			
Biphenyl	1.1	64%	36%		
Bis(2-Ethylhexyl)Phthalate (Dehp)	4.9	100%			
Bromoform	0.36	100%			
Butyraldehyde	0.08	100%			
Carbon Disulfide	1.4	84%	16%		
Carbon Tetrachloride	0.8	47%	53%		

Table 3: 1999 Minnesota Air Toxics Emissions Inventory Statewide Summary

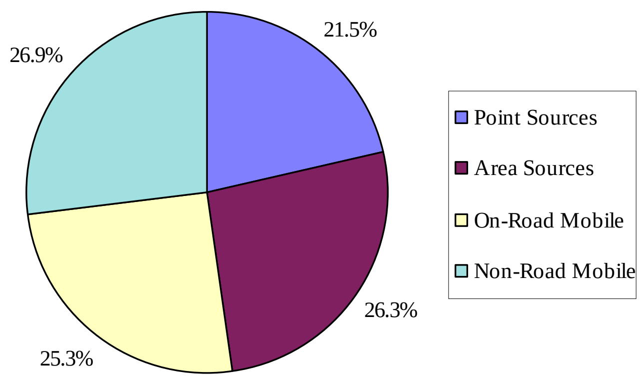
Pollutant	Total (short tons)	Point (%)	Area (%)	On-road Vehicles (%)	Non-road Sources (%)
Carbonyl Sulfide	106	99%	1%		
Catechol	0.32	100%			
Chlorine	261	3%	97%		
Chloroacetic Acid	0.000	100%			
Chlorobenzene	172		100%		
Chloroform	27	80%	20%		
Chloroprene	0.0005	100%			
Cresol/Cresylic Acid (Mixed Isomers)	26	100%			
Crotonaldehyde	0.06	100%			
Cumene	23	72%	28%		
Cyanide Compounds	96	26%	74%		
Di-N-Octylphthalate	0.5	100%			
Dibenzofuran	0.02	10%	90%		
Dibutyl Phthalate	1.3	94%	7%		
Dichlorobenzenes	0.03	100%			
Diethanolamine	0.09	82%	18%		
Diethyl Sulfate	0.003	100%			
Dimethyl Phthalate	1.8	99%	1%		
Dimethyl Sulfate	0.45	100%			
Ethyl Acrylate	2.3	100%			
Ethyl Chloride	27	22%	78%		
Ethylbenzene	2750	5%	2%	50%	44%
Ethylene Dibromide (Dibromoethane)	0.28	99%	1%		
Ethylene Dichloride (1,2-Dichloroethane)	1.3	60%	40%		
Ethylene Glycol	101	23%	77%		
Ethylene Oxide	57	10%	90%		
Ethylidene Dichloride (1,1-Dichloroethane)	0.49	2%	98%		
Formaldehyde	5916	7%	43%	25%	25%
Glycol Ethers	1616	30%	70%		
Hexamethylene Diisocyanate	1.8	100%			
Hexane	4964	24%	34%	24%	17%
Hydrazine	0.0005	100%			
Hydrochloric Acid (Hydrogen Chloride [Gas Only])	12938	100%			
Hydrogen Fluoride (Hydrofluoric Acid)	1365	100%			
Hydroquinone	3.3	36%	64%		
Isophorone	13	42%	58%		
Lindane, (All Isomers)	0.002	100%	0		
M-Dichlorobenzene	0.7	7%	93%		
Maleic Anhydride	0.32	100%			
Methanol	2513	31%	69%		
Methyl Bromide (Bromomethane)	537	1%	99%		
Methyl Chloride (Chloromethane)	173	29%	71%		
Methyl Chloroform (1,1,1-Trichloroethane)	866		100%		
Methyl Ethyl Ketone (2-Butanone)	2367	25%	75%		
Methyl Iodide (Iodomethane)	0.003	100%			

Table 3: 1999 Minnesota Air Toxics Emissions Inventory Statewide Summary

Pollutant	Total (short tons)	Point (%)	Area (%)	On-road Vehicles (%)	Non-road Sources (%)
Methyl Isobutyl Ketone (Hexone)	1074	16%	84%		
Methyl Methacrylate	41	100%			
Methyl Tert-Butyl Ether	8.6	26%	1%	73%	
Methylene Chloride (Dichloromethane)	379	24%	76%		
Methylhydrazine	1.6	100%			
N,N-Dimethylformamide	29	18%	82%		
Nitrobenzene	0.24	100%			
O-Dichlorobenzene	202		100%		
Pentachlorophenol	0.000005	100%			
Phenol	108	100%			
Phosphine	0.43	51%	49%		
Phosphorus Compounds	38	55%	45%		
Phthalic Anhydride	0.38	100%			
Polychlorinated Biphenyls (Aroclors)	0.0006	91%	9%		
Polychlorinated Dibenzo-P-Dioxins And Furans, Total	0.00001	100%			
Polychlorinated Dibenzodioxins, Total	0.009	8%	92%		
Propionaldehyde	218	2%		37%	61%
Propylene Dichloride (1,2-Dichloropropane)	0.10	3%	97%		
Propylene Oxide	0.32	100%			
Quinoline	0.0001	100%			
Quinone (p-Benzoquinone)	0.9	100%			
Styrene	1418	73%		20%	8%
Tetrachloroethylene (Perchloroethylene)	202	19%	81%		
Toluene	27872	4%	19%	33%	44%
Trichloroethylene	213	93%	7%		
Trichlorofluoromethane (CFC-11, R-11)	20	1%	99%		
Trichlorotrifluoromethane (CFC-113, R-113)	277		100%		
Triethylamine	2.3	13%	87%		
Trifluralin	42		100%		
Trimethylbenzene	44	18%	82%		
Vinyl Acetate	21	70%	30%		
Vinyl Chloride	6.7	6%	94%		
Vinylidene Chloride (1,1-Dichloroethylene)	1.2	9%	91%		
Xylenes (Mixed Isomers)	14797	7%	24%	35%	34%
m-Xylene	1.7	9%	91%		
o-Xylene	104	4%	96%		
p-Dioxane	6.2	99%	1%		
p-Phenylenediamine	0.05	100%			
p-Xylene	0.07	100%			
Non-Metal Compound Total	105336	21%	26%	26%	27%
Grand Total	106436	22%	26%	25%	27%

The following pie chart summarizes air toxics pollutant emissions in Minnesota from 1999. Each principal source category is responsible for approximately a quarter of total emissions with slightly more from non-road mobile sources (26.9%) and slightly less from point sources (21.5%).

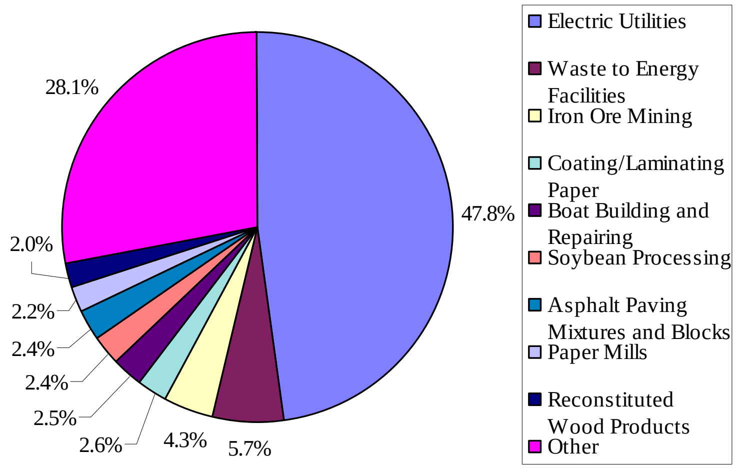
Contribution of Principal Source Categories to 1999 Air Toxics Emissions in Minnesota



Total air toxics emissions in 1999: 212,872,544 pounds

A more detailed breakdown of emissions for each principal source category is shown in the following three pie charts. For point sources, there are nine categories that collectively account for about 72% of the total point source emissions. The largest source category is Electric Utilities, which accounts for 47.8% of point source emissions.

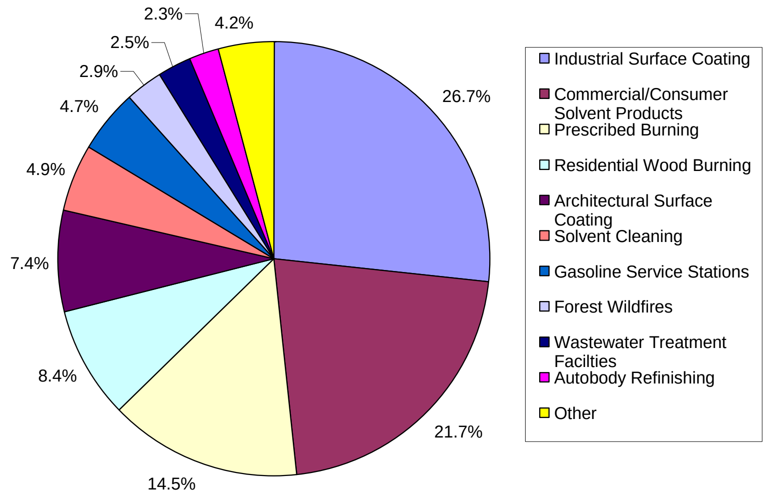
Contribution of Major Categories to 1999 Point Source Air Toxic Emissions in Minnesota



Total air toxics point source emissions: 45,774,769 pounds

For area sources, the major contributors of emissions are Industrial Surface Coating and Commercial/Consumer Solvent Products. About half of the area source emissions are attributed to these two source categories.

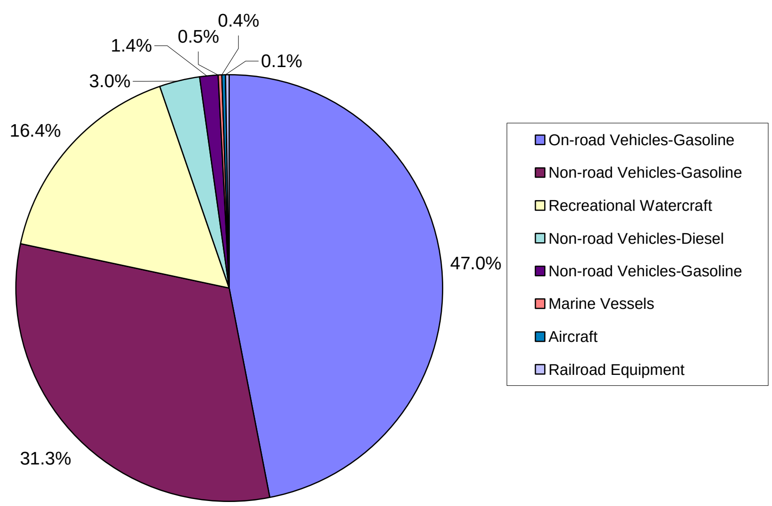
Contribution of Major Categories to 1999 Area Source Air Toxics Emissions in Minnesota



Total emissions of area sources of air toxics in 1999: 55,991,116 pounds

For mobile sources, the largest emission contributor is Highway Vehicles – Gasoline, which accounted for 47% of total mobile source emissions in 1999. The second largest contributor of mobile source emissions is Non-road Vehicles – Gasoline, which is primarily made up of recreational vehicles. Snowmobiles contribute a significant fraction (70%) of emissions from recreational vehicles.

Contribution of Major Categories to 1999 Mobile Source Air Toxics Emissions in Minnesota



Total emissions from mobile sources of air toxics in 1999: 111,106,673 pounds

For more information on air toxics, the Minnesota Air Toxics Emission Inventory and the Great Lakes Air Emissions Inventory, see the following web sites:

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

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

http://www.glc.org/air/

Chapter 2: 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 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 to make sound 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 (septic) systems. Nonpoint sources are most significant during periods of high precipitation and stream flow.

Minnesota has been successful in controlling 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 are increasing in proportion with changing land uses and expanding population and development. 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 or ground water supply 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 from a combination of point and nonpoint sources.

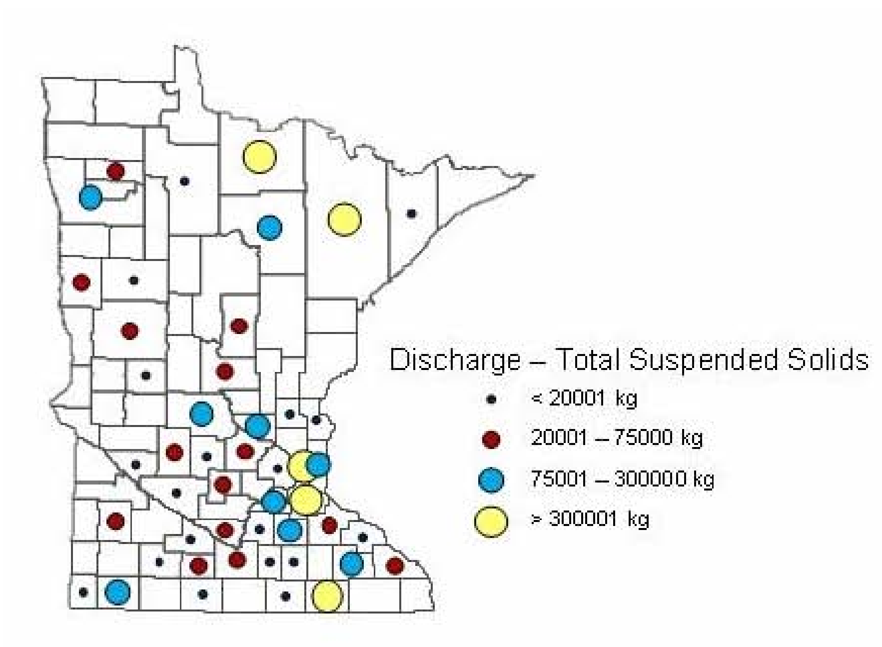
Major Water Discharge Parameters and Trends

This section presents discharge information for the following water pollutants that are released from 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). A summary table of the data from 1999-2003 (the five most recent years for which data are available) and an analysis of trends for these pollutants are found on page 3 of this report.

Total Suspended Solids

Total suspended solids 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 algal blooms that are harmful to fish and other aquatic organisms. Based on results of Discharge Monitoring Reports for 86 major treatment facilities, the estimated discharge of total suspended solids to waters of the state for the year 2003 was 8,266,000 kilograms, a decrease of 6.6% from the 8,852,000 reported in 2002. In 2003, precipitation levels returned to closer to average from the flooding conditions and persistent high flows that occurred in 2002, and suspended solids decreased accordingly. The figure below shows the 2003 total suspended solids discharges to surface waters by major point sources of water pollutants, aggregated by county.

Total Suspended Solids Discharges from Major Point Sources, 2003

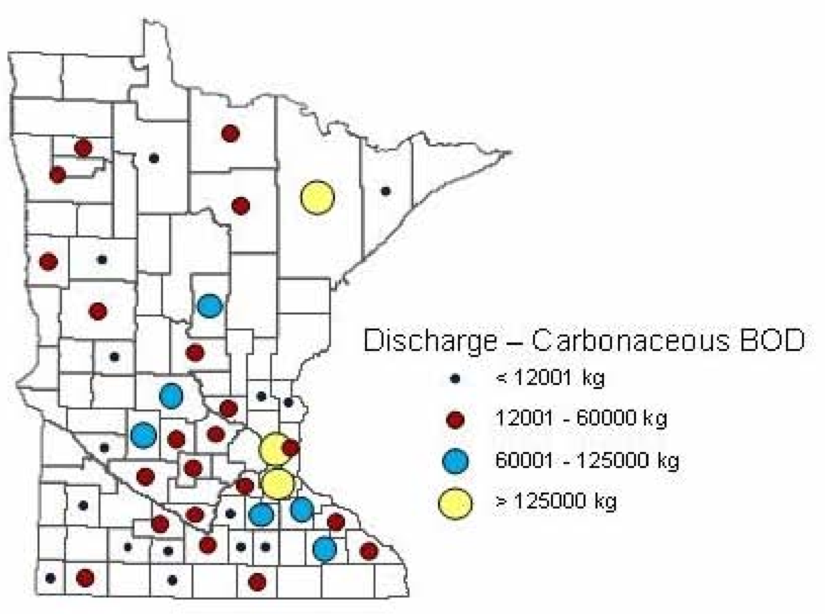


Biochemical Oxygen Demand

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 biochemical oxygen demand (BOD), while carbonaceous biochemical oxygen demand (CBOD) is the amount of oxygen required for microorganisms to decompose waster carbonaceous materials. Both BOD and CBOD are indicators of the strength of waste effluent and effectiveness of treatment. For purposes of this report, BOD and CBOD are totaled together on the table on page 3 and reported as BOD, since their effects on receiving waters are similar. A high demand for oxygen 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.

Based on results of Discharge Monitoring Reports for 86 major treatment facilities, the estimated discharge of the combined total of BOD and CBOD to waters of the state for 2003 was 6,789,000 kilograms, a 14.2% increase over 2002. The combined BOD-CBOD discharge to waters of the state has increased each year since 2000, although the rate of increase slowed between 2002-2003 compared with 2001-2002 (15.6%). The figure below shows only the 2003 BOD discharges to surface waters by major point sources of water pollution, aggregated by county. Distribution of discharges for CBOD is similar.

Biochemical Oxygen Demand Discharges from Major Point Sources, 2003

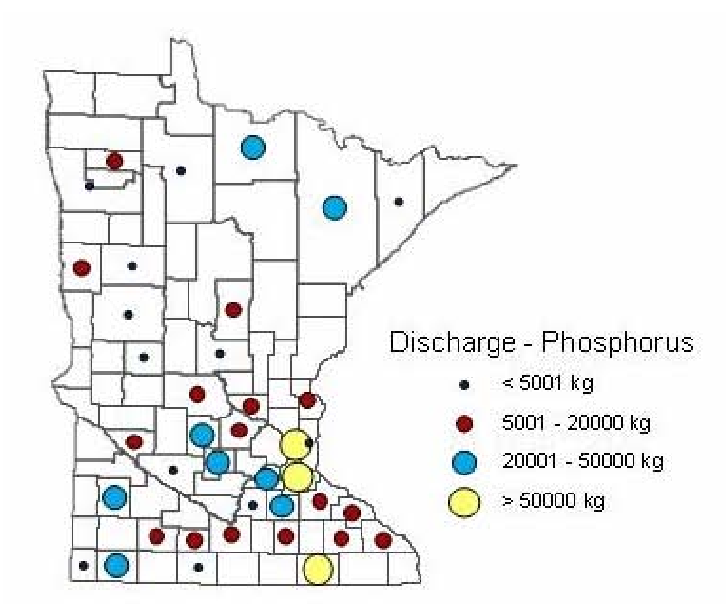


Total Phosphorus

Total phosphorus 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 in place 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 practical extent whenever sources of nutrients are considered to be actually or potentially detrimental to the preservation or enhancement of designated waters."

Based on the results of Discharge Monitoring Reports for 86 major treatment facilities, the estimated discharge of total phosphorus to waters of the state for the year 2003 was 1,546,000 kilograms, an increase of 16.6% from 2002. This reverses a downward trend in total phosphorus that was observed beginning in 2001. The reasons for the increase are not known, and will need to be watched in future years to determine if this is the beginning of a trend or a one-time occurrence. It should be noted that the Metropolitan Council Environmental Services (MCES) Metro Wastewater Treatment Plant, which discharges to the Mississippi River, was required to implement phosphorus removal to 1 mg/l from a 2.97 mg/l average phosphorus effluent concentration by the end of 2005. Metro achieved the 1 mg/l limit during 2004, but the reduction is not fully reflected in the 2003 yearly figures cited in this year's report (Table 2). A continued reduction in phosphorus concentrations to 1 mg/l will result in reduction of an estimated 581,000 kilograms of phosphorus per year, which should be reflected in the 2004 phosphorus totals in Table 2 of next year's report. As a headwaters state, Minnesota seeks to do its share to reduce its contribution from phosphorus to national problems, like the hypoxic zone in the Gulf of Mexico. The figure below shows the 2003 total phosphorus discharges to surface waters by major point sources of water pollutants, aggregated by county.

Total Phosphorus Discharges from Major Point Sources, 2003

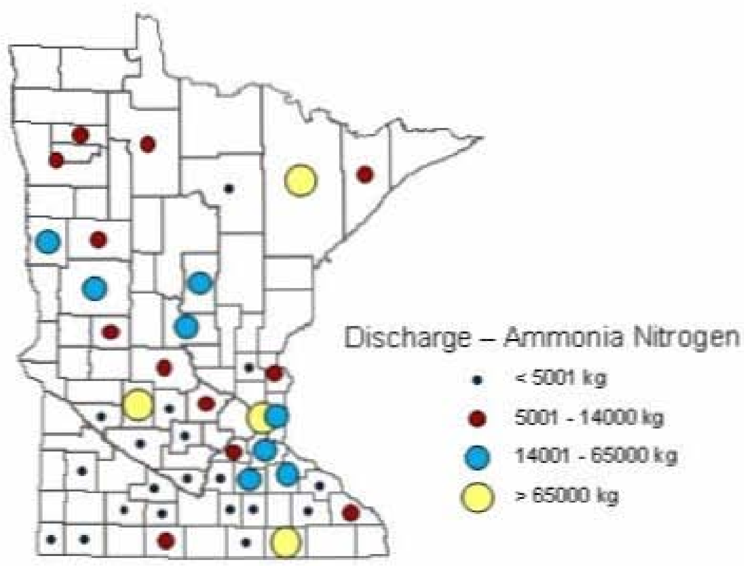


Nitrogen

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 systems), 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 can be a significant problem in ground water supplies. Nonpoint sources of nitrogen from agricultural and urban runoff are an important 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 the results of Discharge Monitoring Reports for 86 major treatment facilities, the estimated discharges for the year 2003 were 1,521,000 kilograms of ammonia and 3,576,000 kilograms of nitrate, an increase of 25.9% for ammonia and a decrease of 15.5% for nitrate, respectively. For nitrate, the decrease continues a trend that began in 1998. After increasing somewhat from 1999-2000, ammonia discharges decreased significantly in 2001, before increasing in both 2002 and 2003. The figure below shows the 2003 ammonia discharges to surface waters by major point sources of water pollutants. Distribution of discharges for nitrate is similar.

Ammonia Discharges from Major Point Sources, 2003



Nonpoint Source Pollution

As previously discussed, Minnesota has made significant progress in cleaning up point sources of water pollution as measured by discharges of pollutants in municipal and industrial wastewater. An indicator of this success is shown by the fact that the 86 major treatment facilities discharging more than one million gallons per day of treated effluent have cut their total amount of pollutants discharged to waters of the state by over 3,000,000 kilograms since 1997, despite significant year-to-year variation in levels of individual pollutants due to factors such as climate variability, change in flow conditions, and even fluctuations in the economy.

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. Despite significant improvements in recent years, too much phosphorus and nitrogen continue to reach our waters, carried in soil erosion and runoff from roads, yards, farms and septic systems.

Over the past few years, more regulatory controls for sources like feedlots, septic systems and stormwater have been implemented, but these sources of nonpoint pollution can be diffuse and difficult to manage. Much of the work to control nonpoint source pollution thus far has used financial incentives to encourage voluntary adoption of best management practices (BMPs). The Board of Water and Soil Resources (BWSR) has attempted to quantify the amount of nonpoint source pollutants like nitrogen, phosphorus and sediment avoided by use of BMPs. See pages 16-17 of the 2004 "Watershed Achievements" report at http://www.pca.state.mn.us/publications/reports/wq-cwp8-04.pdf for information on pollution savings estimates associated with financial incentive programs administered by the MPCA, Clean Water Partnership and Clean Water Act Section 319 programs.

Many of the stresses from nonpoint sources of pollution that affect Minnesota's surface and ground water resources are the result of choices that individuals make every day, such as lawn care practices, 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.

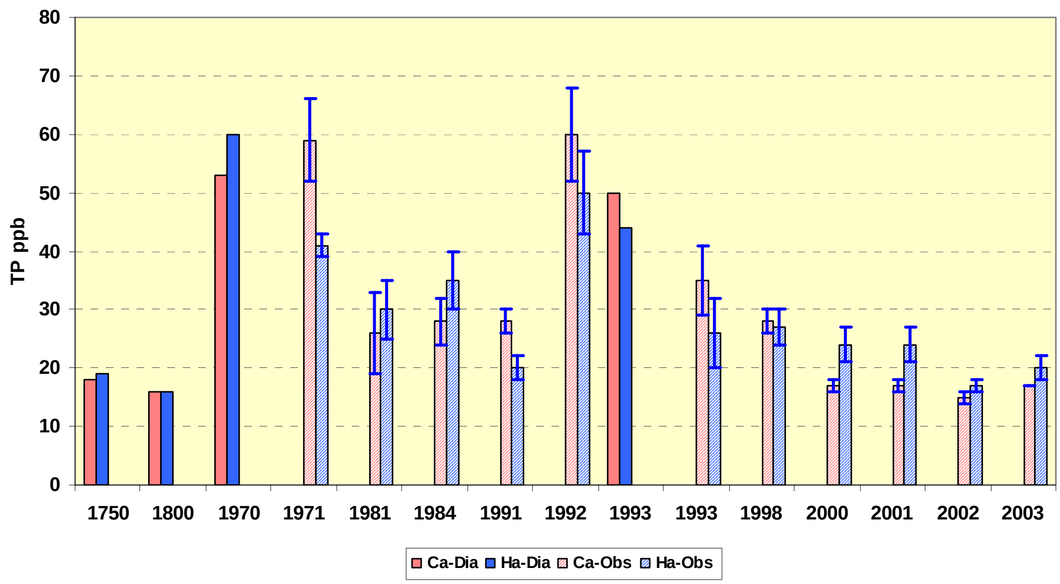
Measuring the effects of nonpoint source pollution can be difficult and expensive. For example, the best long-term data about Minnesota streams comes from measuring six key pollutants at 80 stream locations over the past 40 years. These locations are chosen to not be unduly influenced by the effects of point source pollution, although the results certainly reflect the contribution of all discharges upstream of the monitoring point. The results generally agree with those shown by point source discharges from Discharge Monitoring Reports. As another example, ground water data collected from several hundred wells across the state in aquifers that are sensitive to nitrate contamination showed that 60% of the wells monitored had nitrate levels above one part per million (ppm), suggesting possible anthropomorphic impacts to the aquifer that the well taps. Of these, 18% contained nitrates above the drinking water standard of 10 ppm. More about nitrates in Minnesota's ground water is discussed at http://www.pca.state.mn.us/water/groundwater/pubs/nitrate.pdf

Nonpoint Pollution Case Study: Minneapolis Chain of Lakes

The Minneapolis Chain of Lakes, located two-and-a-half miles southwest of downtown, receives urban runoff from a watershed of about 7,000 acres. Lakes Calhoun (420 acres) and Harriet (340 acres) are among the largest lakes in the Twin Cities Metropolitan area. Decades of intense recreational use and urban development in the watershed slowly degraded the lakes' water quality. In 1990, a group of concerned citizens and conservation groups came together to form the Minneapolis Chain of Lakes Clean Water Partnership (CWP). Over the past 15 years, this initiative accomplished about $12.4 million of rehabilitation actions, in one of the largest urban lake restoration projects in the country.

The MPCA has used diatom fossils preserved in the lake sediments to reconstruct historical total phosphorus concentrations. Diatom studies help measure the effect of human activity on the lakes over time and the effectiveness of various restoration efforts. Pre-European settlement concentrations of total phosphorus in lakes Harriet and Calhoun have been estimated to be on the order of 16-19 ppb (see figure below.) By the 1970s, however, total phosphorus concentrations were on the order of 50-60 ppb based on the diatom reconstructions, following extensive storm sewering that occurred during the previous 40 years.

Lakes Calhoun and Harriet Diatom-inferred and Observed Total Phosphorus



As also can be seen above, water quality monitoring from the early 1970s independently corroborates the diatom reconstruction. Beginning in the late 1990s, some significant declines in total phosphorus levels in both lakes were noted as compared with the 1970s. By 2002-2003, both lakes were in the 18-20 ppb range, a substantial improvement from the early 1970s and relatively close to pre-European concentrations. These recent declines in TP can be attributed to aggressive implementation of best management practices including street sweeping, better stormwater treatment in the watershed, and alum treatment of both lakes in 2001. A recently published report of how the MPCA uses diatom data to assess status and trends of quality in selected Minnesota lakes may be found at: http://www.pca.state.mn.us/publications/environmentalbulletin/tdr-eb04-04.pdf

Nonpoint Pollution Case Study: Road Salt in the Shingle Creek Watershed

The Shingle Creek watershed is a largely urban watershed located in the northwestern part of the Minneapolis metropolitan region. The creek itself is heavily used for stormwater management. The creek is approximately 11 miles long and drops approximately 66 feet from its source in northwestern Hennepin County to its mouth at the Mississippi River. The MPCA determined that waters in the Shingle Creek watershed exceed the state chloride standard for aquatic life (Class 2 water). Class 2 waters include a chronic standard of 230 mg/l to address long-term exposure over a four-day average, and an acute standard of 860 mg/l to address short-term exposure of one-hour duration.

Section 303(d) of the Clean Water Act requires the MPCA to identify waters that do not meet state water quality standards and to develop Total Maximum Daily Loads (TMDLs) for those water bodies. A TMDL is the total amount of a pollutant that a water body can assimilate and still meet its designated uses, such as for drinking water, fishing, swimming, irrigation or industrial purposes. A water body may have several TMDLs, each one determining limits for a different pollutant. Through the TMDL, pollutant loads can be studied and allocated among the point and nonpoint sources in the watershed. The TMDLs set the environmental goals and recommend approaches for improving water quality in a watershed. Pollutant load allocations can be used as a tool to make science-based decisions about land use decisions in the watershed. A description of the impaired waters program at MPCA which includes reports and maps describing efforts to develop TMDLs for waters of the state may be found at: http://www.pca.state.mn.us/water/tmdl/

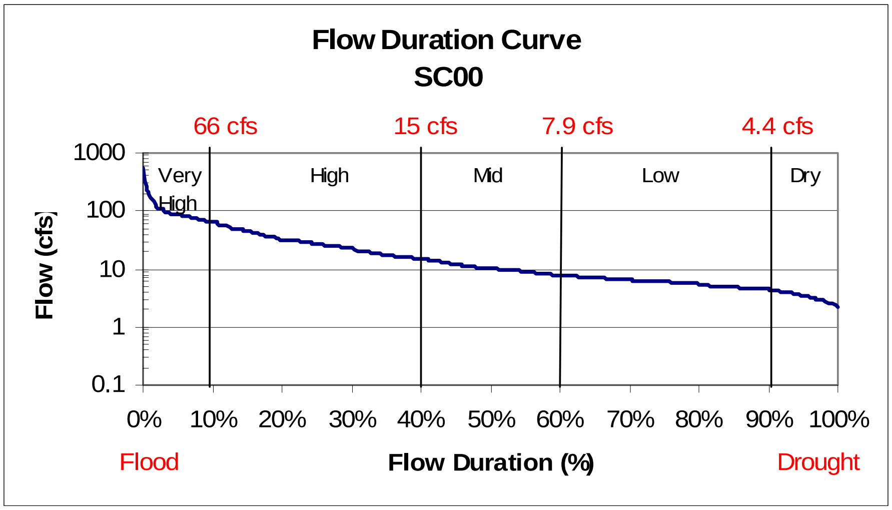
In 2004, the Shingle Creek Watershed Management Association and MPCA contracted with Wenck Associates to develop a chloride TMDL for the Shingle Creek watershed. The primary objectives were to:

- define the spatial extent, persistence and severity of chloride exceedances in the watershed,
- identify and quantify the sources of chloride in Shingle Creek including point and nonpoint sources; and
- allocate Shingle Creek's assimilative capacity to both point and nonpoint sources, and develop safety margins protective of state water quality standards.

In order to understand chloride dynamics in an urban environment, monitoring of conductivity, chloride and discharge was conducted. In addition to obtaining grab samples biweekly and during runoff events, seven sites in the watershed were continuously monitored for flow and conductivity. An inventory of point and nonpoint sources was also conducted in the watershed. An inventory of salt storage piles and maintenance facilities as well as a compilation of salt application rates by the state (MnDOT), Hennepin County and the major cities in the watershed was done. Other potential sources of chloride in the watershed that were considered include private industrial and residential deicing, landfills, railway and airport deicing, fertilizer application, ground water discharge and natural sources (as a result of soil erosion and precipitation).

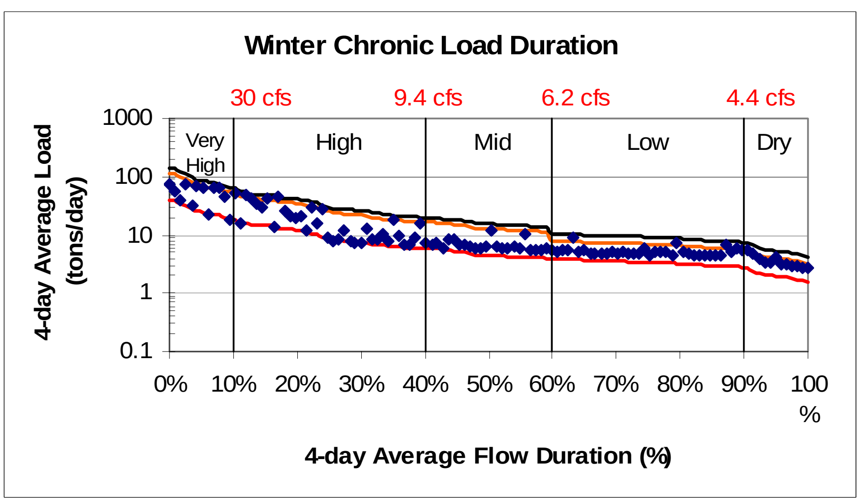
Wenck Associates used the monitoring results and observations compiled above to develop the TMDL for Shingle Creek. The analytical data collected in the watershed was used to identify flow conditions and time of year when most chloride exceedances occurred. Measured loads were used to develop wasteload allocations needed to meet water quality standards for chloride in Shingle Creek. An example chloride load duration curve for the outlet of the watershed is shown in figure on the next page. Using the monitoring data, seasonal load duration curves can be developed and compared.

Flow Duration Curve for the Outlet of the Shingle Creek Watershed



Because chloride is largely a nonpoint source issue in the Shingle Creek watershed, the TMDL cannot be assigned a single number, but rather is a curve that represents an allowable daily load across all flow regimes. The figure below shows the chloride TMDL developed by Wenck Associates applied to the 2002-2003 monitoring season. The red (bottom) line represents the acceptable chloride load for the 2002-2003 monitoring season. The orange (middle) line represents the chloride load for flow durations where the allocated load reduction results in meeting the standard for 90% of samples taken. The black (top) line represents loads for flow durations where the allocated load reductions would result in all the measured loads meeting the standard. The difference between the orange and black lines represents the margin of safety. To view the complete report from which this summary was abstracted, see: http://www.shinglecreek.org/tmdl.pdf

Chloride TMDL Applied to the 2002-2003 Monitoring Season



Other Contaminants of Concern in Minnesota's Environment

There are many newly recognized environmental contaminants (sometimes called "emerging contaminants") that are not commonly monitored but which have the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects. These contaminants are commonly derived from municipal, agricultural and industrial wastewater sources and pathways. They represent a shift in traditional thinking as many are produced industrially yet are dispersed to the environment from domestic, commercial and industrial uses. In some cases, release of these contaminants to the environment has occurred for a long time, but may not have been recognized because methods to detect them had not been developed. In other cases, synthesis of new chemicals or changes in use and disposal of existing chemicals can create new sources of emerging contaminants.

Increasing knowledge of the environmental occurrence or toxicological behavior of emerging contaminants has resulted in concern for their potential adverse environmental and human health effects. Public health experts often have an incomplete understanding of the toxicological effects of these contaminants, including the significance of long-term exposure. Even with incomplete knowledge, science and policy must continue to evolve to speed the process of identifying and preventing problems, to ensure protection of human health and the environment.

The following kinds of substances have recently emerged and are currently being investigated as contaminants of concern in Minnesota:

- Pharmaceuticals and personal care products (PPCPs)
- Perfluorinated chemicals (PFOS and PFOA)
- Polybrominated diphenyl ethers (PDBEs)

PPCPs constitute a wide variety of bioactive agents including: antibiotics, hormones, detergents, disinfectants, plasticizers, fire retardants, insecticides and antioxidants. PPCPs are widely used, and are continuously released into the environment through human activities. Primary sources include sewage, manure from confined animal feedlots, landfill leachate, and veterinary clinics. A recent reconnaissance study by the U. S. Geological Survey, MPCA and the Minnesota Department of Health (MDH) showed that industrial and household use compounds and pharmaceuticals are present in streams, ground water and in some Minnesota drinking water supplies. Steroids, nonprescription drugs and insect repellent were the chemical groups most frequently detected. Detergent metabolites, steroids and plasticizers were measured in the highest concentrations. The complete report may be found at http://water.usgs.gov/pubs/sir/2004/5138/

The perfluorinated chemicals (PFOS, PFOA) were manufactured for many years by 3M and other companies. They are produced synthetically or through degradation of other fluorochemical products. PFOS, used in emulsifier and surfactant applications, is found in fabric, carpet and paper coatings, floor polish, shampoos, fire fighting foam and certain insecticides. PFOA is used as a processing aid to produce fluoropolymers and is found in many personal care products and textiles. 3M phased out its manufacture of PFOS and PFOA in 2002.

PFOS and PFOA are widespread and persistent in the environment, but little is known about their toxicity to humans. In animals, high concentrations of PFOS and PFOA cause harm to the liver and other organs. Exposure to high concentrations of PFOA over a long period of time also cause cancer in animals. Developmental problems have been seen in the offspring of rats exposed to PFOS and PFOA while pregnant. Epidemiological studies by 3M of workers exposed during manufacture show no apparent impact on their health. There is no similar epidemiological information on the general population.

Due to limited information and the persistence of PFOS and PFOA, the MDH has set health risk limits (HRLs) of 1 ppb for PFOS and 7 ppb for PFOA in drinking water, which it characterizes as conservative (protective with an extra margin of safety).

PBDEs (polybrominated diphenyl ethers) are commonly used flame retardants found in plastics, textiles, electrical appliances and equipment, furniture, building materials and automobiles. Toxicity concerns include developmental neurotoxicity, thyroid disruption, altered behavior and learning, and dioxin formation when burned. PBDEs have been detected globally in both developed and remote environments. Monitoring studies have measured PBDEs in sediment, air, wildlife, fish, human blood and human milk. A human-milk monitoring program in Sweden showed that PBDE concentrations in breast milk nearly doubled every five years until Sweden banned PBDEs in 1997, when concentrations in breast milk dropped off rapidly. In contrast, PBDE concentrations in breast milk of North Americans, where PBDEs are still widely used, has been shown to be 10 -100 times higher than in Europe, where manufacture and usage has been phased out.

Dietary intake is assumed the primary route of PBDEs exposure in humans, although recent information suggests that inhalation and ingestion of indoor dust also may be an important exposure pathway.

The MPCA has been involved in investigating the impacts of PBDE contamination in Minnesota for several years. A 2001 MPCA study found that PBDEs were present in different environmental settings, including fish and sediments from major river basins in Minnesota. This study also detected PBDEs in waste management processes, including landfill leachate, and wastewater treatment plant sludge.

Additional MPCA analysis nearing completion involves measurement of PBDEs in Lake Superior water, sediment, fish tissue, zooplankton and ambient air; wastewater treatment influent, effluent and sludge; stream fish tissues and bottom sediments; and closed-landfill gases, leachate and ground water.

The European Union and five U.S. states have enacted laws banning or phasing out the manufacture and use of PBDEs over the next three years, and five other states are considering similar measures.

A scientific background paper on PBDEs is expected to be available from the MPCA in April 2005 for those interested in more detailed information.