1972-1995
AMBIENT AIR QUALITY TRENDS SUMMARY

Ambient Monitoring Section
Division of Air Quality

State of North Carolina

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Department of Environment
and
Natural Resources

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Preface

This report summarizes air quality trends for outdoor or ambient air, based on monitoring data collected in North Carolina from 1972 to 1995 by the North Carolina Division of Air Quality and from 1978 to 1995 by the National Atmospheric Deposition Program/National Trends Network (NADP/NTN). It covers the following pollutants: particulate matter (TSP and PM_{10}), carbon monoxide (CO), Ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and lead (Pb). These are referred to as criteria air pollutants because the federal government and the state have established standards for them to protect the public health and welfare. The report also includes data on acid deposition, or acid rain, as measured by pH, based on NADP/NTN monitoring.

For each of the six criteria air pollutants, this report has a section describing its description, important sources, meteorological interactions, the applicable federal and state standards, and health, welfare and environmental effects. Another section presents similar information about acid precipitation. Statewide trends for each pollutant are shown by a graphical summary and a written synopsis.

A more comprehensive *1972-1995 Ambient Air Quality Trends Report* for North Carolina is scheduled for publication in the Spring of 1998. The comprehensive report is written more technically than this *Summary* and contains more detailed pollutant descriptions, statewide and regional trend analyses, and individual trend analyses for many of the state's monitoring sites. The forthcoming report also will contain statewide trends for pH and other pollutants in precipitation.

Copies of the comprehensive *1972-1995 Trends Report*, the Annual Air Quality Reports (beginning in 1985), and additional copies of this trends summary, are available from:

North Carolina Division of Air Quality
P O Box 29580
Raleigh, North Carolina 27626-0580

The division welcomes comments regarding this *Summary* or suggestions for improving future reports. Comments may be sent to Mr. G. Stephen Few or Dr. Wayne L. Cornelius at the Division of Air Quality.

Daily air pollution information for several highly populated areas in North Carolina is available to the public through two telephone numbers that provide the current *Air Quality Index* and *pollen counts* (in some areas) in a computer-updated recorded announcement, 24 hours a day:

Statewide toll-free......... .... 888-AIR-WISE
(for Asheville, Durham, Fayetteville, Greensboro, Greenville, Raleigh, Wilmington, and Winston-Salem areas)

Charlotte area... .... 704-333-SMOG

The North Carolina Division of Air Quality maintains an Internet web page with information about environmental permits, ambient air quality, and the vehicle inspection and maintenance program. The DAQ's web address is: *http://daq.state.nc.us/.*

Contents

1. Introduction

This report summarizes air quality trends for ambient monitoring data collected in North Carolina from 1972 to 1995 by the N. C. Division of Air Quality in the Department of Environment and Natural Resources. The pollutants discussed in this report include: particulate matter (TSP and PM_{10}), carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and lead (Pb). These compounds are referred to as criteria air pollutants because the federal and state governments have established standards for them to protect the public health and the environment. This report also covers the concentration of hydrogen ions in precipitation, which refers to one measure of acid rain or deposition, expressed as pH. The pH of rainfall has been sampled in North Carolina since 1978 by the National Atmospheric Deposition Program/National Trends Network (NADP/NTN).

Chapter 2 lists the federal and state standards for criteria air pollutants. Chapter 3 shows the location of sites in the North Carolina air monitoring network as of 1995. Chapter 4 provides a concise summary of the statistical trends for all of the pollutants, including acid deposition.

Chapters 5 through 11 contain descriptions and discussions for each pollutant. Each chapter identifies and describes a pollutant and then discusses the important sources, meteorological interactions, applicable federal and state standards, and health, welfare or environmental effects. Chapters 5 through 11 also contain graphical summaries of the statewide performance for each pollutant relative to its standards. Most of these graphs contain a Aboxplot@ for each year of data, showing the median, quartiles, minimum and maximum statistics for a concentration measurement relating to one of the standards. We superimpose a Asmoothed trend@ line through the boxplots. After the graphical summary, the trends for each pollutant are discussed.

Carbon monoxide and ozone have exceeded the standards numerous times, which has prompted the EPA to designate portions of North Carolina in Anonattainment@ of the standards during certain periods. Currently, all areas of the state meet the ozone and carbon monoxide standards. For these two pollutants, we have provided a Abarplot@ showing the actual numbers of exceedances in each year. In 1997, the EPA adopted a new, stricter standard for ozone, which is likely to be much more difficult to meet than the old standard.

2. Ambient Air Quality Standards

The measurement of criteria pollutants characterizes air quality in particular areas. The measured values are compared to the corresponding primary and secondary standards. Primary standards are designed to protect public health, while secondary standards protect public welfare assets, such as vegetation, materials and visibility. Ambient air quality standards are expressed in quarterly, yearly, daily, and hourly means. **Table 1** provides a listing of the federal and state ambient air quality standards.

Pollutant	**Ambient Measurement**	**Averaging Period**	**Type of Summary**	**Standard Level Concentration**		
				Primary National	**Secondary National**	**North Carolina**
TSP	24 hour average	1 year	geometric mean	(1)	(1)	75 $\mu g/m^3$
		1 day	2nd maximum	(1)	(1)	150 $\mu g/m^3$
PM-10	24 hour average	1 year	average[2] arithmetic mean	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$
		1 day	2nd maximum[3]	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$
PM-2.5	24 hour average	1 year	average[2] arithmetic mean	15 $\mu g/m^3$	15 $\mu g/m^3$	(4)
		1 day	average[2] 98th percentile	65 $\mu g/m^3$	65 $\mu g/m^3$	(4)
CO	1 hour average	8 hours	2nd maximum	9 ppm (10 mg/m^3)		9 ppm (10 mg/m^3)
		1 hour	2nd maximum	35 ppm (40 mg/m^3)		35 ppm (40 mg/m^3)
O_3	1 hour average	1 hour	expected[5] 2nd maximum	0.12 ppm (235 $\mu g/m^3$)	0.12 ppm (235 $\mu g/m^3$)	0.12 ppm (235 $\mu g/m^3$)
		8 hours	expected arith. mean[5] 4th maximum	0.08 ppm (157 $\mu g/m^3$)	0.08 ppm (157 $\mu g/m^3$)	(6)
SO_2	1 hour average	1 year	arithmetic mean	0.03 ppm (80 $\mu g/m^3$)		0.03 ppm (80 $\mu g/m^3$)
		1 day	2nd maximum	0.14 ppm (365 $\mu g/m^3$)		0.14 ppm (365 $\mu g/m^3$)
		3 hours (non-overlapping)	2nd maximum		0.50 ppm (1300 $\mu g/m^3$)	0.50 ppm (1300 $\mu g/m^3$)
NO_2	1 hour average	1 year	arithmetic mean	0.053 ppm (100 $\mu g/m^3$)	0.053 ppm (100 $\mu g/m^3$)	0.053 ppm (100 $\mu g/m^3$)
Pb	24-hour average	1 quarter	arithmetic mean	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$

NOTES:

[1] National TSP standards were discontinued in 1987 and superseded by standards for PM-10.

[2] Arithmetic mean over the 3 most current years.

[3] In July 1997, the basis for this standard was changed to the 99th percentile instead of the 2nd maximum.

[4] National PM-2.5 standards became effective in July 1997 and probably will be adopted as North Carolina standards.

[5] Arithmetic mean over the 3 most recent complete calendar years.

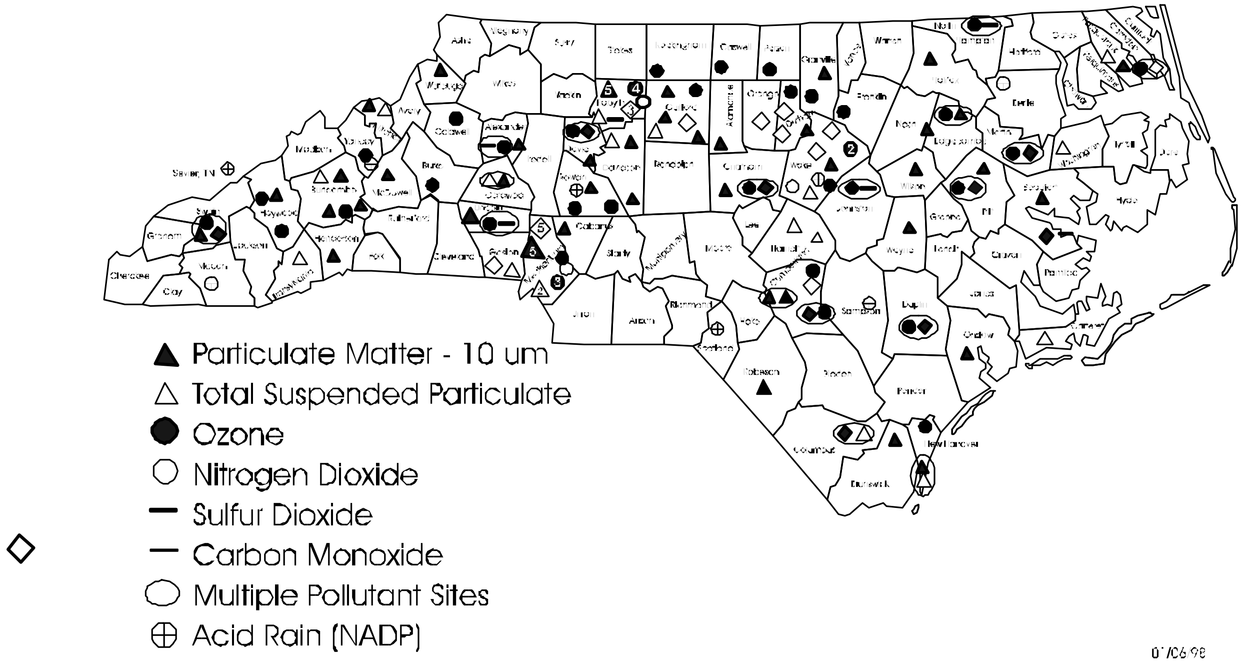
[6] The 8-hour average ozone standard became effective in July 1997 and probably will be adopted as the North Carolina standard.

3. Monitoring Sites

North Carolina has 117 sites for monitoring air quality across the state. This network includes: 76 sites operated by the Division of Air Quality; 29 sites operated by local program agencies in Forsyth, Mecklenburg, Buncombe and Haywood Counties; 4 rural ozone monitoring sites operated by contractors for the U.S. Environmental Protection Agency Clean Air Status and Trends Network (called CASTNet) and 8 sites operated by the NADP/NTN.

The map below (**Figure 1**) illustrates the North Carolina and NADP/NTN air monitoring network for 1995. Each year, some sites are discontinued, and
new sites are established in response to population changes, changes in location of emission sources, and factors such as changing availability of suitable locations for monitors. For example, there were many more TSP monitors and fewer monitors for most other pollutants in the 1970s than there were in 1995.

Locations of Monitoring Sites



01/06/98

NOTE: The Iron Station Site has been Replaced with the Crouse Site in Lincoln County.

4. Trend Analysis Summary

For most air pollutants, monitoring has found long-term declines in North Carolina. Levels of particulates, carbon monoxide, sulfur dioxide and lead in ambient air have dropped substantially since the 1970s. Long term trends are less clear for ozone and nitrogen dioxide, both of which have remained fairly constant. Acid precipitation, as shown by pH, has shown a moderate increase since the 1970s. The numerical increase in pH signifies *decreasing* acidity, which is consistent with the ambient concentration trends.

A summary of concentration trends for major air pollutants during specific ranges of years is shown in **Table 2** on page 8. Arrows indicate *statistically significant* trends. ANo change@ means that the trend is not statistically significant, not necessarily that the data are constant.

Pollutant or Analyte	**Sample Interval**	**Statistic**	**Range of Years**			
			1972-95	**1978-95**	**1985-95**	**1972-90**
TSP	24 hour	annual geometric mean	„			
	24 hour	annual second maximum	„			
PM_{10}	24 hour	annual arithmetic mean			„	
	24 hour	annual second maximum			„	
CO	1 hour	annual second maximum	„			
	8 hour	annual second maximum	„			
O_3	1 hour	annual second maximum	no change	no change	no change	
SO_2	1 hour	annual arithmetic mean	„			
	3 hour	annual second maximum	„			
	24 hour	annual second maximum	„			
NO_2	1 hour	annual arithmetic mean	no change		no change	
Pb	24 hour	quarterly arithmetic mean				„
pH	7 day	annual arithmetic mean		f		

5. Particulate Matter (TSP, PM_{10}, and $PM_{2.5}$)

Particulate matter refers to a mixture of solid particles and liquid droplets found in the air. Particles are classified by their size:

- Total Suspended Particulates (TSP) are airborne particles up to 100 micrometers (μm) in diameter.
- Coarse particles, or PM_{10}, are those with diameters up to 10 μm.
- Fine particles, or $PM_{2.5}$, are those with diameters up to 2.5 μm.

These categories are not mutually exclusive. For example, TSP also includes coarse and fine particles. The EPA no longer regulates TSP particles over 10 μm, because it doesn't consider them to be a general health risk. However, North Carolina regulates TSP as a nuisance pollutant.

Sources

Particulate matter comes from various man-made and natural sources. Man-made sources include diesel trucks, power plants, wood stoves and industries. Some smaller particles are formed from gaseous pollutants. Natural sources include wind-blown dust, forest fires, volcanic eruptions and plant pollen. The chemical and physical composition of particles can vary widely. While individual particles cannot be seen with the naked eye, collectively they can appear as black soot, dust clouds, or gray hazes.

Fine particles can remain suspended in the air and travel long distances. For example, a puff of exhaust from a diesel truck in Los Angeles can end up over the Grand Canyon. In fact, one third of the Grand Canyon haze comes from Southern California. Factors that affect the dispersion of particulate matter and the distance it travels include wind, humidity, and the size, shape, and density of particles. The stability of the atmosphere near a pollutant source determines the dispersal pattern of the emissions. In addition, rain can wash particles from the atmosphere.

Effects

Particulates can cause adverse health effects, particularly breathing disorders. The finest particles easily can reach the deepest recesses of the lungs. Those most at risk are the elderly, children, asthmatics, and individuals with pre-existing heart or lung disease.

A major economic effect of particulate pollution is the soiling of vehicles and buildings, which can be costly to clean and maintain. Acidic particles also can accelerate building deterioration. Particulate matter can also interfere with plant photosynthesis, by forming a film on leaves that reduces exposure to sunlight. These are some of the reasons why North Carolina has kept its TSP standard.

Suspended particles can absorb and scatter visible light, thus reducing visibility. Such haze is a national concern for vehicle safety, as well as the aesthetics of parks, historic sites and scenic attractions visited by tourists. In many parts of the United States, the visual range has been reduced 70 percent from natural conditions. In the East, the current range is only 14-24 miles, compared to a natural visibility of 90 miles.

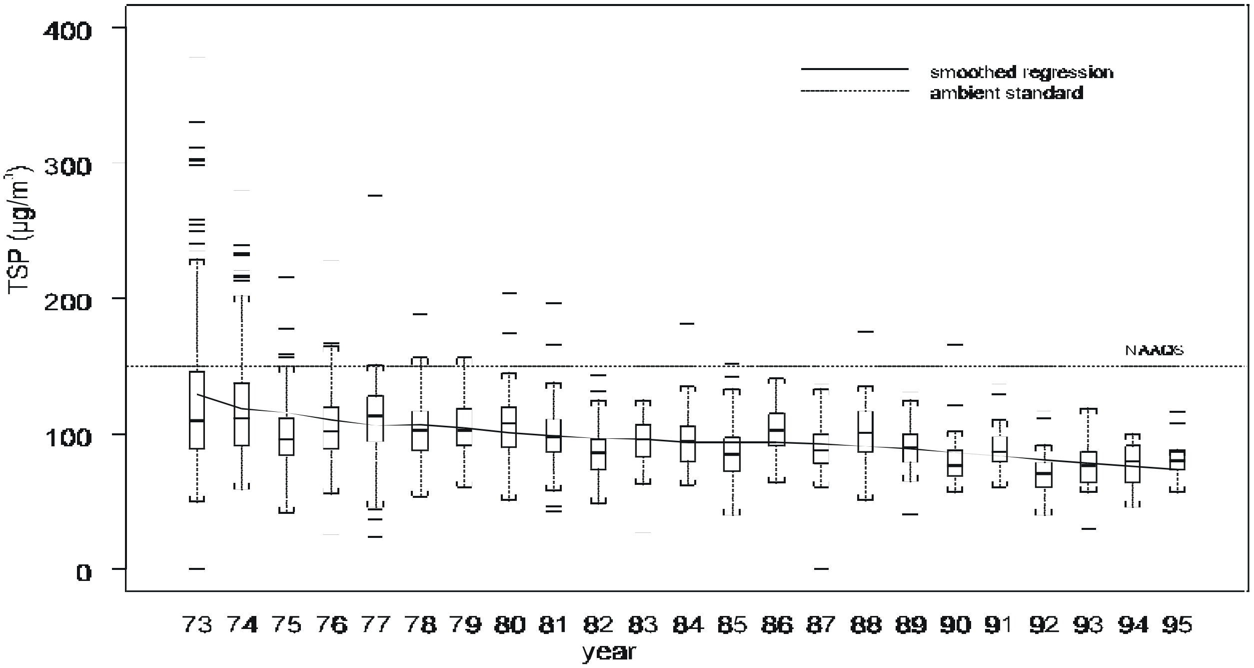
Trends

Particulate levels have decreased steadily in North Carolina over the past two decades. Although TSP concentrations exceeded the standards every year in the 1970s, only one exceedance has occurred since 1990 (**Figure 2**, **Figure 3**).

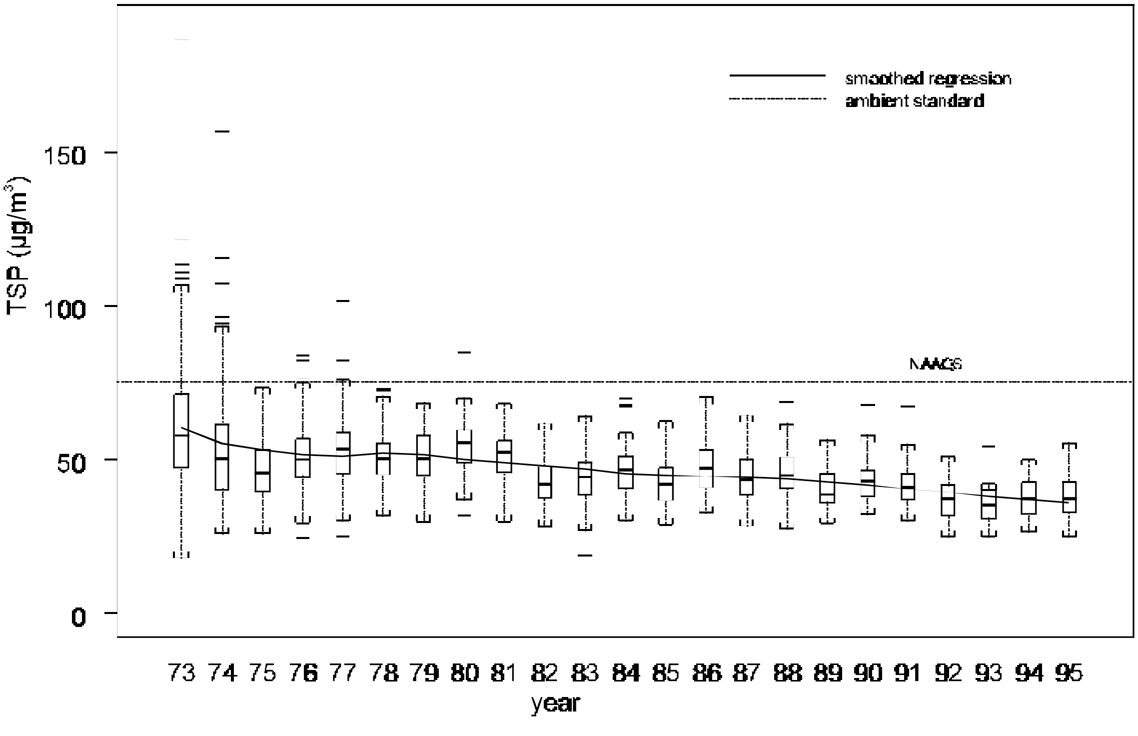
Monitoring for coarse particulates (PM_{10}) began in 1985, due to a change in National Ambient Air Quality Standards. Since then, PM_{10} concentrations in North Carolina have remained well below the standards, with a general decline from 1985 to 1995 (**Figure 4**, **Figure 5**).

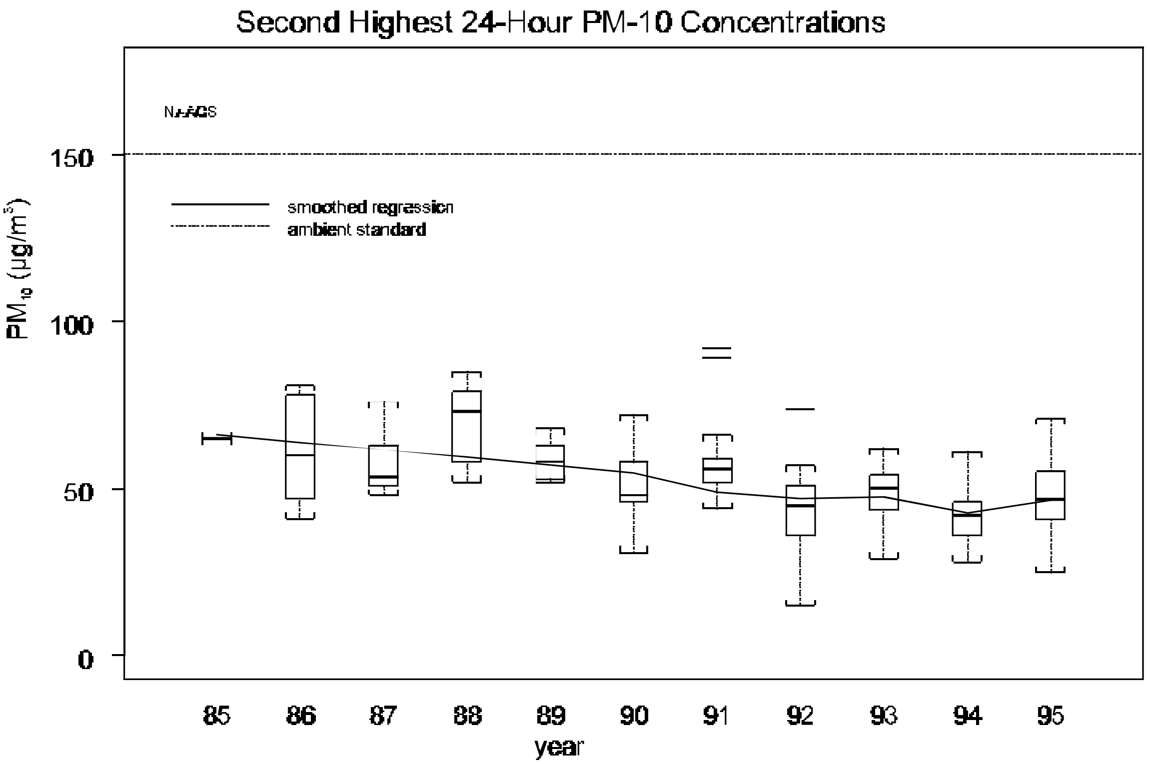
New EPA standards for $PM_{2.5}$ became effective in July 1997, but are not being evaluated in the present report. Although some $PM_{2.5}$ data have been collected in North Carolina in the past, they are not adequate for assessing trends. New $PM_{2.5}$ data will be collected using new sampling methods, beginning in 1998.

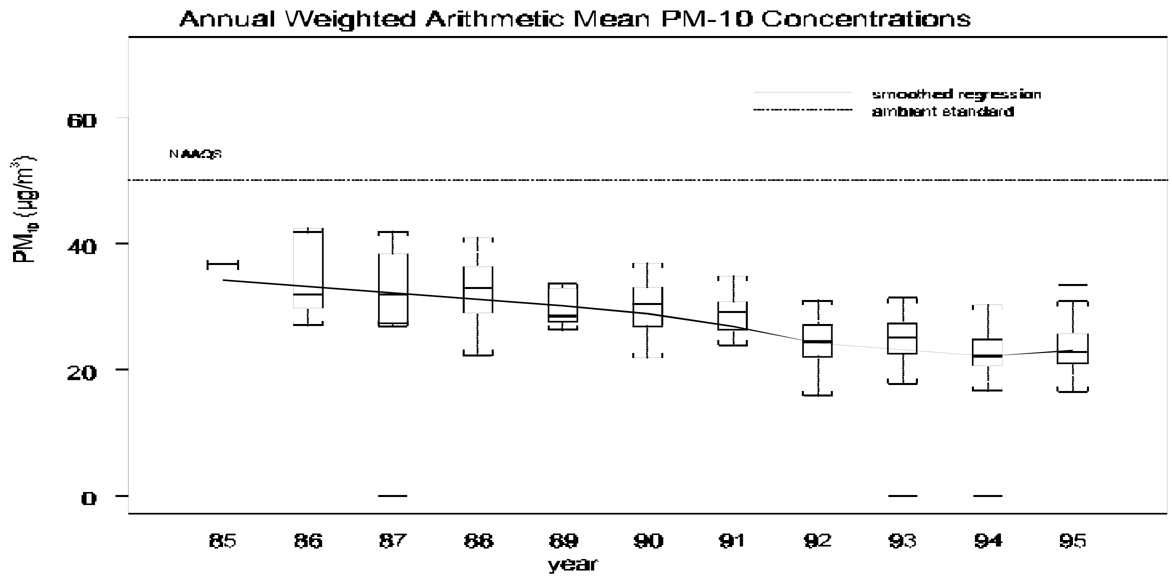
Second Highest Total Particulate 24-hour Average



Average Annual Total Suspended Particulate Geometric Mean







6. Carbon Monoxide (CO)

Carbon monoxide (CO) is a colorless, odorless, tasteless, and poisonous gas. The most commonly occurring global air pollutant, CO is produced by the incomplete burning of carbon-containing fuels.

Sources

The major natural source of atmospheric CO is from the decomposition of organic matter. The major man-made source is motor vehicle exhaust, which can account for more than 90 percent of all CO in large urban areas. Secondary sources include industrial processes and solid waste incineration. Although the EPA has measured an overall downward trend in CO concentrations throughout the United States, several large urban areas (outside of North Carolina) are still experiencing high levels of CO.

Effects

CO binds to blood hemoglobin more readily than does oxygen. CO inhalation reduces the ability of the blood to carry oxygen, causing harm to the cardiovascular and nervous systems.

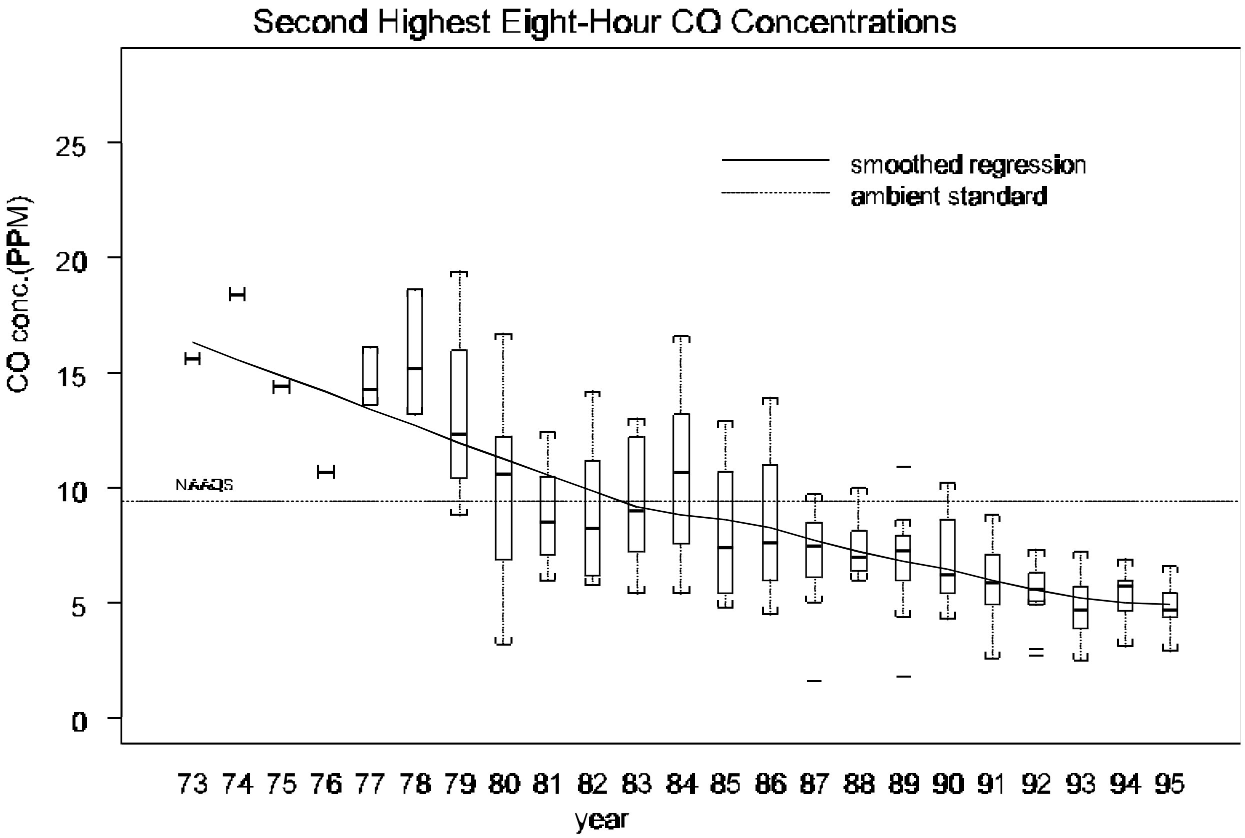
Individuals with anemia and heart and lung diseases are particularly sensitive to elevated CO levels. Low concentrations can impair thinking, vision and alertness. High concentrations can increase fatigue, cause dizziness and headaches, reduce work capacity, and harm fetal development.

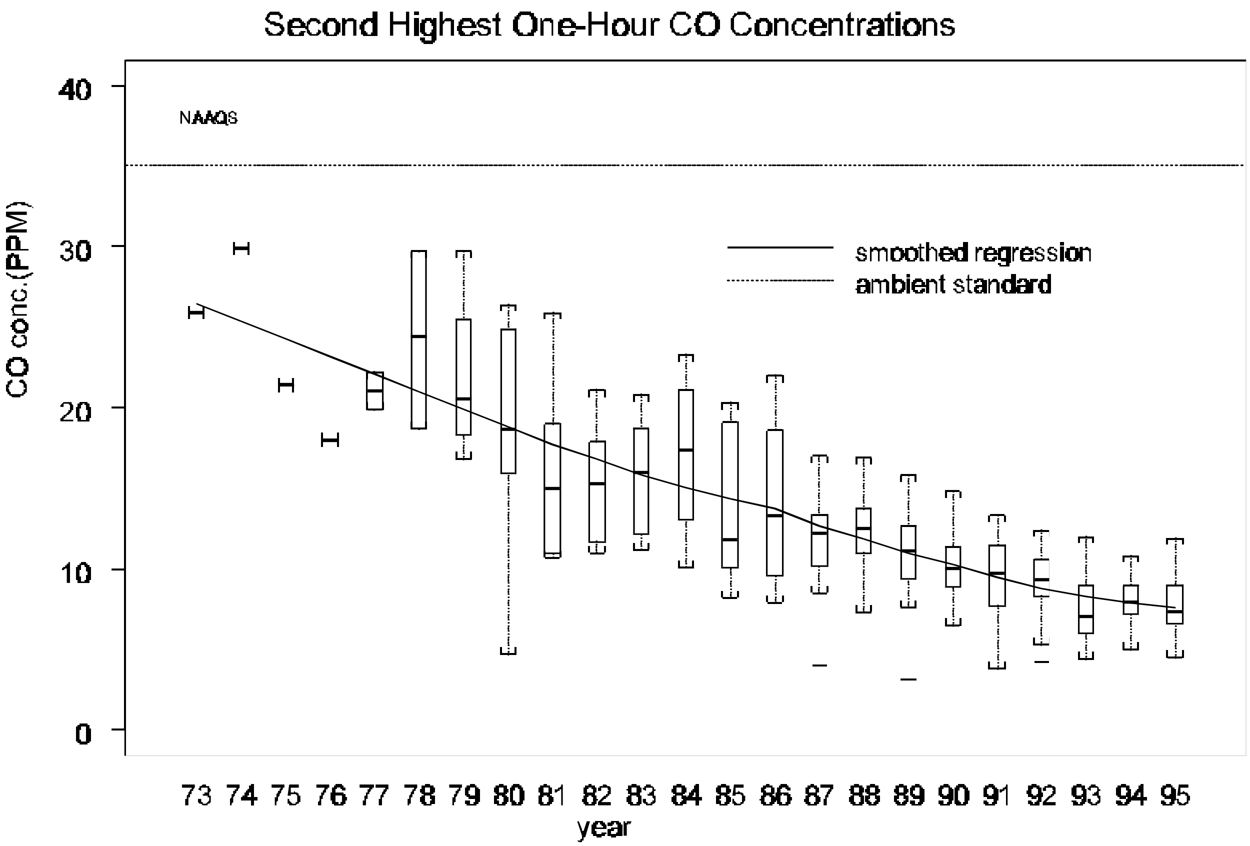
Although elevated levels of CO do not directly harm the environment, CO blocks the removal of the greenhouse gases blamed for global climate warming. CO removes hydroxyl radicals in the atmosphere; these hydroxyl radicals help lower the concentration of many greenhouse gases, especially methane.

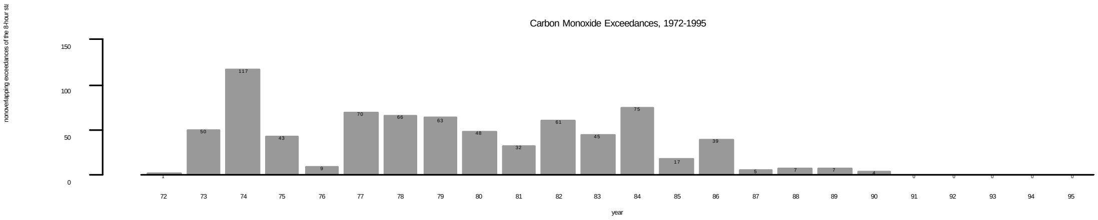
Trends

Carbon monoxide levels have declined steadily in North Carolina, dropping about 20 percent from 1972 to 1995 (**Figure 6**, **Figure 7**). Although North Carolina exceeded the 8-hour standard for CO many times before 1987, no exceedances have occurred since 1990 (**Figure 8**). There has never been an exceedance of the 1-hour standard in North Carolina.

The decline in CO concentrations is primarily due to stricter controls on automobile exhaust, leading to Acleaner@ cars. This drop is remarkable because it occurred while population was growing rapidly in North Carolina, causing more traffic and urban sprawl.


Second Highest Eight-Hour CO Concentrations


Second Highest One-Hour CO Concentrations


Carbon Monoxide Exceedances, 1972-1995

7. Ozone (O_3)

Ozone is a highly reactive colorless gas that is harmful to people, animals, vegetation, and materials even at very low exposure levels. The most widespread criteria air pollutant in North Carolina, ozone is the major component of a complex mixture of compounds known as photochemical oxidants, or smog.

Ozone also occurs naturally in the upper atmosphere (stratosphere), where it shields the earth from harmful effects of ultraviolet solar radiation. Stratospheric ozone can be damaged by emissions of chlorofluoro-hydrocarbons (CFCs) such as Freon.

Sources

Ozone is not a source specific pollutant for which specific controls can be established. Instead it is formed in the lower atmosphere by a series of complex chemical reactions involving atmospheric oxygen, nitrogen oxides (NO_x), and reactive hydrocarbons known as volatile organic compounds (VOCs). Key factors that promote the formation of ozone are sunlight, elevated temperatures and low wind speedsBconditions usually associated with high pressure systems that develop over North Carolina during the summer. It is estimated that 90 percent of all atmospheric NO_x is from the combustion of fossil fuels; coal, petroleum, and natural gas. Transportation (highway and off-highway vehicles) and stationary fuel combustion (electricity generating plants and industrial furnaces/boilers), respectively, are the two largest sources of NO_x. VOCs primarily are emitted by industrial processes, transportation activities, and vegetation. Industrial processes (chemical manufacturing, petroleum processing, and waste disposal), and highway vehicles account for most of the manmade hydrocarbon emissions. These industrial and transportation based emissions are concentrated around the major population centers and areas of highest ozone concentrations. Vegetative or biogenic VOC emissions are seasonal with the majority entering the atmosphere during the summer months. These biogenic VOC emissions are distributed across the entire state and create the background levels during the spring, summer, and fall ozone season, onto which manmade VOC emissions are added.

Ozone is considered a seasonal pollutant in North Carolina. The ozone season and monitoring period in North Carolina is from late spring to early autumn. This is when the temperature is above 60EF, sunlight is more intense, and high pressure systems with associated light winds occur frequently. At most sites, ozone concentrations peak in the mid to late afternoon and decrease during the night.

Effects

Ozone is harmful to both people and animals, although the complete effects are still under intense investigation. Exposure to low levels of ozone can cause respiratory problems, aggravate asthma, cause temporary decreases in lung capacity, and cause inflammation of lung tissue. Ozone exposure also impairs the body=s immune system, resulting in an increased incidence of respiratory infections such as pneumonia and bronchitis. As the concentration, length of exposure, and frequency of exposure increases, the severity of adverse effects also increases. Significant associations have been found with elevated ozone levels and emergency room visits and hospital admissions for respiratory distress. This is true for healthy and asthmatic individuals, especially children whose respiratory systems are still developing and individuals who work outside during the summer ozone season. Some effects are not reversed during periods of clean air exposure, raising concern about the cumulative impact that seasonal exposures may have over the years.

Ozone in the lower atmosphere has an adverse effect on plants and damages manmade and natural materials. Ozone affects plant growth and reproduction by interfering with the plants= ability to produce and store food. This reduces overall plant health, making plants more susceptible to disease, pests and the effects of environmental stresses such as high temperatures, drought conditions, and other pollutants. Ozone can directly damage plant foliage and affect essential plant processes. For example it can reduce the amount of carbohydrates produced and alter the overall growth pattern of plants. Long-lived species such as trees suffer from the cumulative effects of repeated exposures. Ozone also can reduce yields of many agricultural crops that are important to North Carolina, including tobacco, nursery stocks, cotton, corn, soybeans, wheat, and peanuts.

Ozone damages natural rubber and synthetic polymers, textile fibers and dyes. Fibers such as cotton, nylon, and acrylic show varying degrees of degradation due to exposure to ozone. Other studies have reported a causal relationship between ozone and changes in color of certain dyes used in textiles.

Ozone has been shown to have a detrimental effect on fine paintings. Frequently, the paints used in older paintings have undergone substantial and permanent color changes after exposure to ozone.

Trends

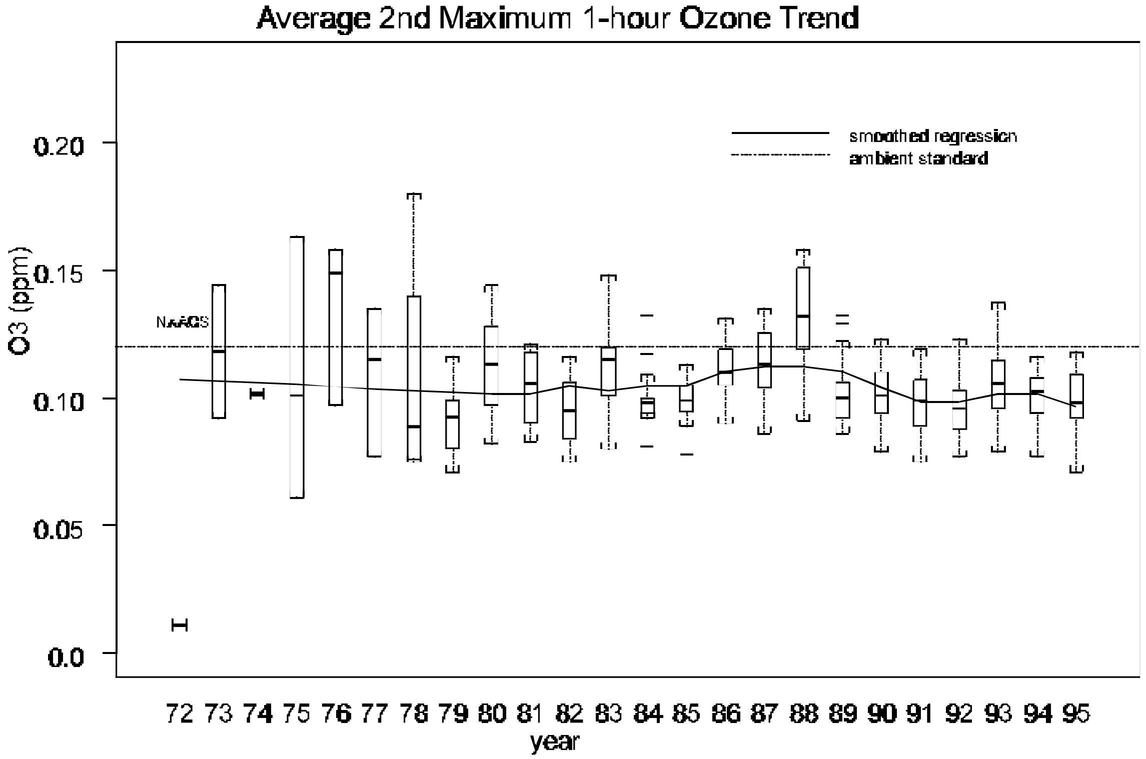
Ozone is the most difficult to control of the six criteria air pollutants for which National Ambient Air Quality Standards (NAAQS) have been established. Currently, all of North Carolina meets the ozone standard, although three areas in North Carolina previously have been designated as AModerate Nonattainment Areas for Ozone.@ These former nonattainment areas, with their respective ozone attainment redesignation dates, include: Charlotte-Gastonia (July 5, 1995), Greensboro--Winston-Salem--High Point (November 8, 1993), and Raleigh-Durham (June 17, 1994).

Ozone levels have tended to decrease over the long term in North Carolina, with average concentrations varying between 0.09 PPM and 0.11 PPM (**Figure 9**). Higher than usual concentrations occurred in 1987-1988.

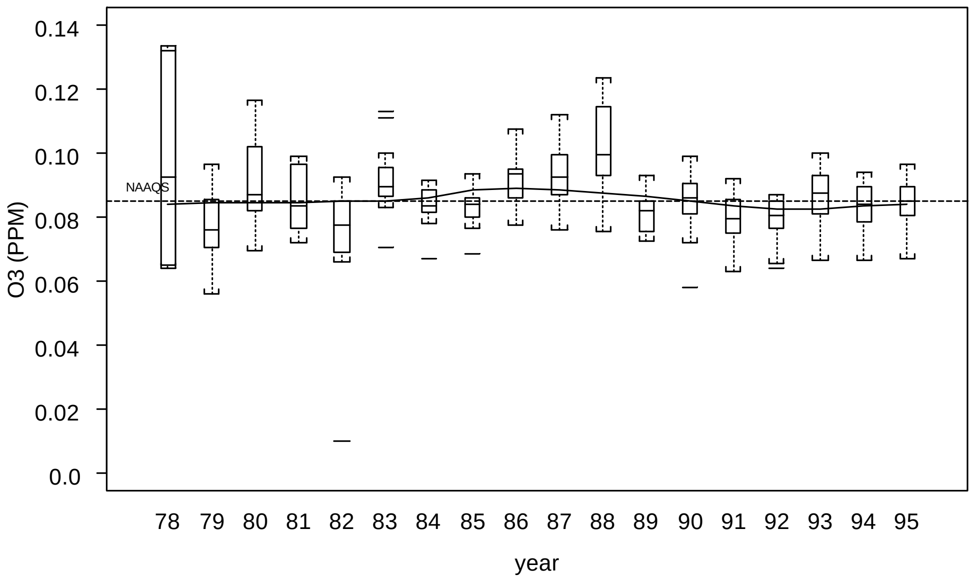
The maximum ozone concentrations are highly variable. Exceedances have occurred within the state in 20 of the 24 years from 1972 to 1995 (**Figure 10**).

In July 1997, the EPA adopted a new federal ozone standard of 0.08 parts per million measured over eight hours. Violations will occur when ozone levels exceed the standard, based on a three-year average of the fourth-highest ozone readings at each monitor. The EPA plans to determine which areas exceed the standard in July 2000, based on monitoring during the years 1997 through 1999.

Based on historical data, there is good reason to expect violations of the new standard at about half of the monitors in North Carolina. For the 1995-1997 period, 17 counties would have violated the new standard. The metropolitan areas of these counties include 28 counties and over half of the state's population. Statewide, the average 8-hour concentration of ozone was nearly constant at 0.085 ppm for the years 1978-1995 (**Figure 11**).



Average 4th Maximum 8-hour Ozone Trend



8. Sulfur Dioxide (SO_2)

Sulfur dioxide (SO_2) is a colorless, corrosive gas that is odorless at low concentrations but has a pungent odor at very high concentrations. Smaller concentrations of sulfur trioxide and other sulfate compounds also are found in SO_2 emissions. Sulfur oxides contribute to the formation of acid rain and particles that reduce visibility.

Sources

The main sources of SO_2 are combustion of fossil fuels (coal and oil) containing sulfur compounds, primarily from electric utilities, industries, and the manufacture of sulfuric acid from chemical plants. Other sources include petroleum refineries, smelting of ores that contain sulfur, paper mills, apartment-house furnaces and boilers.

The highest ambient air concentrations of SO_2 tend to occur near major sources. Unlike carbon monoxide and ozone, SO_2 concentrations do not appear to have seasonal variations. SO_2 dispersal depends on wind speed and patterns.

Effects

The most obvious health effect of sulfur dioxide is irritation and inflammation of body tissues that come in contact with the gas. Sulfur dioxide can increase the severity of existing respiratory diseases such as asthma, bronchitis, and emphysema. It can also aggravate existing cardiovascular disease.

Sulfur dioxide injures many plants. A bleached appearance between the veins and margins on leaves indicates damage from SO_2 exposure. Commercially important plants that are sensitive to SO_2 include cotton, sweet potatoes, cucumber, alfalfa, tulips, apple trees, and several species of pine trees.

Sulfur dioxide also is a precursor to sulfates, which can acidify lakes and streams, corrode buildings and monuments, and reduce visibility.

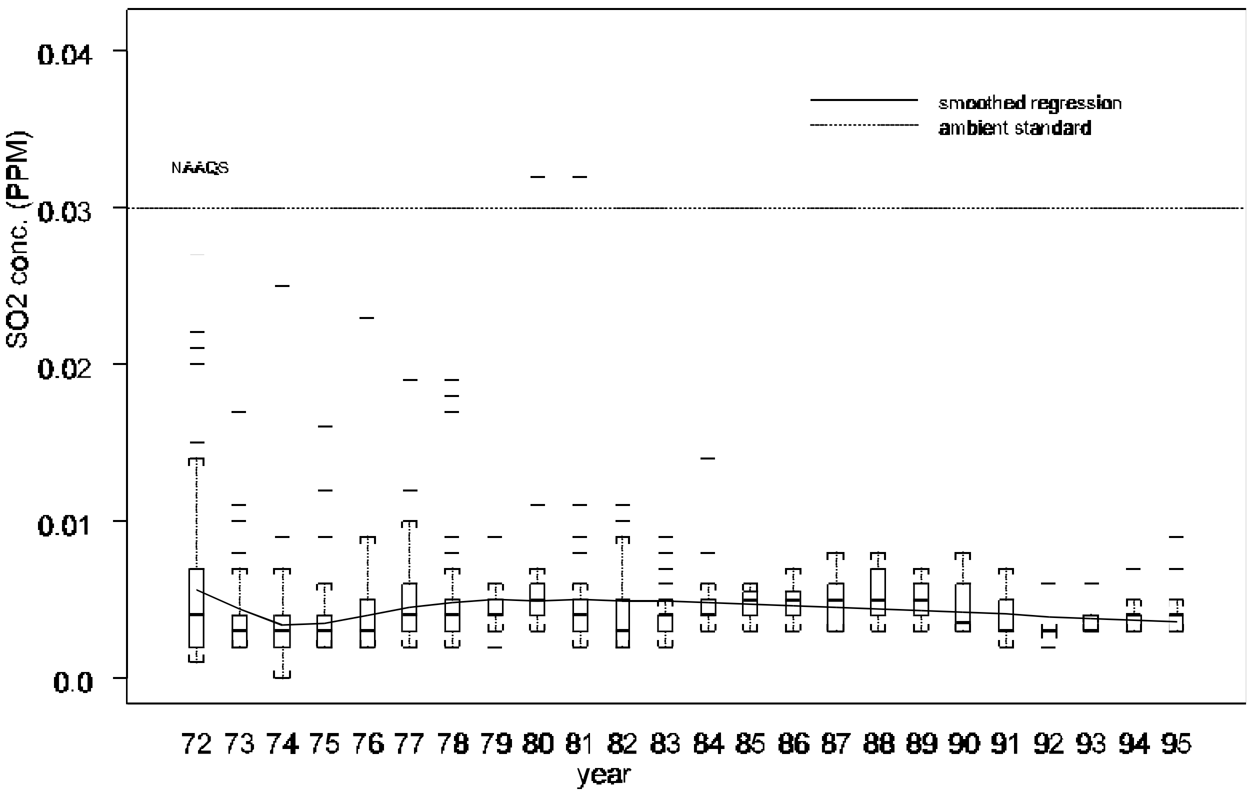
Trends

Sulfur dioxide (SO_2) data were reported from 179 sites between 1972 and 1995. Many of these sites have been discontinued, and others were designed for short term studies.

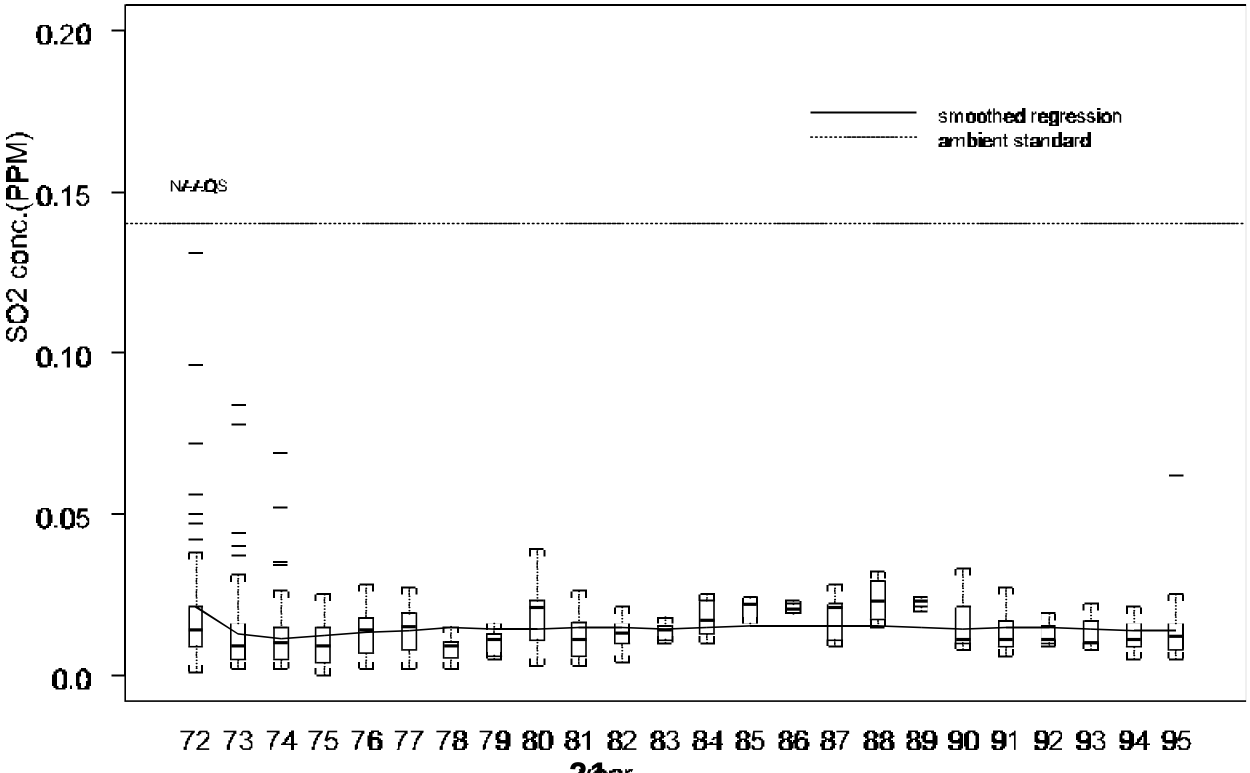
In general, all SO_2 concentrations in North Carolina are less than half of the standards (**Figure 12**, **Figure 13**, **Figure 14**). However, there were single exceedances of the SO_2 standard for annual arithmetic mean (**Figure 12**) and maximum three-hour average (**Figure 14**) in 1980 and 1981, and several monitors had moderately high annual means throughout the 1970s.

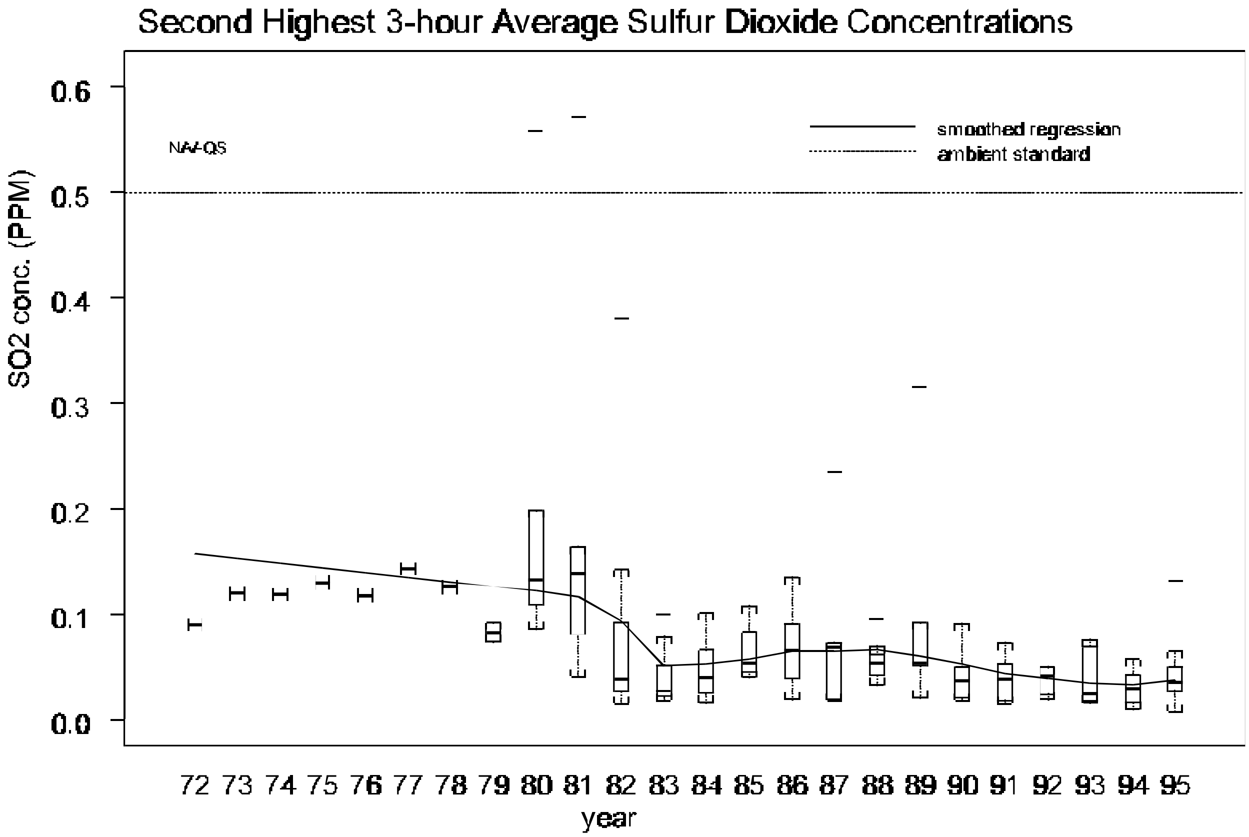
Over the long term, SO_2 levels have declined steadily since the 1970s, with some evidence that concentrations have leveled off in recent years.

Annual Arithmetic Mean Sulfur Dioxide Concentrations



Second Highest 24-hour Average Sulfur Dioxide Concentrations





9. Nitrogen Dioxide (NO_2)

Several gaseous oxides of nitrogen are normally found in the air, including nitrogen dioxide (NO_2), nitrous oxide (N_2O), and nitric oxide (NO). There are national and state ambient air quality standards only for NO_2.

NO_2 is a reddish-brown gas that is not usually visible at typical ambient concentrations. High concentrations of NO_2 may reduce visibility. A significant portion of the brownish coloration sometimes observed in polluted air in winter months may be due to NO_2.

N_2O is a stable gas with anesthetic characteristics and typical ambient concentrations well below the threshold concentration for a biological effect. N_2O behaves as a greenhouse gas, thus contributing to global climate warming. N_2O also has been identified as having an important role in the depletion of stratospheric ozone.

NO is a colorless gas with ambient concentrations generally low enough to have no significant biological effect.

Sources

The most important nitrogen oxide emissions result from the burning of fossil fuels such as coal, oil and gasoline. Atmospheric nitrogen and nitrogen compounds in fuel react with oxygen when they burn. The primary combustion product is NO, which reacts with hydrocarbons, ozone and other atmospheric compounds to form NO_2. Globally, man-made and natural sources of nitrogen oxides are comparable in scale.

Effects

At high ambient concentrations, NO_2 has significant health effects as a pulmonary irritant, especially upon asthmatics and children. However, a much greater health concern in North Carolina is ozone, which is formed in the air when nitrogen oxides react with hydrocarbons on hot, sunny days.

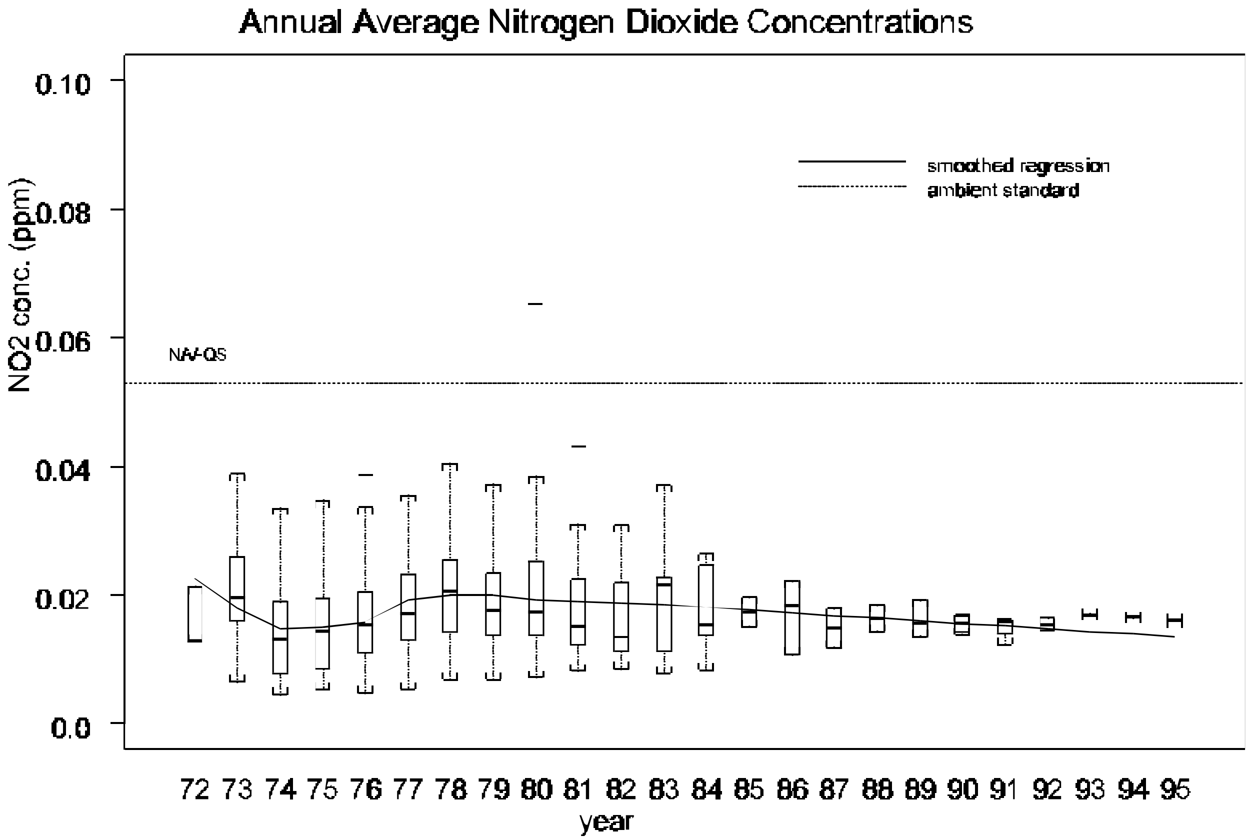
Some types of vegetation are very sensitive to NO_2, including oats, alfalfa, tobacco, peas and carrots. Chronic exposure causes leaf yellowing (chlorosis) and acute exposure usually causes irregularly shaped lesions on leaves.

NO and NO_2 do not directly damage materials. However, NO_2 can react with moisture in the atmosphere to produce nitric acid, which corrodes metal surfaces and contributes to acid precipitation. Nitric acid is removed from the atmosphere by dry deposition, wet deposition (acid rain) or by further reaction with gaseous ammonia to form ammonium nitrate particulates.

Nitrogen oxides also can react photochemically with atmospheric hydrocarbons and radicals to form ozone, PAN (peroxy acetyl nitrate), and a host of other secondary pollutants.

Trends

NO_2 concentrations average 0.015 ppm across the state. Although NO_2 levels declined from the late 1970s to mid-1980s, concentrations have leveled off in recent years (**Figure 15**).



Annual Average Nitrogen Dioxide Concentrations
NO2 conc. (ppm)
0.10
0.08
0.06
0.04
0.02
0.0
smoothed regression
ambient standard
NAAQS
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
year

10. Lead (Pb)

Lead (Pb) is one of the most widespread toxic metals in the environment. It also is one of the most familiar air pollutants because of its long history and multitude of uses.

Sources

Historically, the major sources of atmospheric lead have been from the combustion of lead-containing fuels, primarily gasoline. Since the phase-out of leaded gasoline, the most significant sources of Pb are point sources such as smelting industries. Other sources include the sandblasting of lead-coated surfaces and the combustion of coal.

Wind and rain affect the dispersion and deposition of atmospheric lead similar to particulate matter.

Effects

Lead enters the body primarily through the consumption of lead-contaminated food and secondarily by direct inhalation. Lead is absorbed into the blood through the digestive tract or the lungs. Most lead (90 percent) is stored in the red blood cells, with the remainder ending up in bones, brain tissue and other organs. Those most at risk are young children, newborn infants and pregnant women. Children are more likely to have higher lead blood levels, due to their activity around lead-containing substances such as paint and dust. Pregnant women are a major risk group because lead can pass through the placenta to the fetus. The major toxic effect of lead is the reduced production of hemoglobin, the oxygen-carrying component of the blood. This can lead to anemia, damage to the central nervous system, kidney and liver, and high blood pressure in older adults. Lead can bio-accumulate over an individual's lifetime, eventually reaching toxic levels.

Even though the EPA has measured a decisive downward trend in outdoor lead concentrations, lead contamination is still a concern because of the metal's ability to accumulate over time in both the environment and humans.

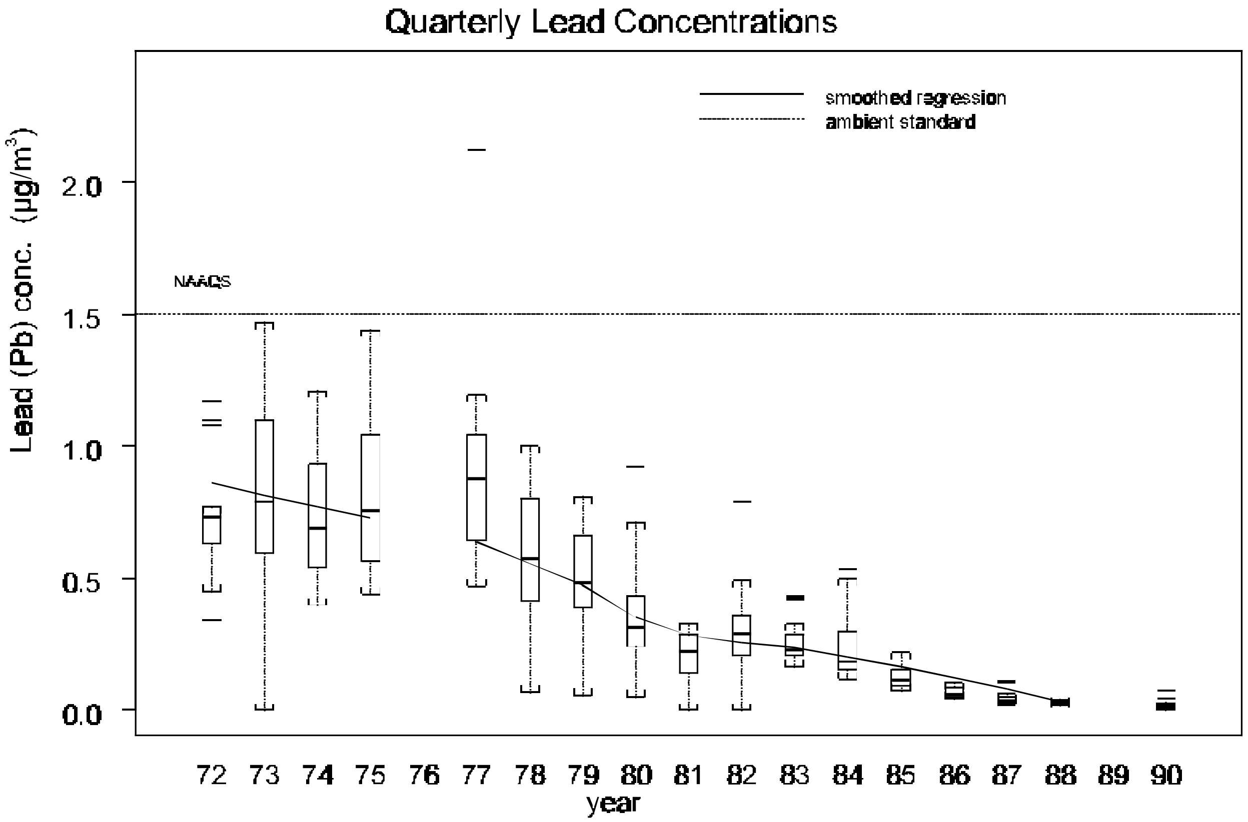
Lead effects in animals are similar to the effects in humans, including the destruction of hemoglobin and central nervous system damage. Animals tend to be more at risk to lead exposure due to their intimate association with the environment. Thus, lead levels tend to accumulate and bio-magnify in wildlife.

Perhaps the greatest environmental impact of lead is its ability to interfere with the bacterial decomposition of cellulose, an important nutrient source for plants and animals. Lead also has been linked with deforestation in the higher elevations of the Appalachian Mountains.

Trends

Routine monitoring for lead in the atmosphere in North Carolina was discontinued after 1982. However, particulate filters from state and local monitors have been provided to EPA for analysis of lead concentrations, and summary statistics are available for most years from 1972 through 1990.

These records show that lead concentrations in ambient air have been declining for twenty years in North Carolina. Mean concentrations decreased more than 90 percent from 1972 to 1990 (**Figure 16**).



11. Acid Deposition

Acid deposition occurs when nitrate and sulfate ions in the upper atmosphere react with moisture in the air to form acid rain or precipitation. Monitoring of pH and other ion concentrations in precipitation helps identify trends and demonstrates the results of efforts made to reduce emissions from mobile and industrial sources.

Sources

Sulfur and nitrogen oxides are emitted by automobiles, industries and agricultural sources. These oxides combine with water to form sulfuric acid and nitric acid.

Effects

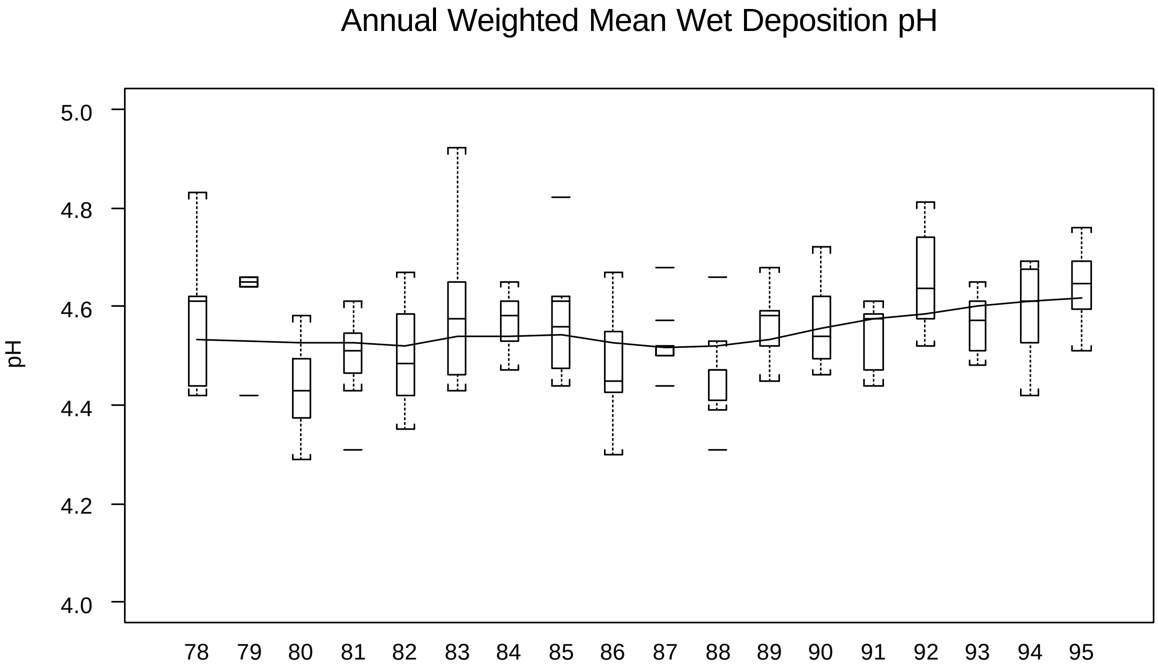
Many agricultural crops in North Carolina are sensitive to acid rain. Forests are subject to mineral loss from acid precipitation exposure and may also suffer root damage. Acid fogs and mists, typical in the mountains of North Carolina, can expose trees and plants to even higher acid concentrations and directly damage their foliage. Lakes, rivers, and streams that are too acidic impede fish and plant growth.

Effects of acidic depositions on wildlife are complex and difficult to evaluate. Documented direct effects on terrestrial wildlife are meager, but indirect effects may result from soil acidification and contamination of food sources. Acid deposition also may elevate amounts of toxic metals, especially mercury and cadmium, in soils, water and forage vegetation.

Trends

Acidity is measured using a ApH@ scale numbered from 0 to 14, with 0 being extremely acidic and 14 being extremely basic. A substance with a pH of five is ten times as acidic as one with a pH of six, 100 times as acidic as a substance with a pH of seven, etc. Neutral water with an equal concentration of acid and base ions has a pH of seven. Pure water in equilibrium with the air is slightly acidic, because of chemical reactions with carbon dioxide and other naturally occurring substances in the atmosphere. Annual averages of acidity in the United States range from pH 5.7 in the West to pH 4.1 in some areas of the Ohio Valley.

pH values have been monitored by agencies cooperating with the National Atmospheric Deposition Program/National Trends Network at several North Carolina sites since 1978. The statewide distributions of pH in 7-day wet deposition samples are shown, along with a trend line, in **Figure 17**. Although annual averages have fluctuated, the apparent average trend pH was approximately constant, near 4.55 until 1990. However, pH levels have drifted upward since 1990, to about 4.60 in 1995. The change since 1990 represents about a 10 percent decrease in average acidity. This improvement is occurring concurrently with the implementation of new controls on major sources, likely resulting from the 1990 revisions to the federal Clean Air Act.



The data summarized in this section were provided by the National Atmospheric Deposition Program (NRSP-3)/National Trends Network (1997): NADP/NTN Coordination Office, Illinois State Water Survey, Champaign, IL 61820.

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