AIR QUALITY TRENDS SUMMARY 1972-1989

[redacted]

STATE OF NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES

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Foreword

This trends summary is issued by the North Carolina Department of Environment, Health, and Natural Resources. This document presents air quality trends for ambient monitoring data collected in North Carolina from 1972 to 1989. The ambient air monitoring data was collected by the North Carolina Division of Environmental Management (DEM)*. Air pollutants monitored are 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 termed criteria air pollutants with established State and federal standards designed to protect public health and welfare. Table 1 provides a listing of these standards.

This summary describes each pollutant individually and provides information on pollutant sources, health and welfare effects, State and federal standards, and air quality trends. The ambient air quality trends are determined from results of statistical tests performed on the actual pollutant measurements. The statistical data are derived by averaging the mean values from all monitoring sites for that particular year and calculating an annual average. The yearly mean is plotted as a line graph and a trend line analysis is performed on the averages to illustrate the existence and direction of any trends.

A larger document, the Ambient Air Quality Trends Report, will provide a more detailed statistical analysis of the monitoring data. The report will include air quality trends by monitoring site, AQCR (Air Quality Control Region), and State. The Trends Report will be available in late spring of 1991 from the Division of Environmental Management, Air Quality Section at (919) 733-3340. Supplies of the Trends Report will be limited and there will be a charge for requested copies.

A discussion of current data is available in the annual Ambient Air Quality Report. An up-to-date report of the "real-time" air quality status is available through the Air Quality Index (AQI) described in Section III of this document.

● REGIONAL OFFICE
■ LOCAL AGENCY COUNTY

* The ambient air data included in this summary was collected by the Division of Environmental Management with regional offices located in Asheville, Fayetteville, Mooresville, Raleigh, Washington, Wilmington, and Winston Salem and four local agencies located in Buncombe and Haywood, Forsyth, Guilford, and Mecklenburg Counties. This map illustrates the location of each regional office and local agency.

I. *Ambient Air Quality Standards*

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

Table 1: Summary of N.C. and National Ambient Air Quality Standards (NAAQS)

Pollutant	Mean Value	Nat. Prim. Std.	Nat. Sec. Std.	N.C. Std.
TSP	Annual Geometric	75 $\mu g/m^{3a}$	None	75 $\mu g/m^3$
	24 Hour[b]	260 $\mu g/m^{3a}$	150 $\mu g/m^{3a}$	150 $\mu g/m^3$
PM-10	Annual Arithmetic[a]	50 $\mu g/m^{3a}$	50 $\mu g/m^{3a}$	50 $\mu g/m^{3a}$
	24 Hour[a,c]	150 $\mu g/m^{3a}$	150 $\mu g/m^{3a}$	150 $\mu g/m^{3a}$
SO_2	Annual Arithmetic	80 $\mu g/m^3$	None	80 $\mu g/m^3$
	24 Hour[b]	365 $\mu g/m^3$	None	365 $\mu g/m^3$
	3 Hour[b]	None	1300 $\mu g/m^3$	1300 $\mu g/m^3$
NO_2	Annual Arithmetic	.053 ppm	.053 ppm	.053 ppm
CO	8 Hour[b]	9 ppm	None	9 ppm
	1 Hour[b]	35 ppm	None	35 ppm
O_3	1 Hour[c]	0.12 ppm	0.12 ppm	0.12 ppm
Pb	Quarterly Annual Arithmetic[b]	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$

a. The National Total Suspended Particulate (TSP) standards were replaced by National Particulate Matter-10 micrometer, aerodynamic diameter, (PM-10) standards on 7-31-87 by EPA. The North Carolina PM-10 standard was effective July 1, 1988.

b. Not to be exceeded more than once per year.

c. Not to be exceeded more than an average of one day per year. Four days with an exceedance at a site in three years or less is a violation.

$\mu g/m^3$ - micrograms per cubic meter of air
ppm - parts per million
microgram - one millionth of a gram, where 454 grams = 1 pound

II. Pollutant Information

Particulate Matter

Atmospheric particulate matter is defined as any airborne material, except uncombined water (water, mist, steam) which exists in a finely divided form as a liquid or solid at standard temperature and pressure and has an aerodynamic diameter of less than 100 micrometers (μm). Two types of particulate matter, Total Suspended Particulate (TSP) and Particulate Matter-10 micrometers (PM-10) are measured in North Carolina. TSP has an aerodynamic diameter of 45 micrometers or smaller and is measured by an EPA gravimetric analysis procedure. A twenty year history of TSP measurements exists in North Carolina.

PM-10 has an aerodynamic diameter of 10 μm or smaller and is also measured by the EPA gravimetric analysis procedure. PM-10 sampling began in 1985 and has increased over the past years. On July 31, 1987, the U.S. Environmental Protection Agency adopted new ambient air quality standards for PM-10 which replace the federal TSP criteria. North Carolina adopted the new PM-10 standards on July 1, 1988, and also retained the State TSP standards.

Particulate Sources

Particulate matter is emitted from both man-made and natural activities. Man-made sources include combustion processes, motor vehicle use, industrial operations, agricultural tilling, and open-burning. Natural sources include dust, dirt, forest fires, volcanic eruptions, and pollen.
Particles emitted directly from a source can be either fine or coarse; however, particles formed in the atmosphere are generally fine. Fine particles have diameters 2.5 μm or smaller while the larger, coarse particles have diameters between 2.5 and 60 μm.

Particulate Effects

Presence of particulate matter in the atmosphere can affect the health and welfare of the surrounding population and environment. Health effects can change the physical and mental well-being of those exposed to the pollutant. Welfare effects are those that influence an individual's quality of life other than human health effects.

Health effects from inhaled particles are influenced by the depth of penetration into the respiratory system and the biological reaction to the deposited particles. The risks of adverse health effects are greater when particles enter the tracheobronchial and alveolar (bronchial tubes and lungs) portions of the respiratory system. However, healthy respiratory systems can better trap particles larger than 10 μm before they enter the lower respiratory system and can more easily remove those that do penetrate the lower respiratory system. Health effects of particulate matter inhalation include: stress on the breathing system, aggravation of existing lung and heart disease, effects on lung clearance, changes in form and structure of organisms, and cancer development. The individuals most sensitive to particulate matter inhalation are those with chronic lung obstruction or heart disease, those with flu, asthmatics, the elderly, children, and mouth breathers.

Welfare effects of particulate matter exposure include: plant damage, property damage, and visibility reduction. Visibility is a national and State concern, particularly in places such as urban areas, national parks, historic locations, and scenic attractions.

Particulate Trends

Particulate matter trends provided in this summary are based on TSP concentrations because only limited PM-10 data are available for the last five years. The average second maximum 24 hour concentration and annual geometric means are plotted on a line graph and a line of best fit is drawn through the values to demonstrate the existence and direction of particulate matter trends. The eighteen year trend in TSP concentrations is shown in Figures 1 and 2. The trend line forms a downward line through the data points which indicates a trend of decreasing particulate values from 1972 to 1989. This downward trend is evidence that control of particulate sources and decreased open burning are improving the air quality.

FIGURE 1.

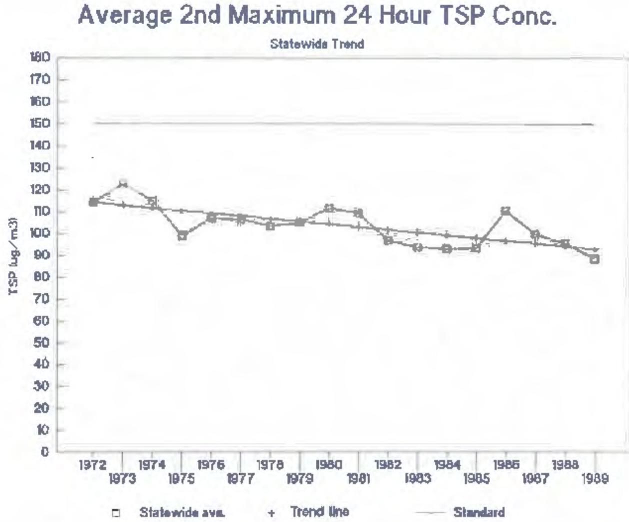
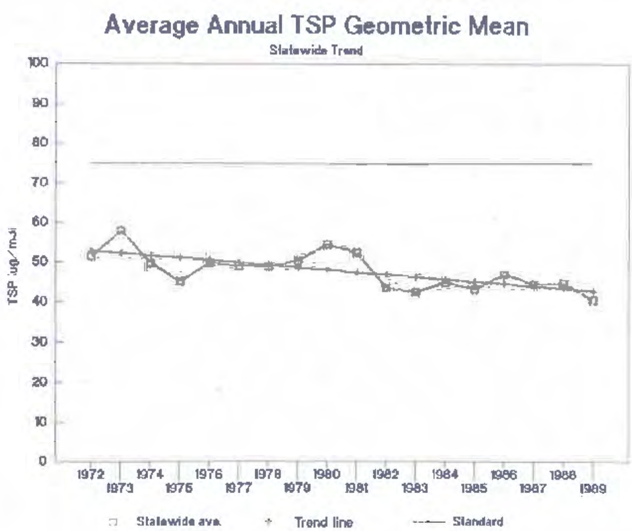


FIGURE 2.



Carbon Monoxide

Carbon monoxide is an odorless, colorless gas produced by incomplete combustion of carbon containing compounds such as wood, coal, and gas. CO pollutant concentrations are determined by a non-dispersive infrared light method. North Carolina's CO monitoring sites are located in major metropolitan areas where CO is very common.

Carbon Monoxide Sources

Most atmospheric CO is produced by incomplete combustion of fuels used for vehicles, space heating, industrial processes and solid waste combustion. Transportation activities account for the majority of the CO emissions. Boilers and other fuel burning heating systems are also significant sources of CO. Generally, the larger urban areas have more sources of CO and have higher ambient air concentrations.

Historical monitoring data indicate that most CO exceedances occur during the autumn and winter months. During the colder months, North Carolina experiences increased atmospheric inversions resulting in lower mixing heights and poor dispersion of air pollutants. Carbon monoxide becomes trapped under a warm layer of air in the lower atmosphere and continues to accumulate until atmospheric dispersion improves. In colder months, motor vehicles emit more CO due to inefficient combustion during cold starts and warm-ups. Additionally, more cars operate in the urban areas during seasonal shopping in November and December. Fueling woodstoves and furnaces during the cold winter months also increases the total of CO emissions.

Carbon Monoxide Effects

Breathing carbon monoxide affects the blood's oxygen carrying capacity. Hemoglobin in the blood attaches to CO more readily than it does to oxygen, depriving the body of vital oxygen.

Carbon monoxide diminishes pulmonary function. Individuals with anemia, lung, and heart diseases are particularly sensitive to CO effects. At low concentrations, mental function, vision, and alertness are affected. At high concentrations, CO exposure can increase fatigue, reduce work capacity, and may adversely effect fetal development. Cardiac damage may result from chronic exposure to CO at levels as low as 70 ppm (80 mg/m^3).

Ambient concentrations do not adversely affect vegetation or materials. The effects on animals are similar to those on humans.

Carbon Monoxide Trends

The second maximum averages were employed in trend analyses because these values are used to determine if the given areas are attaining the air quality standards. Figures 3 (1 hour average trend) and 4 (8 hour average trend) illustrate the decline of CO concentrations in North Carolina from 1972 to 1989. This significant decrease can be attributed to the following factors: older, more polluting vehicles are being replaced with newer, lower emitting models; traffic flow has improved with construction of new roads and streets, reduced onstreet parking, and better traffic signal coordination. Also, a motor vehicle Inspection and Maintenance (I/M) program has been in operation since 1982 for Mecklenburg County and 1986 for Wake County. Additional Motor Vehicle I/M programs will likely be a part of air pollution control strategies for other areas reporting carbon monoxide violations.

FIGURE 3.

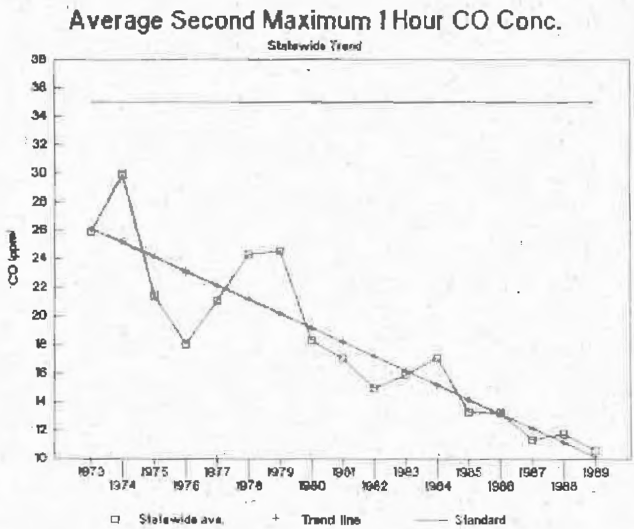
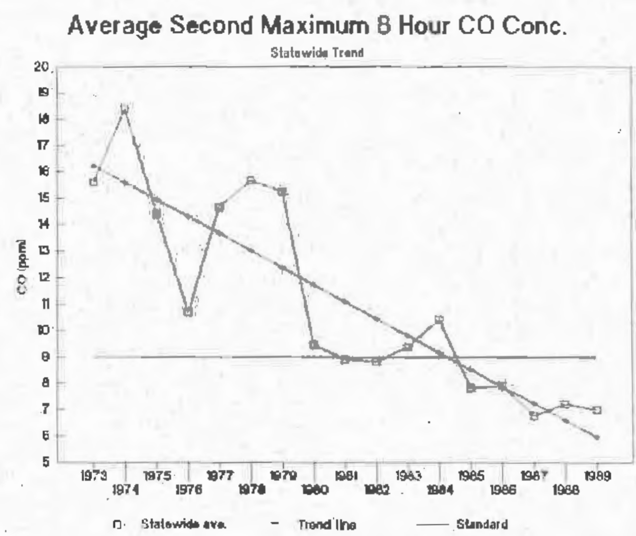


FIGURE 4.



Ozone

Ozone ambient air standards and monitoring are designed for measurement of concentrations in the lower atmosphere (troposphere). In the troposphere, high concentrations of ozone are a major health and environmental concern. Ozone in the troposphere is harmful to people, animals, vegetation, and materials. Ozone is the criteria pollutant of greatest concern in North Carolina. This tropospheric ozone should not be confused with the stratospheric ozone in the upper atmosphere. That protective layer of ozone is necessary to prevent harmful effects of ultraviolet radiation exposure.

Ozone Sources

Ozone is a highly reactive gas and is the main component of the air pollutant mixture known as smog. Ozone is formed by reaction of sunlight with hydrocarbons and nitrogen oxides. Nitrogen oxides are formed as by-products of fuel burning sources such as power plants and motor vehicles. Ozone concentrations are usually higher in the spring and summer months when temperatures are warmer and days are longer.

Most of the monitors operate in the warmer months, April through October. Ozone is measured using ultra-violet photometry. Two natural sources of ozone are electrical discharge during thunderstorms and solar radiation in the stratosphere. These two sources are not considered significant in lower atmosphere ozone concentrations.

Ozone Effects

Ozone is a pulmonary irritant affecting the respiratory membranes and functions. Symptoms include shortness of breath, pain when inhaling deeply, coughing, and wheezing. People with asthma, bronchitis, or emphysema will probably experience breathing difficulty when exposed to short-term concentrations between 0.15 and 0.25 ppm. With repeated or long-term exposure, permanent lung damage may occur. Reports have been received of noticeable shortness of breath and "feeling different" from healthy people exercising when concentrations are between 0.06 to 0.12 ppm. Ozone accelerates material aging, cracking rubber, fading dye, and eroding paint. Ozone also damages vegetation by injuring plant leaves. The most common vegetation effects occur on broad-leaf plants, leaving small flecks on the upper surfaces. This problem has been severe on sensitive varieties of tobacco and is commonly known as weather fleck. Studies conducted by North Carolina State University in 1988 found the following crop losses due to ozone exposure: 7 percent for soybean, 2 percent for field corn, 9 percent for cotton, 9 percent for peanut, 4 percent for tobacco, and 7 percent for clover-fescue. These percent losses were based on a limited data base and the effects to crop damage from seasonal climatological variations were unknown (1988 Estimates of Crop Losses in North Carolina Due to Plant Diseases & Nematodes, C.E. Main and Sharon K. Glutz, North Carolina State University, Department of Plant Pathology, Special Publication Number 8).

Ozone Trends

Ambient ozone concentrations are neither increasing or decreasing; however, the greatest number and intensity of violations were reported in 1988. Weather conditions play an important role in the annual variability of the ozone concentration. Ozone has become North Carolina's most serious criteria pollutant. The trend line in Figure 5 forms a horizontal line which demonstrates no statistically significant trend in ozone concentrations from 1972 to 1989.

All ozone exceedances reported during the analysis period are illustrated in Figure 6. During the 1988 ozone monitoring period, the greatest number and intensity of exceedances were measured. A total of sixty-nine exceedances occurred at thirteen of the nineteen monitors between May and September of 1988.

FIGURE 5.

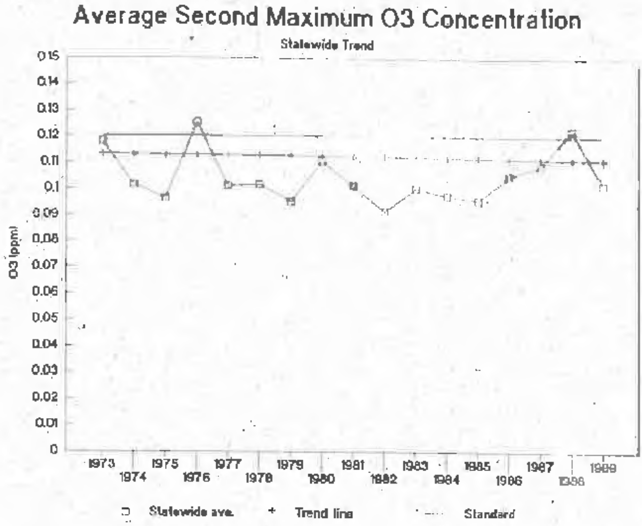
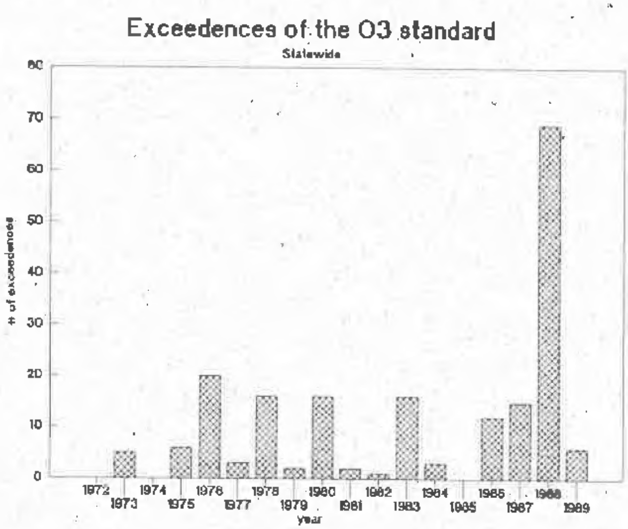


FIGURE 6.



Sulfur Dioxide

More than 90 percent of sulfur oxide emissions occur as sulfur dioxide with a balance of sulfur trioxide and other sulfates. SO_2 is a colorless gas that is detected by taste at concentrations of 0.38 to 1.15 ppm. Sulfur oxide monitoring is for sulfur dioxide. SO_2 is collected using pulsed fluorescence caused by ultraviolet light. To determine attainment status compared to the sulfur dioxide ambient air quality standard, the data is evaluated in 3 hour averages, 24 hour averages, and annual arithmetic means. Elevated sulfur dioxide levels do not exist over large areas as ozone does. The highest ambient sulfur dioxide concentrations are generally for short periods of time near major sources. Sulfur dioxide is a source dependent pollutant and is not influenced by the size of an urban area. Major source characteristics such as type, size distribution, control devices, operating conditions, and dispersion characteristics significantly affect the amount and impact of ambient sulfur dioxide produced.

Sulfur Dioxide Sources

Major sources of sulfur dioxide are combustion of fossil fuels containing sulfur compounds and manufacture of sulfuric acid. Other sources include refining of petroleum and smelting of sulfur containing ores.

Sulfur Dioxide Effects

The most obvious health effects of sulfur dioxide exposure are irritation and inflammation of body tissues. Sulfur dioxide can aggravate existing respiratory diseases such as asthma, bronchitis, and emphysema. Sulfuric acid and fine sulfate particles, sulfur dioxide transformation products, may also cause significant health problems. Sulfur dioxide can damage many types of vegetation. Exposure to ambient sulfur dioxide causes a bleaching of the veins and margins of plants. Many plants of economic importance are impacted by this effect. Another effect of sulfur dioxide transformation products is visibility reduction. Visibility is reduced when water is absorbed by fine sulfate particles present in the atmosphere.

A principal concern is the suspected role of ambient sulfur dioxide concentrations in acid rain formation. Acid rain lowers the pH in soils and natural waters, causes mineral leaching, damages vegetation, depletes fish population in some lakes, and damages materials.

Sulfur Dioxide Trends

As shown in Figures 7, 8, and 9, ambient sulfur dioxide concentrations in North Carolina have continued to be well below the standards. However, there is a significant trend upward in the 3 and 24 hour average concentrations from 1972 to 1989. Although the trends in these values are increasing, the eighteen year average for the 3 and 24 hour sample periods are only 8 percent and 14 percent of the corresponding standards. The annual arithmetic mean has remained fairly constant without much deviation in the data analysis period. Nationally imposed acid rain controls are expected to prevent sulfur dioxide from becoming a "problem" pollutant in North Carolina.

FIGURE 7.

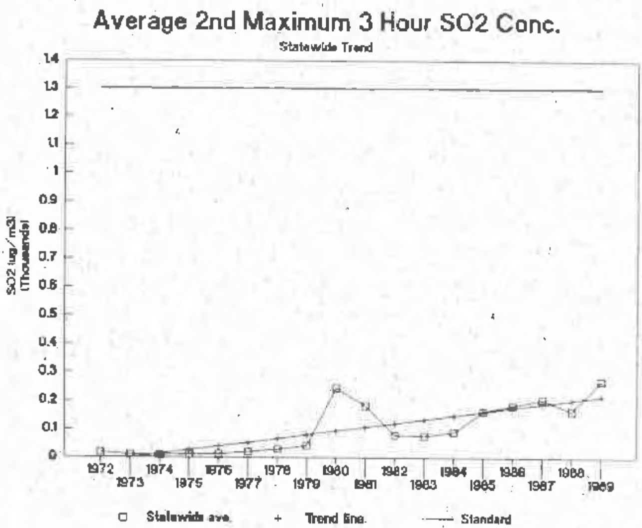


FIGURE 8.

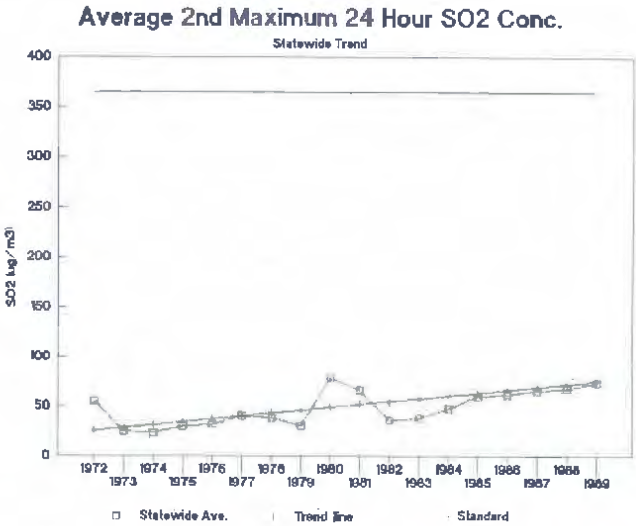
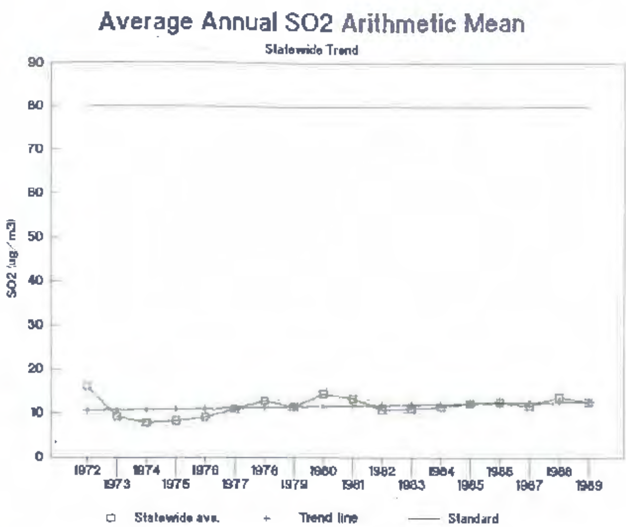


FIGURE 9.



Nitrogen Dioxide

Several nitrogen oxides exist in the atmosphere with nitrogen oxide (NO) and nitrogen dioxide (NO_2) as the most abundant. Nitrogen oxides are an important component in the formation of ozone during warmer months. Nitrogen dioxide is measured using chemiluminescence during reaction with ozone. No exceedances of the standard have ever been reported from any of the NO_2 continuous monitors in North Carolina.

Nitrogen Dioxide Sources

Most nitrogen oxide emissions occur from burning fossil fuels. Nitrogen oxide compounds are formed during combustion when atmospheric nitrogen and the fuel being burned are oxidized.

Nitrogen Dioxide Effects

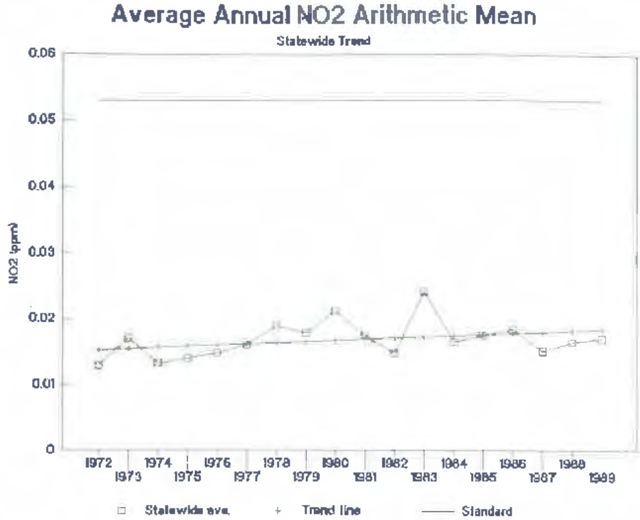
Exposure to NO_2 affects human health. Asthmatics and children can be affected by NO_2 concentrations as low as 0.5 ppm. Nitrogen oxides also indirectly affect human health by contributing to formation of ozone.
The following types of vegetation are very sensitive to nitrogen dioxide exposure: oats, alfalfa, tobacco, peas, and carrots. Chronic NO_2 exposure causes yellowing of plant leaves while acute exposure forms irregular shaped lesions.

Nitrogen dioxide and particulate nitrates are among the air pollutants that reduce visibility. In high concentrations, NO_2 gas is reddish-brown and thought to form a portion of the brownish color observed in polluted air. Nitrogen oxides also contribute to acid rain by forming nitric acid which comprises 25 to 30 percent of the acidity in precipitation.

Nitrogen Dioxide Trends

The trend line in Figure 10 forms a slightly upward line through the data points which signifies the presence of an air quality trend in ambient NO_2 concentrations measured from 1972 to 1989. The actual means are increasing by small amounts; however, the trend is statistically insignificant.

FIGURE 10.



Lead

Lead exists in the atmosphere as gas or particulate. North Carolina has not routinely collected lead samples since 1982. However, the State and local agencies provide EPA with filters for sample analysis. The most recent year of lead data is from 1988, and no lead data has been collected by the State since 1987.

Lead Sources

The major source of atmospheric lead has been from combustion of leaded gasoline (tetraethyl lead was widely added as an antiknock agent). Battery manufacturers are a minor source of lead in the State. Lead is also used in paints, insecticides, and newspaper inks. With the continued decrease in the use of leaded fuels and reduced concentrations of lead in motor fuel, the most significant sources of ambient lead are from sandblasting of bridges, overpasses, and water tanks and from the combustion of large amounts of coal.

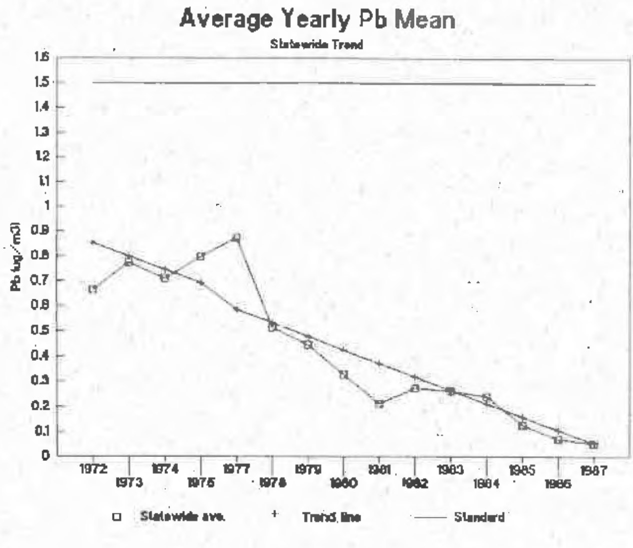
Lead Effects

Lead concentrations persist and accumulate in the environment and human body. Lead enters the body through eating and breathing and is absorbed into the blood stream and distributed to all body tissues. Exposure to low concentrations interferes with specific enzyme systems and blood production. Lead is also believed to cause kidney and nerve cell damage. Brain damage has been documented in cases of lead exposure in children. People at greatest risk include battery workers, solderers, sandblasters, and small children who play near lead sources. Additionally, studies have found that IQ deficits can occur in young children with exposure to lead levels below 25 µg/dl.

Lead Trends

Ambient air lead concentrations are clearly decreasing. The most obvious factor is the reduction of the amount of leaded gasoline used. As shown inFigure 11, the trend line forms a definite downward line.

FIGURE 11.



III. AIR QUALITY INDEX

Current air quality information is available 24 hours a day in four areas of the State through the Air Quality Index (AQI). This data can be accessed by calling any of the following telephone numbers: Charlotte, (704)333-SMOG; Raleigh and Durham (919)733-DATA; and Fayetteville (919)486-9413. When you call these numbers, a recorded message provides the current air quality index which is updated every four hours.

The index is based on the highest ambient measurements from local air monitors. The report describes the expected effect of the pollutant concentration on the surrounding population.

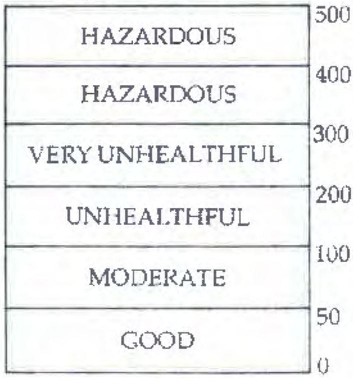
An index is reported in five ranges from zero to five-hundred. An index of 0 to 49 is considered "good". Indices between 50 and 99 are "moderate" with no adverse health effects expected and no protective actions recommended. An index between 100-199 is described as unhealthful and can aggravate existing conditions and decrease exercise tolerance in persons with heart or lung disease.

Ratings between 200 and 299 are considered very unhealthful and can produce significant aggravation of existing symptoms and decreased exercise capability in healthy persons. An index above 299 is hazardous. When indices range from 300-399, premature onset of certain diseases and decreased exercise capability in healthy persons can occur. The general population should avoid outdoor activity when the AQI exceeds 299.

Indices between 400 and 500 may cause premature death of ill and elderly individuals. Healthy persons will experience adverse effects that impact their normal outdoor activities. All persons should remain indoors, keeping windows and doors closed, and minimize physical exertion. An index above 150 has never been reported in North Carolina.

The following illustrates the air quality index values:

AIR QUALITY INDEX



An example of the Air Quality Index is as follows:
"This is the North Carolina Department of Environment, Health, and Natural Resources Air Quality Report.
The air quality index for most of Cumberland County is 88 for the four-hour period ending at 12 noon. This index is regarded as moderate. The responsible pollutant is ozone. This report will be updated at 4 pm. Thank you for calling."

1,000 copies of this summary were printed on recycled paper at a cost of $.67 per copy.