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The Effect of the Clean Air Act on Environmental Quality: Air Quality Trends Overview

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In the United States, between 1900 and 1970, emissions of the six principal pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM-10), and sulfur dioxide (SO_2), increased significantly.[1] However, since the Clean Air Act (CAA)[2] and the Clean Air Act Amendments of 1990 (CAAA)[3] were signed into law, emissions of all but one of these pollutants have declined, in some cases dramatically.[4]

At the same time, between 1970 and 1994, total emissions of the six principal pollutants decreased while the gross domestic product, population, and total vehicle miles traveled, all increased significantly.[5] Between 1985 and 1994, air quality continued to improve as monitored concentrations of each of the six pollutants declined.[6] This demonstrates that

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1. *See* 1994 EPA NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, at 1-1 (EPA 454/R-95-014) [hereinafter TRENDS REPORT].

2. Clean Air Act (CAA) §§ 101-618, 42 U.S.C. §§ 7401-7671q (1994).

3. Clean Air Act Amendments (CAAA), Pub. L. No. 101-549, 104 Stat. 2399 (1990).

4. *See* TRENDS REPORT, *supra* note 1 at 1-1.

5. *See id.* at 1-3.

6. *See id.*

economic growth and environmental protection can go hand-in-hand.[7]

Although short-term changes, between 1993 and 1994, showed slight increases in monitored concentration levels of NO_2[8] and CO,[9] monitored concentration levels of Pb,[10] O_3,[11] and SO_2[12] continued to decrease, and PM-10[13] remained unchanged. During this same one year period, emissions of CO,[14] nitrogen oxides (NOx),[15] PM-10,[16] and volatile organic compounds (VOCs)[17] also increased. Despite improvements in air quality since 1970, approximately 62 million people lived in counties where air quality levels exceeded the National Ambient Air Quality Standards (NAAQS) for at least one of the six principal pollutants in 1994.[18]

I. Background

Air pollution originates from many different sources. These sources may generally be classified into one of three categories: stationary sources, mobile sources, or natural sources. "Stationary sources" include factories, power plants, and smelters.[19] "Mobile sources" include of mobile pollutant sources such as cars, buses, planes, trucks, and trains.[20] "Natural sources" encompasses natural pollutant sources such as wildfires, windblown dust and volcanic eruptions.[21] These sources all contribute to air pollution in the United States.

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7. *See id.*
8. *See id.* at 2-10, figure 2-14.
9. *See* TRENDS REPORT, *supra* note 1 at 2-10, figure 2-14.
10. *See id.* at 2-7, figure 2-7.
11. *See id.* at 2-13, figure 2-19.
12. *See id.* at 2-20, figure 2-32.
13. *See id.* at 2-17, figure 2-25.
14. *See* TRENDS REPORT, *supra* note 1 at 2-4, figure 2-2.
15. *See id.* at 2-10, figure 2-15.
16. *See id.* at 2-17, figure 2-26.
17. *See id.* at 2-14, figure 2-23.
18. *See id.* at 1-3.
19. *See* TRENDS REPORT, *supra* note 1 at 2-1.
20. *See id.*
21. *See id.*

The CAA provides the principal framework for state, tribal, national, and local efforts to protect air quality. Under the CAA, which was last amended in 1990, the EPA has a number of responsibilities, including:

1. setting NAAQS for pollutants considered harmful to public health and the environment;[22] and
2. ensuring that these air quality standards are met or attained (in cooperation with the states) through national standards and strategies to control air pollutant emissions from sources such as automobiles and factories.[23]

The CAA established two types of national air quality standards.[24] Primary air quality standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.[25] Secondary air quality standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.[26]

The EPA has set national air quality standards for the six principal pollutants discussed previously.[27] These pollutants are often referred to as "criteria" pollutants. It should be noted that the pollutant O_3 is not emitted directly to the air, but is formed by sunlight acting on emissions of NOx and VOCs.[28]

For the past 22 years, the EPA has examined air pollution trends for each of the six principal pollutants in this country. It examines changes in air pollution levels over time and summarizes the current air pollution status. Each year, the EPA publishes a comprehensive technical document entitled "National Air Quality and Emissions Trends Report."[29]

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22. *See id.* at 5-1.
23. *Id.*
24. *See* TRENDS REPORT, *supra* note 1 at 1-1.
25. *See id.*
26. *See id.*
27. *See id.*
28. *See id.*
29. *See* TRENDS REPORT, *supra* note 1 at i.

II. Long-Term Emissions Trends

Before the CAAA were signed into law in 1970, the 20th century witnessed a significant, continued increase in air pollution levels. Although the efforts made during the 1960s by state and local air pollution agencies, particularly in the polluted cities in the Northeast, did help reduce pollution in some local areas, emissions continued to increase on the national level.[30] Between 1900 and 1970, emissions of NOx increased 690%, VOCs increased 260%, and SO_2 increased 210%.[31] Since the passage of the Clean Air Act Amendments of 1970,[32] emissions of these pollutants have decreased significantly. Without these amendments, it is likely that emissions would have continued to increase.

III. Summary of Air Quality and Emissions Trends

The 1994 Air Quality and Emissions Trends Report tracked two kinds of trends: air concentrations based on actual measurements of pollutant concentrations in the air at selected sites throughout the country, and emissions based on engineering estimates of the total tonnage of these pollutants released into the air annually.[33] Each year, the EPA gathers and analyzes air quality concentration data from more than 4,000 monitoring stations around the country.[34] The monitoring stations are operated by state, tribal, and local government agencies as well as some federal agencies, including the EPA.[35] Trends for 1994 were derived by averaging direct measurements from these monitoring sites. Over the last ten years (1985 through 1994), air quality has continued to improve. The most notable improvements were an 86% decrease in Pb concentrations[36] and a 28% decrease in CO concentrations.[37] Improvements in measured concentrations

30. *See id.* at 7-6.
31. *See id.*
32. *See supra* note 3.
33. *See* TRENDS REPORT, *supra* note 1 at 1-1.
34. *See id.*
35. *See id.* at 2-1.
36. *See id.* at 1-3.
37. *See id.*

were also noted for the other principal pollutants, including NO_2, O_3, PM-10, and SO_2 during this time frame.[38]

The EPA estimates nationwide air pollutant emissions trends based on engineering calculations of the amounts and types of pollutants emitted by automobiles, factories, and other sources.[39] Emissions trends are based on many factors, including the level of industrial activity, technology developments, fuel consumption, vehicle miles traveled, and other activities that cause air pollution.[40] Emissions trends also reflect changes in air pollution regulations and installation of emissions controls. Over the last ten-year period (1985 through 1994), air pollutant emissions have shown improvement (decreased) for all pollutants except NOx.[41] The slight emissions increase (3%) observed for NOx can be attributed to increased processing or manufacturing by industry and increased amounts of fuels burned by electric utility plants.[42]

Since 1970, the combined emissions of the six principal pollutants decreased 24%, while U.S. population increased 27%, vehicle miles traveled increased 111%, and gross domestic product increased 90%.[43] Thus, the dramatic improvements in emissions and air quality occurred simultaneously with significant increases in economic growth and population. The improvements are a direct result of effective implementation of clean air laws and regulations.

IV. Six Principal Pollutants

A. Carbon Monoxide (CO)

1. Nature and Sources of the Pollutant:

Carbon monoxide is a colorless, odorless, poisonous gas formed when carbon in fuels is not burned completely. It is a by-product of motor vehicle exhaust, a source which contrib-

38. *See* TRENDS REPORT, *supra* note 1 at 1-3.
39. *See id.* at 2-1.
40. *See id.* at 1-1.
41. *See id.*
42. *See id.* at 2-9.
43. *See id.* at 1-1.

utes more than two-thirds of all CO emissions nationwide.[44] In cities, automobile exhaust can cause as much as 95% of all CO emissions.[45] These emissions can result in high concentrations of CO, particularly in local areas with heavy traffic congestion. Other sources of CO emissions include industrial processes and fuel combustion in sources such as boilers and incinerators. Despite an overall downward trend in concentrations and emissions of CO, some metropolitan areas still experience high levels of CO.[46]

2. Health and Other Effects:

Carbon monoxide enters the bloodstream and reduces oxygen delivery to the body's organs and tissues.[47] The health threat from CO is most serious for those who suffer from cardiovascular disease. Healthy individuals are also affected, but only at higher levels of exposure. Exposure to elevated CO levels is associated with visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, and difficulty in performing complex tasks.[48] The EPA's health-based national air quality standard for CO is nine parts per million (ppm) measured over eight hours.[49]

3. Trends in Carbon Monoxide Levels:

Long-term improvements continued between 1985 and 1994. National average CO concentrations decreased 28% while CO emissions decreased 15%.[50] Long-term air quality improvement in CO occurred despite a 32% increase in vehicle miles traveled in the U.S. during the past ten years.[51] Between 1993 and 1994, national average CO concentrations increased 2% while total CO emissions increased 4%.[52] Transportation sources now account for 78% of the nation's

44. *See* TRENDS REPORT, *supra* note 1 at 2-3.
45. *See id.*
46. *See id.*
47. *See id.*
48. *See id.*
49. *See* TRENDS REPORT, *supra* note 1 at 2-3.
50. *See id.*
51. *See id.*
52. *See id.*

total CO emissions.[53] The observed increase in CO emissions between 1993 and 1994 is attributed to two sources: transportation emissions (up 2%) and wildfire emissions (up 160%).[54]

B. Lead (Pb)

1. Nature and Sources of the Pollutant:

Smelters and battery plants are the major sources of lead in the air. The highest concentrations of Pb are found in the vicinity of nonferrous smelters and other stationary sources of Pb emissions.[55]

2. Health Effects:

Exposure to Pb mainly occurs through inhalation of air and ingestion of Pb in food, paint, water, soil, and dust. Pb accumulates in the body in blood, bone and soft tissue. Because it is not readily excreted, Pb can also affect the kidneys, liver, nervous system, and other organs.[56] Excessive exposure to Pb may cause anemia, kidney disease, reproductive disorders, and neurological impairments such as seizures, mental retardation, and other behavioral disorders.[57] Even at low doses, Pb exposure is associated with changes in fundamental enzymatic, energy transfer and other processes in the body. Fetuses and children are especially susceptible to low doses of Pb, often suffering central nervous system damage or slowed growth.[58] Recent studies show that Pb may be a factor in high blood pressure and subsequent heart disease in middle-aged white males.[59] Pb may also contribute to osteoporosis in post-menopausal women.[60] The EPA's health-

53. *See id.*
54. *See* TRENDS REPORT, *supra* note 1 at 2-3.
55. *See id.* at 2-6.
56. *See id.*
57. *See id.*
58. *See id.*
59. *See* TRENDS REPORT, *supra* note 1 at 2-6.
60. *See id.*

based national air quality standard for Pb is 1.5 micrograms per cubic meter (mg/m3), measured as a quarterly average.[61]

3. Trends in Lead Levels:

Between 1985 and 1994, average Pb concentrations in urban areas throughout the country decreased 86% while total Pb emissions decreased 75%.[62] These reductions are a direct result of the use of unleaded gasoline in automobiles.[63] The large reduction in Pb emissions from transportation sources has changed the nature of the air quality problem for Pb in the United States. Violations of the Pb air quality standard still occur, but tend to occur near large industrial complexes such as lead smelters.[64] Between 1993 and 1994, Pb emissions remained unchanged while national average Pb concentrations decreased 20%.[65]

C. Nitrogen Dioxide (NO_2)

1. Nature and Sources of the Pollutant:

Nitrogen dioxide belongs to a family of highly reactive gases called NOx. These gases form when fuel is burned at high temperatures, and come principally from motor vehicle exhaust and stationary sources such as electric utilities and industrial boilers.[66] A suffocating brownish gas, NO_2 is a strong oxidizing agent that reacts in the air to form corrosive nitric acid as well as toxic organic nitrates.[67] It also plays a major role in the atmospheric reactions that produce ground-level O_3 (smog).

2. Health and Other Effects:

NO_2 can irritate the lungs and lower resistance to respiratory infections such as influenza. The effects of short-term exposure are still unclear, but continued or frequent exposure

61. *See id.*
62. *See id.*
63. *See id.*
64. *See* TRENDS REPORT, *supra* note 1 at 2-6.
65. *See id.*
66. *See id.* at 2-9.
67. *See id.*

to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children. The EPA's health-based national air quality standard for NO_2 is 0.053 ppm, measured as an annual average.[68] Nitrogen oxides are important in forming O_3 and may affect both terrestrial and aquatic ecosystems. Nitrogen oxides in the air are a potentially significant contributor to a number of environmental effects such as acid rain and eutrophication in coastal waters like the Chesapeake Bay.[69] Eutrophication occurs when a body of water suffers an increase in nutrients that reduces the amount of oxygen in the water, producing an environment that is destructive to animal and aquatic life.[70]

3. Trends in Nitrogen Dioxide Levels:

Nationally, annual NO_2 concentrations remained relatively constant throughout the 1980s and decreased in the 1990s.[71] Average NO_2 concentrations in 1994 were 9% lower than the levels recorded in 1985.[72] The two primary sources of the NOx emissions in 1994 were fuel combustion (50%) and transportation (45%).[73] Since 1985, emissions from highway vehicles decreased 7% while fuel combustion emissions increased 8%.[74] Between 1993 and 1994, NOx emissions and NO_2 concentrations increased. These emissions increases are attributed to increased emissions from off-highway vehicles and wildfires.[75] Despite an increase in NOx emissions, 1994 was the third consecutive year that all monitoring locations across the nation, including Los Angeles, met the federal NO_2 air quality standard.[76]

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68. *See id.*
69. *See* TRENDS REPORT, *supra* note 1 at 2-9.
70. *See id.*
71. *See id.*
72. *See id.*
73. *See id.*
74. *See* TRENDS REPORT, *supra* note 1 at 2-9.
75. *See id.*
76. *See id.*

D. Ozone (O_3)

1. Nature and Sources of the Pollutant:

Ground-level ozone (the primary constituent of smog) is the most complex, difficult to control and pervasive of the six principal pollutants. Unlike other pollutants, O_3 is not emitted directly into the air by specific sources. O_3 is created by sunlight acting on NO_x and VOC emissions in the air.[77] There are literally thousands of types of sources of these gases. Some of the more common sources include gasoline vapors, chemical solvents, combustion products of various fuels, and consumer products. These sources can originate from large industrial facilities, gas stations, and small businesses such as bakeries and dry cleaners. Often these "precursor" gases are emitted in one area, but the actual chemical reactions, stimulated by sunlight and temperature, take place in another area. Combined emissions from motor vehicles and stationary sources can be carried hundreds of miles from their origins, forming high O_3 concentrations over very large regions. In 1994, approximately fifty million people lived in counties with air quality levels above the EPA's health-based national air quality standard.[78] The highest levels of O_3 were recorded in Los Angeles.[79] High levels also persist in other heavily populated areas like the Texas Gulf Coast and much of the Northeast.[80]

2. Health and Other Effects:

Scientific evidence indicates that ground-level O_3 not only affects people with impaired respiratory systems (such as asthmatics), but healthy adults and children as well. Exposure to O_3 for six to seven hours, even at relatively low concentrations, significantly reduces lung function and induces respiratory inflammation in normal, healthy people during periods of moderate exercise.[81] It can be accompanied by

77. *See id.*
78. *See id.*
79. *See* TRENDS REPORT, *supra* note 1 at 2-9.
80. *See id.* at 2-12.
81. *See id.*

symptoms such as chest pain, coughing, nausea, and pulmonary congestion. Recent studies provide evidence of an association between elevated O_3 levels and increases in hospital admissions for respiratory problems in several U.S. cities. Results from animal studies indicate that repeated exposure to high levels of O_3 for several months or more can produce permanent structural damage in the lungs.[82] The EPA's health-based national air quality standard for O_3 is 0.12 ppm, measured at the highest hour during the day.[83] Ozone is also responsible for several billion dollars of agricultural crop yield losses in the United States each year.[84] Ozone also damages forest ecosystems in California and in the eastern United States.

3. Trends in Ozone Levels

Groundlevel O_3 has been a pervasive pollution problem throughout the U.S. Ozone concentration trends are influenced by year-to-year changes in meteorological conditions, as well as emissions reductions from ongoing control measures.[85]

Although meteorological conditions in 1994 were conducive to O_3 formation (especially in the Southeast), national O_3 levels were 12% lower than those in 1985.[86] Levels in 1994 were the second lowest national average for the period between 1985 and 1994.[87] The lowest level was recorded in 1992, and the highest in 1988.[88] Recent control measures include regulations to reduce evaporation of fuel and limit NOx and VOC emissions from tailpipe exhaust. Emissions of VOCs (which contribute to O_3 formation) decreased 10% between 1985 and 1994, despite a slight increase between 1993 and 1994.[89]

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82. *See id.*
83. *See id.*
84. *See* TRENDS REPORT, *supra* note 1 at 2-12.
85. *See id.*
86. *See id.*
87. *See id.*
88. *See id.*
89. *See* TRENDS REPORT, *supra* note 1 at 2-12.

E. Particulate Matter (PM-10)

1. Nature and Sources of the Pollutant

Particulate matter is the term for solid or liquid particles found in the air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can be detected only with an electron microscope. Because particles originate from a variety of mobile and stationary sources (diesel trucks, wood stoves, power plants, etc.), their chemical and physical compositions vary greatly.[90]

2. Health and Other Effects

In 1987, the EPA replaced the earlier Total Suspended Particulate (TSP) air quality standard with a PM-10 standard.[91] The new standard focuses on smaller particles that are likely to be responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract. The PM-10 standard includes particles with a diameter of ten micrometers or less (0.0004 inches or one-seventh the width of a human hair).[92] The EPA's health-based national air quality standard for PM-10 is 50 g/m^3, measured as an annual average, and 150 mg/m^3, measured as a daily average.[93] The following are major concerns for human health from exposure to PM-10: effects on breathing and respiratory systems, damage to lung tissue, cancer, and premature death. The elderly, children, and people with chronic lung disease, influenza, or asthma, tend to be especially sensitive to the effects of PM-10. Acidic PM-10 can also damage man-made materials and is a major cause of reduced visibility in many parts of the United States.

3. Trends in PM-10 Levels

Air monitoring networks were changed in 1987 to measure PM-10 (replacing the earlier TSP monitors).[94] Between

90. *See id.* at 2-16.
91. *See id.*
92. *See id.*
93. *See id.*
94. *See* TRENDS REPORT, *supra* note 1 at 2-16.

1988 and 1994, average PM-10 concentrations decreased 20%, while PM-10 emissions decreased 12%.[95] Particulate matter emissions from sources such as fuel combustion, industrial processes, and transportation decreased 17% since 1985.[96] Emissions from residential wood combustion decreased 50% in the past ten years.[97] Fugitive emissions (such as those from construction) are also a significant source of PM-10 in the air. Between 1993 and 1994, PM-10 concentrations remained unchanged.[98] Between 1993 and 1994, emissions of PM-10 increased 1% due to emissions from transportation, industrial sectors, and wildfires.[99]

F. Sulfur Dioxide (SO_2)

1. Nature and Sources of the Pollutant

Sulfur dioxide belongs to the family of sulfur oxide gases (SO_x). These gases are formed when fuel containing sulfur (mainly coal and oil) is burned, and during metal smelting and other industrial processes.[100]

2. Health and Other Effects

The major health concerns associated with exposure to high concentrations of SO_2 include effects on breathing, respiratory illness, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease. Major subgroups of the population that are most sensitive to SO_2 include asthmatics and individuals with cardiovascular disease or chronic lung disease (such as bronchitis or emphysema), as well as children and the elderly. The EPA's health-based national air quality standard for SO_2 is 0.03 ppm, measured on an annual average, and 0.14 ppm, measured over 24 hours.[101] Emissions of SO_2 also can damage the foliage of trees and agricultural crops. Together, SO_2 and NOx are the

95. *See id.*
96. *See id.*
97. *See id.*
98. *See id.*
99. *See* TRENDS REPORT, *supra* note 1 at 2-16.
100. *See id.* at 2-19.
101. *See id.*

major precursors to acid rain, which is associated with the acidification of lakes and streams, accelerated corrosion of buildings and monuments, and reduced visibility.[102]

3. Trends in Sulfur Dioxide Levels

Between 1985 and 1994, SO_2 emissions decreased 9% while national SO_2 concentrations decreased 25%.[103] Between 1993 and 1994, national SO_2 concentrations decreased 4% and SO_2 emissions decreased 2%.[104] The EPA's Acid Rain Program calls for major reductions of SO_2 and NOx, the pollutants that cause acid rain.[105] The program sets a permanent cap on the total amount of SO_2 that may be emitted by electric utilities nationwide, about one-half the amount emitted in 1980.[106]

V. Conclusion

Since the EPA was established in 1970, air quality in the United States has improved tremendously. Many of these improvements can be attributed to pollution control programs instituted by the EPA, state and local agencies, and industry. Because air pollution problems continue in many parts of the country, the EPA and the states are actively seeking innovative and more cost-effective programs to further reduce emissions. Market-based programs like emissions trading provide incentives for industry to develop new pollution control technologies or pollution prevention approaches. Through continued interaction with the regulated community, environmental groups, state, tribal, and local governments, and concerned citizens, the EPA is working to develop effective common sense control strategies to improve our nation's air quality.

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102. *See id.*
103. *See id.*
104. *See* TRENDS REPORT, *supra* note 1 at 2-19.
105. *See id.*
106. *See id.*