Level 3: Air Pollution Trends in the United States

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❖ Background Information

What are we breathing?

Take a deep breath. As you hold the air in your lungs, the oxygen from the air diffuses into small capillaries on the alveoli in your lungs and then is transported through your body by red blood cells. This process of respiration allows your body to take in oxygen and release carbon dioxide when you breathe out. However, when you took that deep breath, you weren't only inhaling oxygen. In fact, oxygen only makes up only 21% of the air we breathe, while the majority of air is nitrogen (78%), and 1% is made up of other compounds. The other 1% is composed of gasses such as water vapor, carbon dioxide, neon, methane, helium, and argon, as well as dangerous pollutants. Even though they make up a small percent of the air we breathe, these polluting gases have a huge impact on the environment and our health.

What is air quality?

You can choose the food you eat, but it's harder to choose the air you breathe. The average adult breathes over 3,000 gallons of air every day, therefore, air quality is of prime importance to our health. Air quality refers to the health and safety of the atmosphere and is determined based on the amount of pollutants in the air. Air pollutants include compounds such as volatile organic compounds (VOCs), carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), gaseous lead (Pb), and particulate matter (PM2.5 and PM10). Particulate matter includes compounds that are grouped into five major categories: sulfate, nitrate, elemental (black) carbon, organic carbon and crustal material.

Pollutants entering the atmosphere from a factory.

Some of these pollutants occur naturally from sources like volcanoes. However, this is a very small fraction of the total air pollution. Most pollution is created by human activities such as driving cars, generating energy at power plants, and factory outputs. Primary pollutants are directly released into the air from these sources, and include ash and carbon monoxide. Secondary pollutants are created by chemical

reactions between compounds in the atmosphere. Ground-level ozone, which is different from atmospheric ozone in the stratosphere, is a very important pollutant and is created by the reaction of nitrogen oxides with VOCs in the presence of sunlight. There are many factors which can impact air quality regionally, including the amount of pollution produced, weather conditions, and topography of the landscape.

What are the impacts of pollution on health?

Cleaner air provides important public health benefits, including preventing premature death, reducing heart attacks and child asthma attacks, and preventing millions of lost work and school days. Older adults, children, and individuals with heart and respiratory diseases are at the highest risk of air pollution related health problems. Our bodies are designed to filter out and repair damage caused by air pollution, however, the duration and levels of exposure and types of pollutants a person is exposed to can overwhelm our filter systems and cause various health risks. Short term impacts to air pollution include temporary eye and respiratory irritation, headaches, and allergic reactions. Long term air pollution exposure includes respiratory disease, lung cancer, and heart disease.

What is the Clean Air Act?

The Clean Air Act was originally passed in 1963 to protect our air quality, then strengthened by congress in 1970 under the Nixon administration. It was further revised in 1990 to give the EPA more control over regulating pollutants. It is the most important piece of legislation that we have to monitor and control the pollutants in our atmosphere. Under the Clean Air Act, National Ambient Air Quality Standards (NAAQS) are set by the EPA for six specific air pollutants in order to protect against the negative impacts of air pollution (Fig. 1). The six common pollutants are carbon monoxide (CO), Lead (Pb), Nitrogen dioxide (NO_2), Ozone (O_3), Particulate matter (PM), and Sulfur dioxide (SO_2).

National Ambient Air Quality Standards

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead		primary and secondary	Rolling 3-month average	0.15 $\mu g/m^3$ (1)	Not to be exceeded
Nitrogen Dioxide		primary	1-hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	Annual	53 ppb (2)	Annual Mean
Ozone		primary and secondary	8-hour	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution	$PM_{2.5}$	primary	Annual	12 $\mu g/m^3$	annual mean, averaged over 3 years
		secondary	Annual	15 $\mu g/m^3$	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide		primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Figure 1- The NAAQS of the six criteria air pollutants. https://www.dec.ny.gov/chemical/8542.html

These six criteria pollutants are also used to determine the daily Air Quality Index (AQI), a tool used to measure the daily air quality in a given location. The AQI tells you how polluted the air is and what health effects might be of concern. In the U.S., ground-level ozone and particulate matter carry the highest threat to human health. The AQI is put into a color coded number scale ranging from 1-500, with low numbers meaning better air quality and high numbers indicating greater levels of pollution and health concerns (Fig. 2).

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health alert: everyone may experience more serious health effects.
Hazardous	301 to 500	Health warnings of emergency conditions. The entire population is more likely to be affected.

Note: Values above 500 are considered Beyond the AQI. Follow recommendations for the "Hazardous category." Additional information on reducing exposure to extremely high levels of particle pollution is available here.

Figure 2- The Air Quality Index Scale. https://airnow.gov/index.cfm?action=aqibasics.aqi

❖ Dataset Timeframe

- Annual Air Pollution USA: 1980- 2015
- Annual Air Pollution New York State: 1980- 2017

❖ Data Collection Methods

The values of the six criteria air pollutants in the annual air pollution of the USA data are the highest mean value reported in that year from all locations throughout the U.S. CO_2 levels are the annual mean global reading from Mauna Loa, Hawaii, rather than relating specifically to the USA. Carbon dioxide is not regulated by the Clean Air Act, so it is not monitored by the EPA in the same way as the other gases listed. The pollutant levels in the New York State data are the highest mean values reported during the year by monitoring sites within the city listed and surrounding suburbs, areas called Core Base Statistical Areas (CBSA). National standards for air quality (NAAQS) are listed in parentheses for each criteria pollutant.

❖ Dataset Variables

Annual Air Pollution USA Sheet

- **Year**: The year the samples were collected
- **Carbon monoxide (ppm):** National annual mean for second highest 8-hr CO concentration (NAAQS = 9 ppm)
- **Nitrogen dioxide (ppb):** National mean of atmospheric NO_2 concentration (NAAQS = 53 ppb)

- **Ozone (ppm):** Average 4th highest daily maximum 8-hr O_3 concentration for three consecutive calendar years (NAAQS = 0.070 ppm)
- **Sulfur dioxide (ppb):** National annual mean atmospheric SO_2 concentration (NAAQS = 75 ppb)
- **Particulate Matter 10 (µg/m^3):** National annual mean atmospheric concentration of particulates smaller than 10 micrometers in diameter (NAAQS = 150 µg/m^3)
- **Lead Max (µg/m^3):** national annual mean maximum atmospheric Pb (NAAQS = 0.15 µg/m^3)
- **Carbon Dioxide (ppm)**: Annual mean global atmospheric CO_2 concentration
- **Total U.S. Population (millions)**: annual mean population of the U.S.
- **Total World Population (billions)**: annual mean population of the world

❖ Data Sources

Air pollution data was collected from the Environmental Protection Agency (EPA) website. Population data was collected from the Census Bureau.

❖ Inquiry Idea Starters

Here are some sample questions you could ask using these data. These are just suggestions, and we hope you'll come up with many interesting questions of your own!

- How did the concentration of NO_2 change between 1980- 2016 in the U.S.?
- How does the trend for Particulate Matter in the U.S. compare to the global levels of CO_2?
- Is there a relationship between the U.S. population and CO_2 levels?
- How do the cities in NY compare with each other in terms of O_3 pollution levels?

❖ Additional Resources

- Real-time Interactive Air Quality Index Map: https://www.airnow.gov/
- Outdoor Air Quality Data- Find specific city or county air pollutant data with this search tool: https://www.epa.gov/outdoor-air-quality-data/air-quality-statistics-report
- WHO: Breathe Life - How air pollution impacts your body: https://www.youtube.com/watch?v=GVBeY1jSG9Y&feature=youtu.be
- Interactive Map of Air Quality Data- Great Resource for showing air pollutant info by location and comparing it to topography and geography. https://www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors
- Google Earth Outreach- Google project that mapped the air pollution in Oakland, CA. https://www.google.com/earth/outreach/special-projects/air-quality/
- Air Quality Trends Data: https://www.epa.gov/air-trends
- Our Nation's Air- Interactive website diving into the air quality trends and providing great graphics: https://gispub.epa.gov/air/trendsreport/2017/#home
- 2016 Combined ozone and PM 2.5 levels on an interactive map: https://gispub.epa.gov/OAR_OAQPS/SeasonReview2016/index.html?appid=c14363d1de994f06960c9d9b7ad84540

- Environmental Public Health Tracker: https://apps.health.ny.gov/statistics/environmental/public_health_tracking/tracker/index.html#/EPHT
- WindyTV- Interactive map of meteorological variables throughout the world. Includes some air pollutant variables as well. https://www.windy.com/

❖ **Extension Ideas**

- Students research the AQI of different locations within their city or county and map the results. (Insert website for students to use)
- Students create a graph tracking the AQI changes of their location over a certain time frame.
- Students create an action plan to help lower the AQI of their location or another location in the U.S.
- Students use windytv.com to analyze various weather variables and how they impact the AQI on particular days. *Note:* This might be most obvious in dense cities.
- Have students use ozone strips to collect data on the ozone levels within their neighborhood. You can make ozone strips or buy them. https://sciencing.com/make-ozone-test-strips-6945375.html
- Students research the reasons why CO_2 is not decreasing, while all the other air pollutants are.
- Students do further research on the health implications of air quality on their city.

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