Ambient Air Quality and Its Standards

Yi Liang
Associate Professor - Air Quality

Air quality affects our health and our environment. Numerous scientific studies have linked air pollution to a broad range of health and welfare effects. Potential health effects associated with air pollution exposures include decreased lung function, aggravation of respiratory and cardiovascular diseases and increased asthma incidence and severity, among a variety of others. Air pollutants have the potential to impact our lives, including damaging vegetation, causing health issues, decreasing visibility and affecting global climate conditions.

Air pollution consists of a complex mixture of different chemical compounds in the form of solid particles of various sizes, liquid droplets and gases. Some of these pollutants are short-lived and remain in the atmosphere a matter of hours or days. Others are long-lived and may remain in the atmosphere for years. The amount of time that a particular pollutant remains in the atmosphere depends on its reactivity with other substances and its tendency to deposit on a surface; these factors are governed by the pollutant form (i.e., chemical compound) and weather conditions, including temperature, sunlight, precipitation and wind speed.

Pollutants are emitted by a wide variety of man-made and naturally occurring sources. Examples of man-made sources include electricity-generating power plants, automobiles and oil and gas production facilities (Table 1). Natural pollutant sources include wildfires, dust storms and volcanic eruptions, among others. Some pollutants, called **primary** pollutants, are emitted directly from a source (including particulate matter [PM], carbon monoxide [CO], nitrogen dioxide [NO_2], sulfur dioxide [SO_2] and lead [Pb]). Others, also known as **secondary** pollutants, are formed by chemical reactions and are often found downwind from the source of the initial compounds. This group includes ozone [O_3], formed by the reaction of nitrous oxides and volatile organic compounds in the presence of sunlight, and some forms of particulate matter. Some pollutants, such as particulate matter, can have both primary (e.g., black carbon – the most strongly light-absorbing component of PM, formed by incomplete combustion) and secondary (e.g., sulfate, nitrate) components.

Pollutant-Specific Health Effects

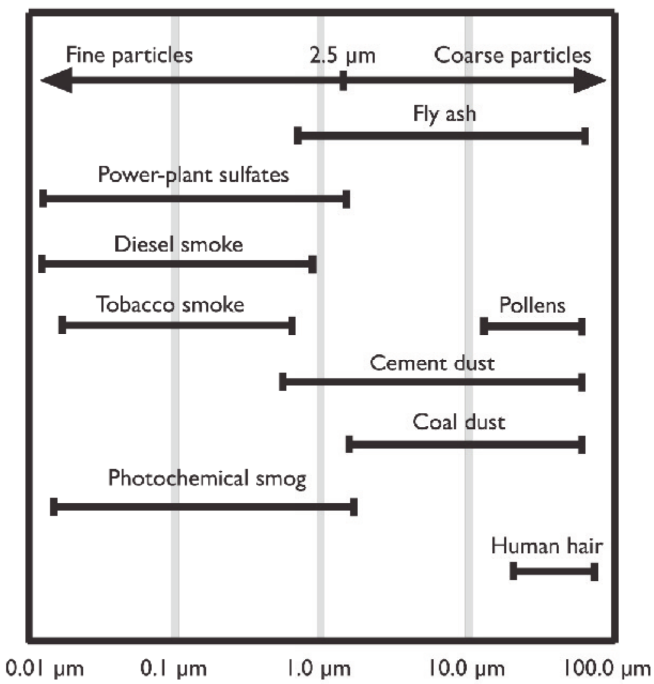
Ozone

Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation and congestion. It can worsen bronchitis, emphysema and asthma. Ground level ozone can also reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue.

Particulate Matter (PM Includes $PM_{2.5}$ and PM_{10})

Breathing particulate matter can cause premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function and increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing. Fine particle exposures have also been linked to respiratory effects including increased hospital admissions and emergency department visits for respiratory effects, such as asthma attacks, as well as increased respiratory symptoms, such as coughing, wheezing and shortness of breath as well as reduced lung development in children.

$PM_{2.5}$ refers to particulate matter that is 2.5 micrometers (µm) or smaller in size while PM_{10} refers to coarse particles between 2.5 and 10 micrometers. To put in perspective, 2.5 micrometers is approximately 1/30 the dimension of human hair.



Concentrations of trace chemicals are commonly expressed in parts per million (ppm, 10^{-6}) and parts per billion (ppb, 10^{-9}) by volume.

Lead (Pb)

Lead damages the developing nervous system, resulting in negative impacts on children's learning, memory and behavior. In adults, it causes cardiovascular and renal effects and early effects related to anemia.

Sulfur Dioxide (SO_2)

Sulfur dioxide aggravates pre-existing respiratory disease in asthmatics leading to symptoms such as coughing, wheezing and chest tightness. Asthmatics are most at risk, but very high levels of sulfur dioxide can cause respiratory symptoms in people without lung disease. Exposures over longer time periods can result in hospital admissions and emergency department visits in the general population.

Nitrogen Dioxide (NO_2)

Nitrogen dioxide increases susceptibility to respiratory infection and aggravates respiratory symptoms. It increases hospital admissions and emergency department visits, particularly in asthmatics, children and older adults.

The response to air pollutants depends on the level of sensitivity of the individual as well as the dose delivered to the respiratory tract. Research has shown that emergency room visits due to asthma attacks in the most sensitive population (e.g., children with asthma or reactive airway disease) increase the following days on which the 1-hour maximum ozone concentrations exceeded 110 ppb (moderately higher than an 8-hour average of 70 ppb). For any population, the dose is a combination of the ambient concentration, the minute ventilation and the duration of exposure. Therefore, individuals performing strenuous activity for several hours continuously are likely to respond to lower concentrations than when exposed at rest for a shorter time.

Atmospheric Pollutants: Their Sources, and Concentration Ranges to Expect

Airborne pollutant concentrations vary significantly over space and time because of variations in local emissions, proximity to pollutant sources and weather conditions. Meteorological processes, including sunlight, temperature, humidity and clouds, can affect pollutant concentrations. For example, stagnant air can lead to pollutant concentrations that gradually increase, whereas strong winds can decrease concentrations by spreading pollutants over a larger geographic area. Pollutant concentrations may vary significantly depending on the time of day, the day of the week and the season. These differences can be attributed to changes in emission patterns, temperature, the activity schedule of the source (weekly traffic patterns, for example), etc.

National Ambient Air Quality Standards (NAAQS)

An ambient air quality standard is a legal limit on concentrations of a regulated atmospheric pollutant. Its establishment is based on the toxicological principle that pollutant exposures below threshold values are relatively safe and, therefore, some level of pollution is acceptable and thus legally permissible. In the U.S., the Environmental Protection Agency (EPA) is required to promulgate air quality standards that provide an "adequate margin of safety," with

Table 1. Summary of common air pollutants, source examples and levels causing concern.

Air Pollutant of Interest	Type	Source Example	Range to Expect	Level Causing Concern*
Ozone (O_3)	Secondary	Formed via UV (sunlight) and pressure of other key pollutants	0-150 ppb	75 ppb (8 hr)
Carbon monoxide (CO)	Primary	Fuel combustion – mobile sources, industrial processes	0-0.3 ppm	9 ppm (8 hr) 35 ppm (1 hr)
Sulfur dioxide (SO_2)	Primary	Fuel combustion – electric utilities, industrial processes	0-100 ppb	75 ppb (1 hr) 0.5 ppm (3 hr)
Nitrogen dioxide (NO_2)	Primary and Secondary	Fuel combustion – mobile sources, electric utilities, off-road equipment	0-50 ppb	100 ppb (1 hr) 53 ppb (1 yr)
Volatile organic compounds (VOCs)	Primary and Secondary	Fuel combustion (mobile sources, industries), gasoline evaporation; solvents	5-100 $\mu g/m^3$	None
Fine particulate matter ($PM_{2.5}$)	Primary and Secondary	Fuel combustion (mobile sources, electric utilities, industrial processes), dust, agriculture, fires	0-40 $\mu g/m^3$ (24-hr)	35 $\mu g/m^3$ (24 hr) 12 $\mu g/m^3$ (1 yr)
Lead (Pb)	Primary	Smelting, aviation gasoline, waste incinerators, electric utilities, and lead-acid battery manufacturers	0-0.1 $\mu g/m^3$ (24-hr)	0.15 $\mu g/m^3$ (3 months)
Benzene (an example of a VOC and air toxic)	Primary	Gasoline, evaporative losses from above-ground storage tanks	0-3 $\mu g/m^3$	None
Black carbon (BC)	Primary	Biomass burning, diesel engines	0-15 $\mu g/m^3$	None

*Levels of concern are based on a particular time length for averaging, and the concentration values are averaged over that time.

special consideration for those sensitive individuals. As a result, these standards are much more stringent than occupational standards, which are designed to protect nominally healthy working adults.

EPA uses six principal pollutants (or **criteria pollutants**) as indicators of air quality, including ozone (O_3), particulate matter (PM), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxide (NO_X) and lead (Pb) and has established for each of them a maximum concentration above which adverse effects on human health may occur (see Table 1 above in Level Causing Concern). These threshold concentrations are called National Ambient Air Quality Standards (NAAQS).

Nonattainment Area

The "nonattainment area" is a locality (usually a county) where air pollution levels persistently exceed NAAQS. Designating an area as nonattainment is a formal rulemaking process, and EPA normally takes this action only after air quality standards have been exceeded for several consecutive years at regulatory air quality monitors. Nonattainment areas are given a classification based on the severity of the violation and the type of air quality standard they exceed. In 2010, with respect to the "criteria pollutants," more than 120 million Americans lived in counties where concentrations exceeded the levels of one or more National Ambient Air Quality Standards. The designations, classifications and nonattainment status for different pollutants can be found here: https://www.epa.gov/green-book. There is no non-attainment designation in the state of Arkansas.

In nonattainment areas, new emission sources and major modifications must employ the most stringent control technology for that pollutant for that type of source. Also, to avoid increasing the total amount of a criteria pollutant in a nonattainment area, a new or expanding business must compensate for its emissions by a decrease in pollution from other sources. Once nonattainment designations take effect, the state and local governments generally have three years to develop implementation plans designed to meet the standards by reducing air pollutant emissions.

Air Quality Index (AQI) – A Tool to Interpret Air Quality

The AQI is an index for reporting **daily** air quality to the public. The purpose of the AQI is to help the public understand what local air quality means to your health. The AQI focuses on health effects you may experience within a few hours or days after breathing polluted air (Table 2). EPA calculates the AQI for five major air pollutants regulated: ground-level ozone, particle matter pollution, carbon monoxide, sulfur dioxide and nitrogen dioxide.

Think of the AQI as a yardstick that runs from 0 to 500. The higher the AQI value is, the greater the level of air pollution and the greater the health concern. An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level that EPA has set to protect public health. AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy – at first for certain sensitive groups of people, then for everyone as AQI values get higher.

To understand easily whether AQI is reaching an unhealthy level in a community, the AQI is divided into six categories, and each is assigned a specific color to make it easier for people to understand quickly whether air pollution is reaching unhealthy levels (Table 2). For a current AQI report and forecast in Arkansas, refer to https://airnow.gov/index.cfm?action=airnow.local_state&stateid=4 for an AQI map of the area.

For questions about the information in this publication or help in obtaining more detailed information, please visit https://www.epa.gov/environmental-topics/air-topics and http://www.adeq.state.ar.us/air/.

Table 2. Air quality index (AQI) categories, color code and their correspondent level of health concern.

Levels of Health Concern	AQI	Meaning
Good (green)	0-50	Satisfactory.
Moderate (yellow)	51-100	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 (orange)	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy (red)	151-200	Everyone may begin to experience more serious health effects.
Very Unhealthy (purple color)	201-300	Health alert: everyone may experience more serious health effects.
Hazardous (maroon)	>300	Health warnings of emergency conditions. The entire population is more likely to be affected.

YI LIANG, Ph.D., is associate professor - air quality, Biological and Agricultural Engineering, University of Arkansas System Division of Agriculture, Fayetteville.

FSA1070-PD-12-2017RV