Air Quality 101

In order to better serve the members of your troop, we have compiled a list of important air quality information that can be used to supplement any activities involving air quality. These are some of the most common air quality topics and discussions that may arise during an air quality lesson or activity.

What is Air?

It is important to understand the properties of air so that scouts, especially those in K-3, understand how air can move and carry pollutants. It is also necessary to understand what is inside of the air - we are not just breathing oxygen - and how that can affect the formation of different types of pollutants.

Properties of Air

Volume: Air takes up space. Air has volume and, if enclosed in a container, will expand to fill the container.

Mass: Air has mass. Air doesn't have as much mass per unit volume as a substance like gold, but it does weigh something. People often use the terms 'weight' and 'mass' interchangeably, because at sea level on Earth they are the same. However, out in space, an object still has mass, but the lack of gravity means it would have almost no weight. At sea level, a liter of air weighs 1.2 grams – about half the weight of a penny.

Pressure: Air exerts pressure. Atmospheric air pressure is a very important concept in meteorology. It refers to the weight of air in a column above a particular point. Atmospheric air pressure is higher at sea level than at the top of Mt. Everest because there is a taller pile of air above a point at sea level than the point on the top of Mt. Everest. We may not notice air pressure much in our day-to-day lives, but have you ever felt your ears pop in a plane or car? That's caused by the change in air pressure from gaining or losing altitude.

Water Vapor: Water vapor is the gaseous form of water. It's invisible. Mist, fog, and clouds are not water vapor. They are water droplets – water that has condensed out of the air.

Latent Heat: Latent heat is the heat given off when water condenses, and the heat absorbed when water evaporates. Everyone has experience with latent heat: the transfer of latent heat is why your skin feels cool when sweat or water on it evaporates in a breeze.

Components of Air

Dry air in our atmosphere consists primarily of nitrogen (about 78%), oxygen (about 21%) and argon (0.9%). There are many other gases present in much smaller amounts: water vapor (<0.01%), carbon dioxide, methane, nitrogen oxides (NO_X), sulfur oxides (SO_X), ozone, etc. Air also contains solids (such as pollen, dust, soot, and various pollutants) and liquids (such as droplets of water and liquid pollutants).

What is Air Pollution?

Why do we care about air pollution?

Air pollution can impact your health and the environment. In North Carolina, asthma or respiratory problems are one major reason our students miss school and adults miss work. Scientific studies have shown that people exposed to high enough levels of certain air pollutants may experience burning in their eyes, an irritated throat or breathing difficulties.

Long-term exposure to air pollution can cause:

- Damage to the immune system
- Cardiovascular disease
- Damage to neurological and respiratory systems.
- Permanent lung damage
- Increased susceptibility to respiratory infections
- Worsening of asthma
- Worsening of emphysema
- Bronchitis
- Heart attacks, strokes or arrhythmia among people with heart disease

Children, up to the age of 18 (whose lungs are still developing) and older adults are at higher risk for health problems when exposed to air pollution, as are people who already have lung conditions, such as asthma, emphysema or chronic bronchitis or heart disease.

What is air pollution?

EPA sets the standards for six criteria pollutants: ground-level ozone, particle pollution (also called particulate matter), nitrogen dioxide, carbon monoxide, sulfur dioxide, and lead. Nationally, the levels of all of these pollutants have fallen significantly since 1980, despite the growth in population, gross domestic product, energy use, and vehicle miles traveled. However, in many urban areas **ozone and particulate matter** still pose a challenge, including those in North Carolina.

Nitrogen dioxide (NO_2) is a kind of nitrogen oxide (NO_X), a pollutant class that also includes nitric oxide (NO). NO_X is formed during combustion in air at very high temperatures (typically 2700°F or higher), such as in a car engine or a boiler at a power plant. NO_X react with other molecules in the air to produce ground-level ozone, ammonia, nitric acid and acid rain. The largest sources of NO_X include cars and other vehicles with internal combustion engines, electrical generation, and industry.

Ground-level ozone is a secondary pollutant that forms when nitrogen oxides (NO_X) and volatile organic compounds (VOCs) react in the presence of sunlight and warm temperatures (usually over 75° F). NO_X comes from burning fuels. VOCs are chemicals containing carbon that evaporate easily – which usually means they are smelly. Sources of VOCs include cleaning chemicals, solvents, paints, unburned gasoline, hog waste lagoons, and natural sources such as trees. In North Carolina, almost all VOCs come from plants and are therefore unable to be controlled. Ozone is most likely to form on a hot summer afternoon near cars and in cities.

Particulate matter (PM) refers to a size rather than a chemical composition. Particulate matter can be either solid particles (such as dust) or tiny liquid droplets. For example, sulfur dioxide and nitrogen oxides can react with other chemicals in the air to form tiny droplets. Particulate matter is divided into two categories. PM_{10}, or "coarse" particles, refers to particles less than 10 micrometers in diameter. $PM_{2.5}$, or "fine" particles, refers to particles smaller than 2.5 micrometers. For comparison, fine beach sand is about 90 micrometers in diameter, and a human hair is between 50 and 70 micrometers in diameter. Reactions in the atmosphere among naturally occurring and manmade chemicals (such as sulfur dioxide and nitrogen oxides) are a major source of particulate matter. Other sources include construction sites, unpaved roads, fields, forest fires, and smokestacks.

Carbon monoxide (CO) is a product of incomplete combustion. When inhaled, it reduces oxygen delivery in the body. By far the largest source of carbon monoxide in the atmosphere comes from vehicles including cars, trucks, construction equipment, airplanes, and trains.

Sulfur dioxide (SO_2) is a kind of sulfur oxide (SO_X). The largest source of sulfur dioxide is fuel combustion during generation of electricity, but it can be generated any time sulfur-rich fossil fuels such as coal are burned. Sulfur dioxide causes health problems, contributes to acid rain, and contributes to particle pollution.

Lead in the air can be inhaled and lead particles can settle onto surfaces, where children can ingest the lead-contaminated dust. However, the amount of lead in the atmosphere

has fallen the most dramatically of the six criteria pollutants, primarily due to the phase-out of leaded gasoline.

Focus on Ozone and Particulate Matter

Ground-level ozone and particulate matter are the pollutants of greatest concern in North Carolina. Because of this, it is important that we fully understand what they are and how they work.

Ozone:

In the stratosphere, UV radiation knocks oxygen molecules (O_2) apart into two single oxygen atoms. These single atoms combine with oxygen molecules to form ozone (O_3). The ozone in the stratosphere absorbs UV radiation, which is good for us since UV radiation contributes to skin cancer, cataracts, and problems with the immune system.

Ground-level Ozone: Near the surface of the Earth, ground-level ozone forms when nitrogen oxides (NO_X) and volatile organics (VOCs) combine in the presence of sunlight and heat. The series of chemical reactions that lead to the formation of ground-level ozone are complex and can vary depending on the form of nitrogen oxides and VOCs involved.

NO_X + VOCs + heat + sunlight = O_3 (ozone)

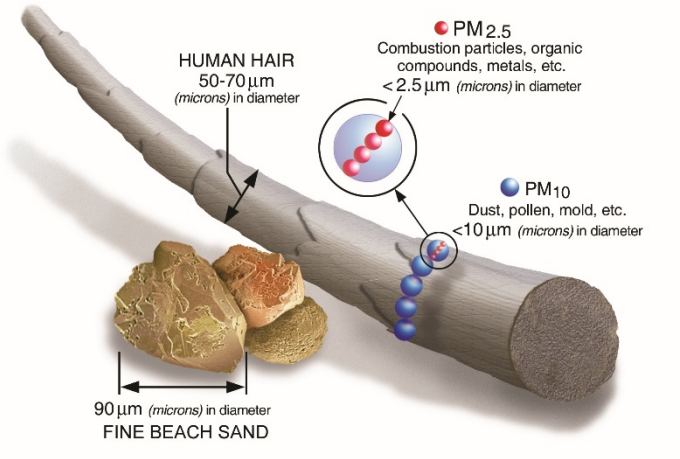
In North Carolina, ground-level ozone is most likely to be a problem on sunny hot days in urban areas where there is a lot of car traffic to produce those nitrogen oxides. This form of ozone is harmful to human, animal, and plant life.

An easy way to remember this is: "Ozone: Good up high, bad nearby."

Particulate Matter

Particle pollution, or suspended particulate matter, refers to solid or liquid particles in the air. Some particles come from manmade sources, like smokestacks. Others, like pollen, come from natural sources, such as vegetation. Some particle pollution, like dust or soot, is natural but can also be caused by human activities, such as clearcutting forests, poor farming practices, or wood burning. The NC Division of Air Quality and the EPA measure particle pollution by weight (micrograms per cubic meter).

Particulate matter can be inhaled into the lungs, where it contributes to health problems, such as asthma and cardiovascular disease. Particulate matter also forms haze that restricts visibility and can change a gorgeous view into an unattractive one.



Air Quality Index

Meteorologists at the Division of Air Quality provides a forecast every day to help inform citizens how good or bad the air quality is expected to be. They use observed measurements of different pollutants along with weather conditions to forecast the Air Quality Index or AQI. The AQI is a number range form 1-500 and has a color-coded chart to make the forecast easy to understand. For example, if the AQI is between 101-150, the weather app on your smartphone or your local TV weatherperson will say it's a "Code Orange" day. That means children, active people, older adults and those with heart or lung issue should avoid being outside for a long time or working hard outside.

If a particular pollutant is mentioned following the AQI, it means that pollutant is expected to have the highest AQI. For example, if the AQI forecast is given as "149 ozone," it means forecasters are expecting a level of ozone that corresponds to "unhealthy for sensitive groups" (orange), but other pollutants are expected to be lower than 149.

Air Quality Index	Guidelines to protect your health
Good 0-50 Code Green	No health effects expected.
Moderate 51-100 Code Yellow	Unusually sensitive people: consider limiting prolonged or heavy exertion outdoors.
Unhealthy for Sensitive Groups 101-150 Code Orange	Children, active people, older adults, and those with heart or lung disease (like asthma): limit prolonged or heavy exertion outdoors.
Unhealthy 151-200 Code Red	Children, active people, older adults, and those with heart or lung disease (like asthma): avoid prolonged or heavy exertion. Everyone else: limit prolonged or heavy exertion outdoors.
Very Unhealthy 201-300 Code Purple	Everyone: avoid all exertion outdoors.

What Do the Numbers Mean?

An AQI number does not have a unit like a measurement does. Measurements of ozone are usually given in parts per million (ppm) or parts per billion (ppb). Particulate matter is measured in micrograms per cubic meter (µg/m_3). However, the AQI number does match up to a specific measured concentration, which is different for each pollutant. This means that a single value on the AQI can have different meanings depending on which pollutant you wish to measure. For example, an AQI value of 75 corresponds to a $PM_{2.5}$ concentration of 23.5 µg/m_3 and an ozone concentration of 62 parts per billion (ppb). To determine the exact concentrations of each pollutant on AQI scale, you can use the U.S. EPA 'AQI Calculator' online at www.airnow.gov/index.cfm?action=airnow.calculator.

PM2.5 and Ozone Measurements and the AQI

Air Quality Index	24-Hour PM 2.5	8-Hour Ozone
Good 0-50 Code Green	0-12 $\mu g/m^3$	0-59 ppb
Moderate 51-100 Code Yellow	12.1-35.4 $\mu g/m^3$	60-75 ppb
Unhealthy for Sensitive Groups: 101-150 Code Orange	35.5-55.4 $\mu g/m^3$	76-95 ppb
Unhealthy 151-200 Code Red	55.5-150.4 $\mu g/m^3$	96-115 ppb
Very Unhealthy 201-300 Code Purple	150.5-250.4 $\mu g/m^3$	116-374 ppb

Source: http://daq.state.nc.us/monitor/aqi/codeChart.shtml

AQI forecasts and reports are available from the Division of Air Quality online at www.ncair.org/airaware/forecast.

You can view the forecast and reports for both ozone and $PM_{2.5}$. Choose from the tabs at the top that say, "Previously Observed," "Today's Forecast," and "Tomorrow's Forecast." You can also view the forecast by downloading the U.S.EPA's 'AirNow' application on your smartphone.

Natural Indicators of Air Pollution

Bioindicators

A **bioindicator** is a species that reacts so strongly to a pollutant or a change in their environment that they can be used to determine the effects of that pollutant. Biomonitoring is when you check the health of the indicator species over time to see a longer-term effect from exposure.

Lichens have been used to directly measure the results of an excess of sulfur dioxide in the air. A lichen is a mini-ecosystem consisting of at least two organisms: a fungus and a photosynthetic partner (algae or cyanobacteria). Lichens have been found to be bioindicators for the general atmospheric conditions since they absorb water and nutrients from the air (including pollution) over their entire surface. The effect of air pollution (primarily from sulfur) on lichens includes:

- bleaching (the loss of chlorophyll in the algal cells)
- development of a red coloration
- blackening
- development of tiny lobes along margins
- decline in growth rate
- failure to produce fruiting bodies
- loss of sensitive species with a possible replacement of tolerant species

Plants can serve as bioindicators as well. Similar to humans, plants have an adverse reaction when they respire polluted air, they just take in CO_2 instead of oxygen. During photosynthesis, the plant will take in CO_2 through structures known as stomata and release oxygen and water vapor. The stomata will open during the daylight hours while photosynthesis is occurring and close at night to prevent water loss within the plant. Stomata will also close if the air is too dry or too hot to conserve water. Plants thrive

best when it is warm and humid (this is why greenhouses work), but these conditions also support the formation of ground-level ozone.

When ozone enters the leaves of the plant through stomata, it travels into the palisade and spongy mesophyll layers, which are responsible for photosynthesis. This weakens the plant's ability to produce and store food, makes them more susceptible to disease and affects their ability to reproduce.

Plants affected by ozone will often show signs of *stippling, or 'purpling'*. Stippled plants will show purple dots and blemishes on the leaf's surface, but will not affect the veins of the leaf. Plants with insect damage will also demonstrate stippling, but you can differentiate the two types of damage by inspecting the veins of the leaf. Insect damaged plants will have stippling on the veins, while ozone damaged plants will not. Some plants have a higher tolerance to ozone than others; on those who are intolerant, older leaves will exhibit more stippling than younger leaves.

Browning on potato leaves shows evidence of exposure to high concentrations of ozone. (Photograph courtesy UDA-ARS Air Quality Program, North Carolina State University; photo by Gerald Holmes)

What Can We Do About Our Air?

Home Energy Choices

One way to reduce air pollution is to save energy because most of the energy we use in the United States involves the combustion of fossil fuels. Homeowners have some choice as to the fuels they use, but not complete freedom. For example, if there are no natural gas lines in your neighborhood, you can't have a gas stove. Renters may have even less choice. However, no matter what type of energy is used at home, people can make choices that result in reduced emission of air pollutants. Individuals can choose to use less energy (turn off lights in unoccupied rooms), purchase more efficient equipment (a more efficient refrigerator), make energy-efficient renovations (adding insulation or weather stripping) or use alternative energy sources (using a solar clothes dryer – a clothesline).

Homeowners know what their average monthly electric or gas bill is in dollars. However, they may not know how many kilowatt-hours of electricity or therms of natural gas they use or the amount of air pollution emissions that results from that use. A good place to

start is by looking at the biggest energy user in the home. In most homes, space conditioning (heating and cooling) is the largest energy expenditure, followed by water heating. Heating and cooling account for as much as half of the energy usage of a home according to the EPA at www.energystar.gov. Good strategies for reducing overall home energy usage include:

- Keeping the thermostat at a reasonable level
- Replacing outdated furnaces or air conditioners with new energy-efficient models
- Adding insulation
- Replacing old, leaky windows

Idling in Cars and Trucks

In North Carolina, motor vehicles are among the largest source of man-made air pollution. Gasoline and diesel vehicles each produce different types of air pollution. Diesel vehicles specifically produce particle pollution in the form of soot. In all vehicles (both gasoline and diesel), the major pollutant emitted is nitrogen oxides (NO_X), a precursor of ground-level ozone. When NO_X combines with volatile organic compounds (VOCs) in the presence of sunlight and heat ground-level ozone is formed. **Ground-level ozone is the air pollutant of greatest concern in NC.**

While vehicles produce air pollution when they are running, idling vehicles, and vehicles that have just been started generally produce more air pollution than those vehicles running at 60 mph on the highway.

Vehicle idling at schools and daycares is concerning because it can impact the health of children. The lungs of children ages 0 - 18 are still developing, and because they breathe more air (compared to their body weight) than adults, they take in more pollution. Twice a day at schools across North Carolina, students and teachers gathered outside are forced to breathe polluted air when parents leave their engines running, often idling for as much as 30 minutes. Even students inside the school can be affected by exhaust gases entering the building through doors, windows, and air intakes.

Turning off your engine can reduce the amount of pollution your vehicle produces and protect schoolchildren and the environment.