

Community Air Monitoring Fundamentals

Webinar 1:
Introduction to Air Quality Concepts and Regulations

TD Enviro

Eastern Research Group, Inc. (ERG)

US EPA Office of Air Quality Planning and Standards



Disclaimers

- This webinar is being performed for the U.S. EPA Office of Air Quality Planning and Standards under contract number 68HERD21A0001.
- Any mention of trade names, manufacturers, or products does not imply an endorsement by the U.S. Government, the U.S. EPA, or its presenters.
- This webinar is a resource for community air monitoring and does not necessarily represent U.S. EPA policies.

Introduction by Chet Wayland

Director, Air Quality Assessment Division
Office of Air Quality Planning and Standards
U.S. EPA



Your Speakers



TD Enviro

Story Schwantes



TD Enviro

Tim Dye

Overview of Webinar Series

Fundamentals of Air Quality:

Webinar #1: Introduction to Air Quality Concepts and Regulations

Webinar #2: Introduction to Air Monitoring and Measurements

Building an Air Monitoring Network:

Webinar #3: Objectives and Data Management

Webinar #4: Selecting Equipment, QAPPs, and Siting a Monitoring Device

Webinar #5: Installation, Operation, Data Analysis, and Communication

Webinar 1 Agenda

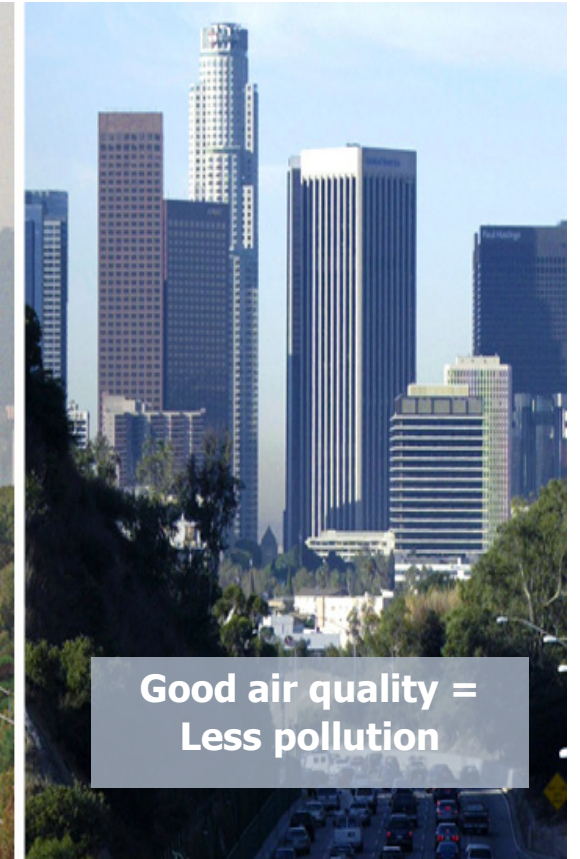
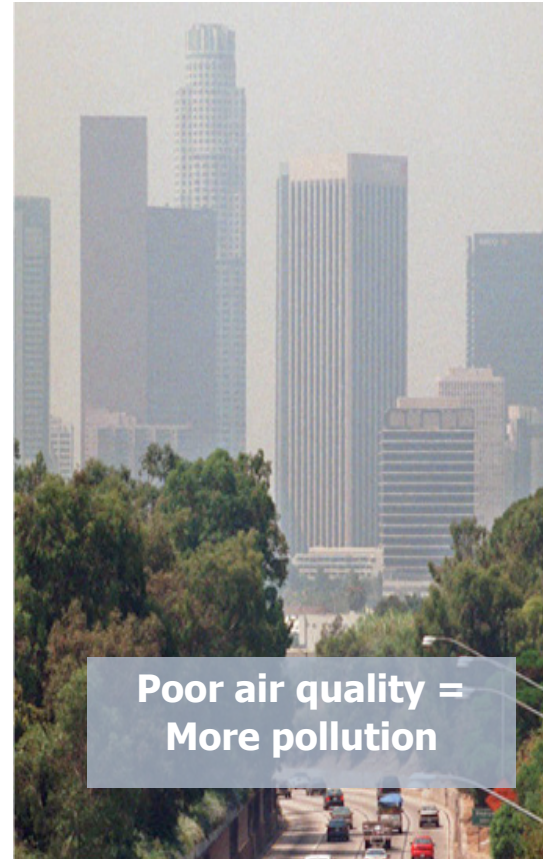
- 1** Air Quality Concepts
- 2** Sources and Emissions
- 3** Pollutants
- 4** Why We Care
- 5** Air Quality Regulations
- 6** Air Monitoring Regulations
- 7** Recap
- 8** What's Next
- 9** Q&A

Air Quality Concepts

DEFINITION

Air Quality

How much pollution is present in the air.



Source: EPA

Air quality changes, much like the weather

We know the weather varies:

- Season to season
- Day to day
- Hour to hour

So does air quality!



Source: National Weather Service

Air Quality Changes with Weather



Winds transport and disperse pollutants. Pollutant concentrations may increase during stagnant conditions.

Rain and frontal systems can remove pollutants from the air.



Sunshine causes some pollutants to undergo chemical reactions, resulting in the development of pollutants or mixtures like ozone or photochemical smog.

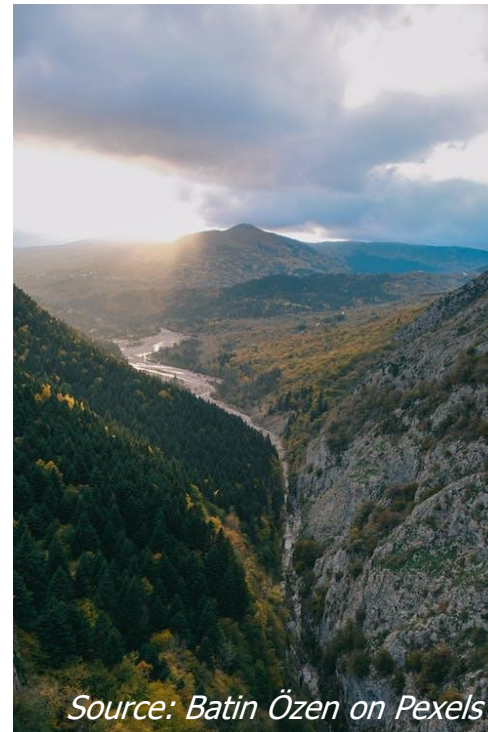
Air Quality Changes with Location

Physical geography can contain, move, and change air quality.



Mountains can act as a guide. The Appalachians act as a channel for moving pollutants up the eastern seaboard.

Geographic features can act as a barrier or bowl, keeping pollutants from moving.



Trees can filter pollutants. But they can also catch fire.



Air Quality Changes with Human Activity

Vehicle Pollution

More pollution during rush hour



Industrial Sources

Pollution may increase during working and production hours

Construction

Higher pollution during activities or when winds blow exposed dirt



Understanding Sources and Emissions

Air pollution comes from a variety of **sources**.

Human-caused (Anthropogenic)

Vehicles

Refineries

Power plants

...and many more

Natural (Biogenic)

Wildfires

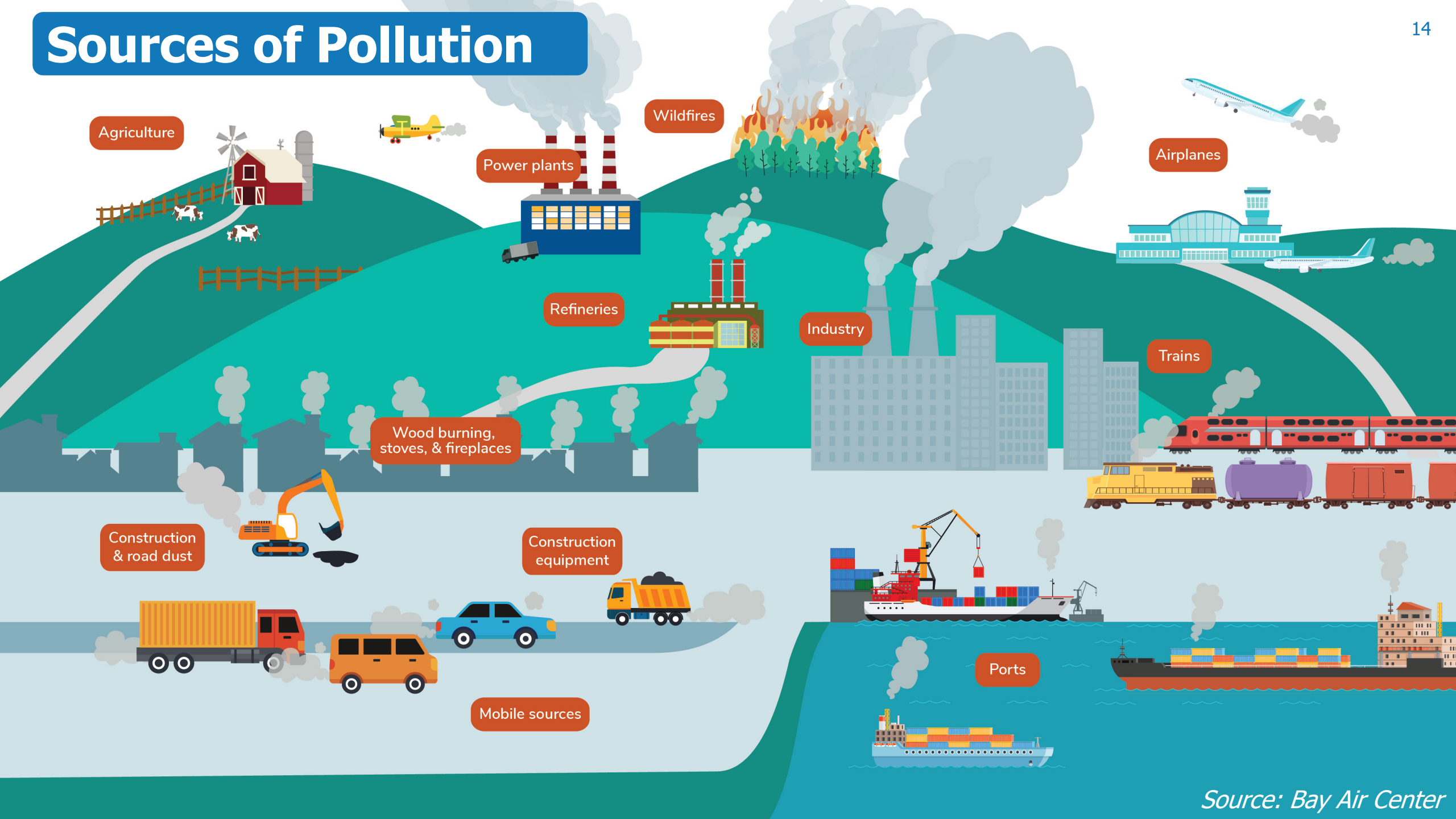
Lightning

Volcanos

...and many more

Emissions are gases and particles that are put into the air by various **sources**.

Sources of Pollution



Sources of Pollution: Classifications

U.S. EPA and States classify emissions into different groups and subgroups.

Category	Examples
On-road mobile sources - vehicles that burn fuel and operate on roads, highway ramps, and during idling	Trucks, buses, passenger cars, motorcycles
Non-road mobile sources - engines that burn fuel and operate in other locations (away from roads)	Construction equipment, lawn and garden equipment, aircraft ground support equipment, locomotives, commercial marine vessels
Stationary: Point sources - emissions from larger sources that are located at a fixed, stationary location	Large industrial facilities, electric power plants, airports, dry cleaners & gas stations, livestock facilities
Stationary: Area sources - include emission sources that individually are too small in magnitude to report as point sources	Residential heating, commercial fuel combustion, asphalt paving, commercial and consumer solvent use
Biogenic sources - naturally occurring emissions	Volcanic emissions, lightning, and sea salt
Fire – emissions from periodic events	Wildfires, prescribed burns

Poll:

What are sources of concern in your region?

Multiple choice, multi-option

- Agriculture
- Power plants
- Wildfires
- Refineries
- Industry
- Airplanes/airports
- Ports
- Trains
- Wood burning, stoves, & fireplaces
- Construction
- Vehicles & roadways
- Other



Air Pollutants

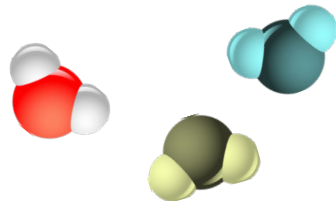
Air Pollution Types

Gases

Gaseous pollutants have no fixed shape or volume and are made up of elemental or compound molecules. Most common gaseous pollutants are invisible.

Example:

- Carbon Monoxide (CO)
- Ozone (O₃)

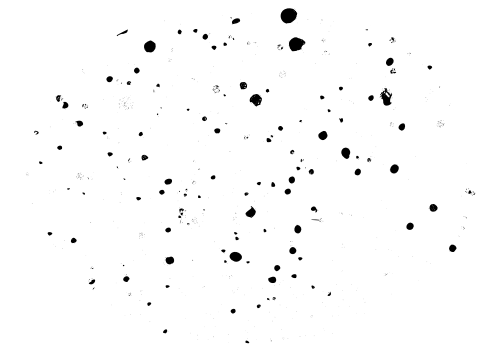


Particles

Particulate pollution is typically made up of a mixture of small solid or liquid particles. This can include things like dirt, dust, or soot.

Example:

- Dust
- Smoke



Pollutant Categories

Criteria Air Pollutants

The group of common pollutants regulated by the Clean Air Act

Air Toxics

Hazardous air pollutants (HAPs) known to cause cancer and/or other serious health issues or environmental effects

Emerging and Other Pollutants

Pollutants increasing in importance as new research is released

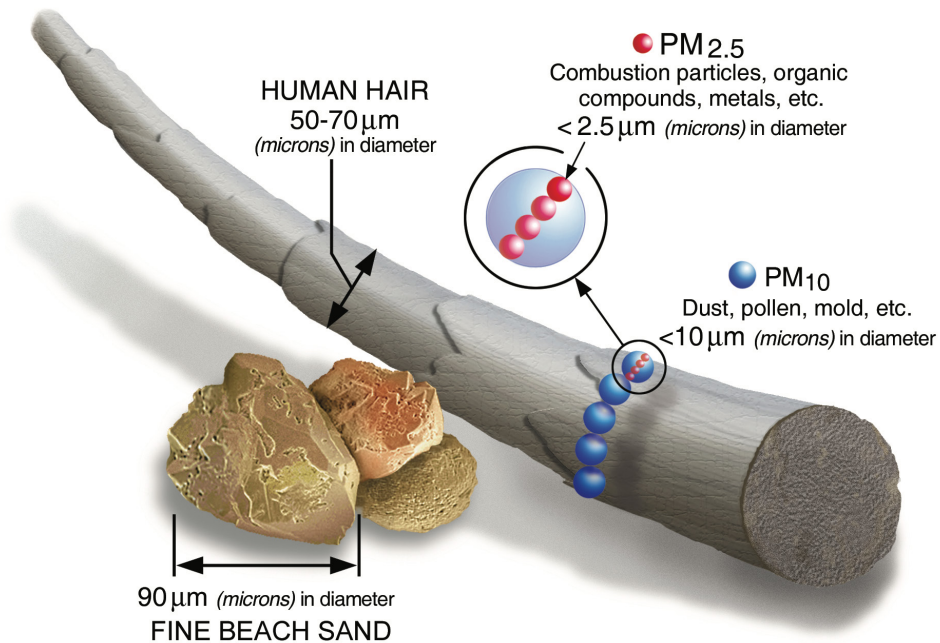
Greenhouse Gases (GHGs)

Gases that trap heat in the atmosphere and contribute to climate change

Criteria Air Pollutants: Particulate Matter (PM_{2.5} & PM₁₀)

Description

A mixture of solid particles and liquid droplets found in the air.



Source: EPA

Sources

- Diesel engines (Diesel Particulate Matter)
- Power plants
- Industries
- Windblown dust (PM₁₀)
- Wood stoves/fireplaces
- Wildfires

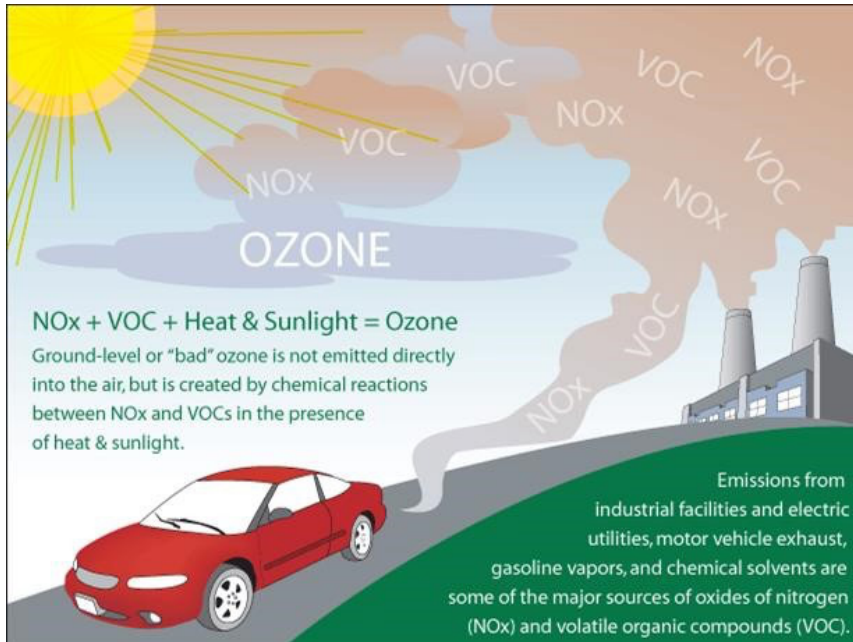
Health Impacts

- Premature death in people with heart or lung disease
- Nonfatal heart attacks
- Irregular heartbeats
- Increased respiratory symptoms
- Decreased lung function

Criteria Air Pollutants: Ozone (O_3)

Description

A highly reactive gas composed of three oxygen atoms



Source: EPA

Sources

- Vehicle exhaust and fumes from other sources that react in the presence of sunlight to create ozone

Health Impacts

- Sore/scratchy throat
- Difficulty breathing
- Damage to airways and lung tissue
- Increase the likelihood of asthma and attacks

Criteria Air Pollutants: Nitrogen Dioxide (NO₂)

Description

Nitrogen oxides are a group of highly reactive gases. NO₂, one of the nitrogen oxides, is used as the indicator for the larger group.



Sources

- Vehicles
- Power plants burning fossil fuels
- Off-road equipment
- Coal-burning stoves

Health Impacts

- Irritate airways
- Make it difficult to breathe
- Aggravate existing respiratory illness
- Increase the likelihood of asthma and attacks
- Increase the risk of developing respiratory infections

Criteria Air Pollutants: Sulfur Dioxide (SO₂)

Description

Sulfur Dioxide (SO₂) is one of a group of gases called sulfur oxides. The other gases in the group are much less common in the atmosphere.



Source: Ella Ivanescu on Unsplash

Sources

- Power plants burning fossil fuels
- Metal ore smelting
- Vehicles
- Ships
- Construction equipment
- Volcanoes

Health Impacts

- Irritate airways
- Make it difficult to breathe
- Increase the likelihood of asthma and attacks

Criteria Air Pollutants: Lead (Pb)

Description

A heavy metal that can be released into the air and cause serious human health impacts



Sources

- Leaded gasoline (airplanes)
- Smelting
- Mining
- Waste incinerators
- Airborne dust

Health Impacts

Most likely to cause neurological effects in children

Can also adversely impact:

- Nervous system
- Kidney function
- Immune system
- Reproductive & developmental systems
- Cardiovascular system

Criteria Air Pollutants: Carbon Monoxide (CO)

Description

A colorless, practically odorless, and tasteless gas or liquid.



Sources

- Vehicles
- Gas stoves
- Lanterns
- Gas fireplaces

Health Impacts

- Reduces the bloods' ability to carry oxygen
- Fatigue
- Dizziness
- Headaches
- Reduced oxygen to the heart accompanied by chest pain

Criteria Air Pollutant	Description	Sources	Health Effects		
Particulate matter (PM _{2.5} and PM ₁₀)	Microscopic particles of soot, dust, or other matter, including tiny liquid droplets	<ul style="list-style-type: none"> · Diesel engines · Power plants · Industries · Windblown dust · Wood stoves/fireplaces · Wildfires 	<ul style="list-style-type: none"> · Cause: <ul style="list-style-type: none"> · Premature death in people with heart or lung disease · Nonfatal heart attacks · Irregular heartbeats · Increased respiratory symptoms · Decreased lung function 		
Ozone (O ₃)	Gaseous pollutant	<ul style="list-style-type: none"> · Vehicle exhaust and fumes from other sources that react in the presence of sunlight to create ozone 	<ul style="list-style-type: none"> · Cause sore/scratchy throats · Make it difficult to breathe · Damage airways and lung tissue · Increase the likelihood of asthma and attacks 		
Nitrogen dioxide (NO ₂)	A gaseous compound made up of nitrogen and oxygen	<ul style="list-style-type: none"> · Vehicles · Power plants burning fossil fuels · Coal-burning stoves 	<ul style="list-style-type: none"> · Irritate airways · Make it difficult to breathe · Aggravate existing respiratory illness · Increase the likelihood of asthma and attacks · Increase the risk of developing respiratory infections 		
Carbon monoxide (CO)	A colorless, odorless gas	<ul style="list-style-type: none"> · Vehicles burning gasoline · Indoor sources: kerosene, burning wood, natural gas, coal burning 	<ul style="list-style-type: none"> · Cause: <table border="0" style="width: 100%;"> <tr> <td style="vertical-align: top;"> <ul style="list-style-type: none"> · Fatigue · Chest pain · Headaches · Confusion </td> <td style="vertical-align: top;"> <ul style="list-style-type: none"> · Dizziness · Nausea · Death at high concentrations </td> </tr> </table> 	<ul style="list-style-type: none"> · Fatigue · Chest pain · Headaches · Confusion 	<ul style="list-style-type: none"> · Dizziness · Nausea · Death at high concentrations
<ul style="list-style-type: none"> · Fatigue · Chest pain · Headaches · Confusion 	<ul style="list-style-type: none"> · Dizziness · Nausea · Death at high concentrations 				
Sulfur dioxide (SO ₂)	Gaseous pollutant made up of sulfur and oxygen	<ul style="list-style-type: none"> · Coal-burning power plants/industries · Coal-burning stoves · Refineries 	<ul style="list-style-type: none"> · Makes it more difficult to breathe · Inflames airways and lung tissue · Increases the likelihood of an asthma attack 		
Lead (Pb)	Metallic pollutant	<ul style="list-style-type: none"> · Vehicles burning leaded gasoline · Metal refineries 	<ul style="list-style-type: none"> · Accumulates in the bones · Negatively affects nervous system, kidney function, immune system, reproductive and developmental systems, and cardiovascular systems. · Causes irreversible neurological damage in infants and children 		

Air Toxics

- 188 Air Toxics (EPA)
- Cause cancer or serious health impacts or environmental impacts
- Also called Hazardous Air Pollutants (HAPs), Toxics, Urban Air Toxics (30 HAPs that pose the greatest potential health threat in urban areas)
- Volatile Organic Compounds (VOCs): A group of chemicals emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects

Air Toxics: BTEX

(Benzene, Toluene, Ethylbenzene, Xylene)

Description

A group of pollutant compounds that frequently occur together



Source: Erik Mclean on Pexels

Sources

- Vehicles
- Aircraft
- Gasoline storage tanks
- Landfill gases
- Refineries
- Factories
- Oil and fossil gas infrastructure

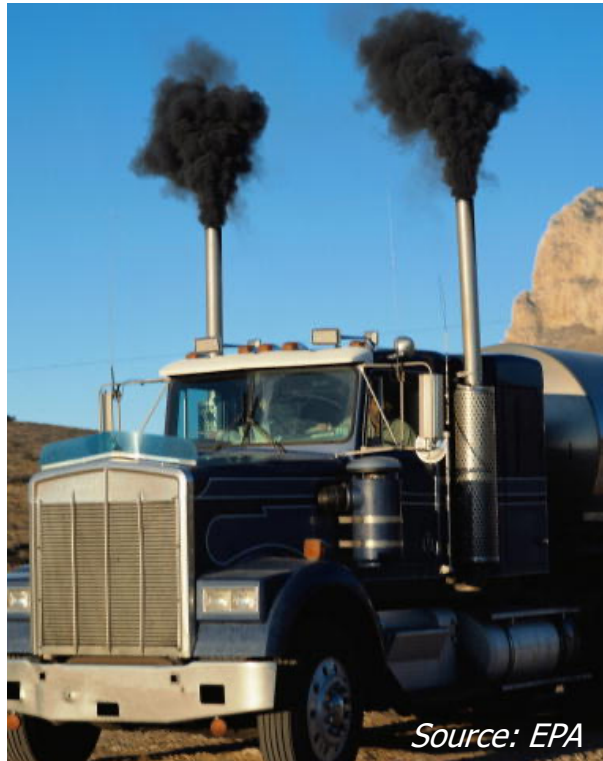
Health Impacts

- Known human carcinogen
- Short-term exposure can cause drowsiness, dizziness, headaches, and irritation to the eyes, skin, and respiratory tract
- Long-term exposure can cause blood disorders and adverse effects to the reproductive system

Other Pollutants: Black Carbon (BC)

Description

- Light-absorbing part of PM_{2.5}
- Soot



Sources

- Fossil fuel burning
- Biomass burning

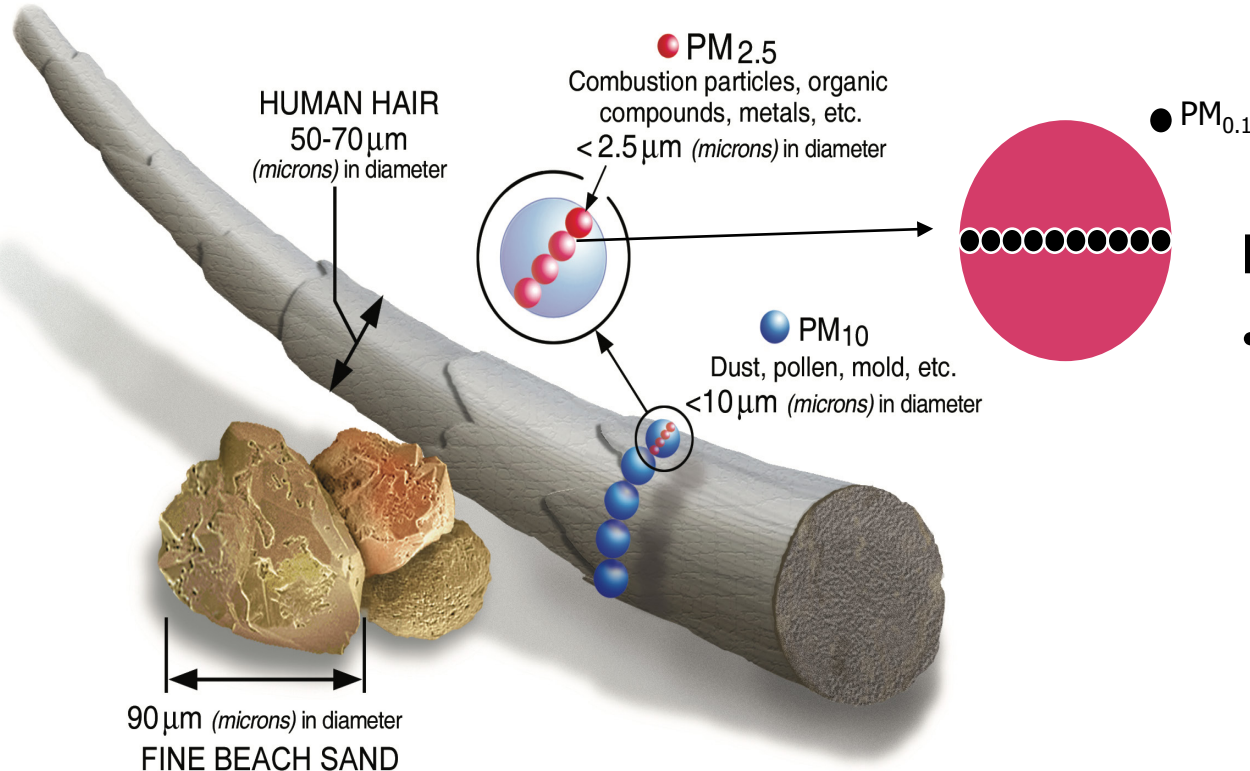
Health Effects

- Similar health effects to PM_{2.5}: pulmonary and cardiovascular disease
- Linked to climate impacts by absorbing solar energy and releasing heat

Emerging Pollutants: Ultrafine Particulate Matter (PM_{0.1} or UFP)

Description

- Smallest form of PM



Sources

- Similar sources to PM_{2.5} and PM₁₀
 - Diesel exhaust
 - Cooking particles
 - Wood burning
 - Aircraft

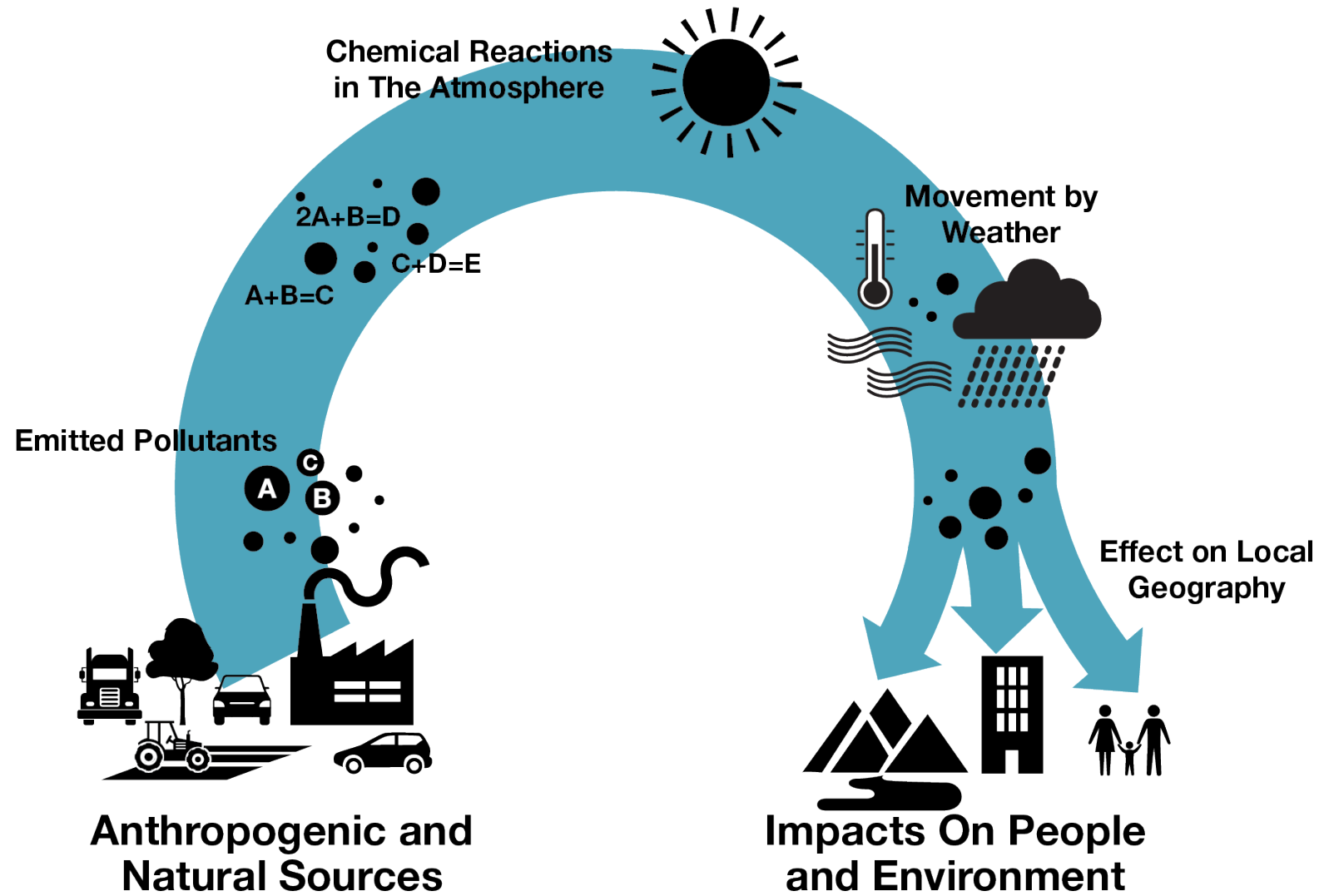
Health Effects

- Similar health effects to PM_{2.5}: pulmonary and cardiovascular disease
- Able to penetrate further into the lungs and cardiovascular systems.

Greenhouse Gases (GHGs)

Gases that trap heat in the atmosphere

Example Greenhouse Gases	Sources	Health/Environmental Effects
Carbon dioxide (CO₂)	<ul style="list-style-type: none"> Fossil fuel burning Biomass burning Wildfires Industry (e.g., cement manufacturing) 	<ul style="list-style-type: none"> Heat-trapping gas Non-toxic: Can be an asphyxiant at high concentrations
Methane (CH₄)	<ul style="list-style-type: none"> Fossil fuel production/transport Livestock and agricultural practices Organic matter decay in landfills 	<ul style="list-style-type: none"> 25-times greater atmospheric heater than CO₂ Non-toxic: Can be an asphyxiant at high concentrations
Nitrous oxide (N₂O)	<ul style="list-style-type: none"> Fossil fuel burning Agricultural practices Industrial activities Wastewater treatment 	<ul style="list-style-type: none"> 265 times greater atmospheric heater than CO₂ Can stay in the atmosphere for 121 years
Fluorinated gases Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride	<ul style="list-style-type: none"> Used as refrigerants Aluminum and semiconductor manufacturing Transmission/distribution of electricity 	<ul style="list-style-type: none"> Can stay in the atmosphere for 270+ years Higher warming potential than CO₂ (10s of thousands times) Can be an asphyxiant at high concentrations



The Pollutant Lifecycle from Source to Impact on People and the Environment

Poll: What are the pollutants of concern in your region?

Multiple choice, multi-option

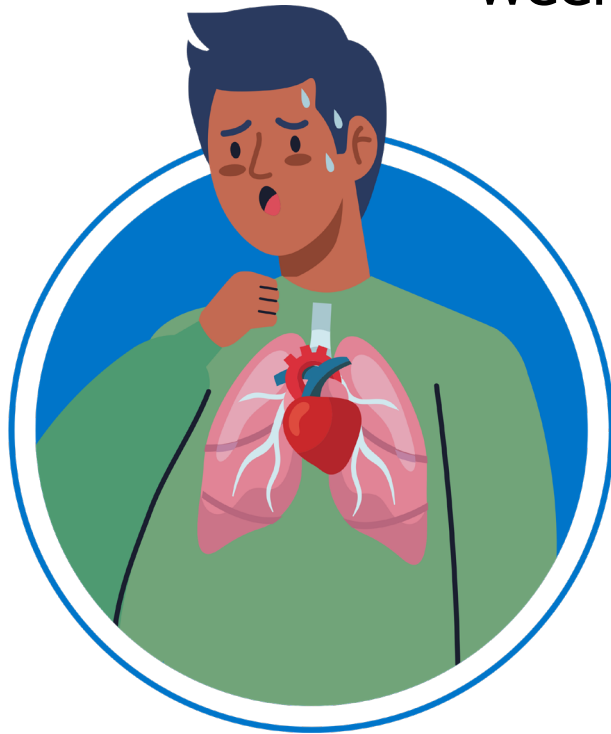
- Particulate matter (PM2.5 or PM10)
- Ozone (O3)
- Nitrogen Dioxide (NO2)
- Sulphur Dioxide (SO2)
- Lead (Pb)
- Carbon Monoxide (CO)
- BTEX
- Other Air Toxics
- Black Carbon
- Ultrafine Particulate Matter



Why do we care about air quality?

Human Health Effects

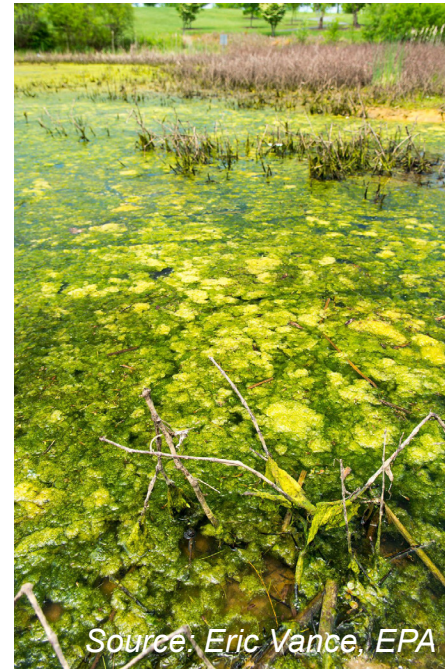
Health effects vary by the type of pollutant or mixture of pollutants, concentration, and exposure time, which can be short term (hours to weeks) or long term (months to years)



- Cause nausea, dizziness, headaches, chest pain
- Cause eye, nose, and throat irritation
- Cause cancer after prolonged exposure
- Make it more difficult to breathe
- Increase the likelihood of heart attacks
- Increase respiratory disease including asthma attacks
- Decrease lung function
- Decrease life expectancy

Environmental Effects

- Reduce visibility
- Create acid rain
- Deposit excessive nutrients in water bodies and cause damaging algae blooms (eutrophication)
- Damage crops/forests
- Deplete the ozone layer
- Impact wildlife health
- Contribute to climate change



Exposure Over Time Leads to Health Effects

Exposure to pollution depends on many individual factors, and you can control some of them.



Health Effects Guest Speaker

Dr. Rima Habre, University of Southern
California



Air Quality Regulations

The Clean Air Act

- A landmark piece of environmental legislation
- Signed into law in 1970 with major changes in 1990
- Under the Act, the U.S. Environmental Protection Agency (EPA) is charged with:
 - Establishing national ambient air quality standards for six common pollutants, known as “criteria pollutants”
 - Regulating hazardous air pollutants from industrial facilities
 - Ensuring new stationary sources to be built with best technology, and allowing less stringent standards for existing stationary sources
 - Addressing acid rain chemical emissions that deplete the stratospheric ozone layer, and regional haze impairing visibility
- States are required to:
 - Adopt enforceable plans to achieve the standards set by the EPA
 - Control emissions that drift across state lines and harm air quality in downwind states



Source: EPA

The National Ambient Air Quality Standards (NAAQS)

- Under the Clean Air Act, the U.S. Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards (NAAQS) for **6 criteria pollutants**.
- Provide public health protection
- Reviewed and may be revised every five years
- When NAAQS are revised, it sets in motion two major actions aimed at ensuring that air quality throughout the country meets those standards:
 - EPA designates areas as meeting (**attainment**), not meeting (**nonattainment**) the standard
 - States are required to develop specific plans to attain and maintain the NAAQS

Criteria Air Pollutants

Carbon Monoxide (CO)

Lead (Pb)

Nitrogen Dioxide (NO₂)

Ozone (O₃)

Particulate Matter (PM_{2.5})

Particulate Matter (PM₁₀)

Sulfur Dioxide (SO₂)

NAAQS Table

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3-month average	0.15 µg/m ³	Not to be exceeded
Nitrogen Dioxide (NO ₂)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb	Annual Mean
Ozone (O ₃)		primary and secondary	8 hours	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	PM _{2.5}	primary	1 year	9.0 µg/m ³	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m ³	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m ³	98th percentile, averaged over 3 years
	PM ₁₀	primary and secondary	24 hours	150 µg/m ³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO ₂)		primary	1 hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

Hazardous Air Pollutants Regulations

Phase 1

Maximum achievable control technology (MACT) standards: standards for controlling emissions of air toxics from industry group sources

Based on emissions levels that are already being achieved by low-emitting industry sources

Phase 2

EPA determines whether more health-protective standards are necessary by assessing the remaining health risks from each source type

Review and revision is required every 8 years

Regulating Green House Gases (GHGs)

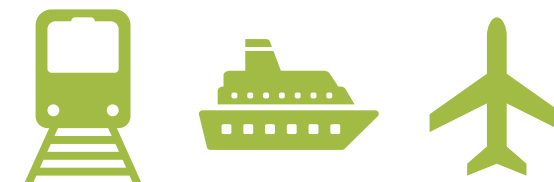
The EPA has passed a number of regulations on different sources of GHGs:

- Federal greenhouse gas emissions standards for passenger cars and light trucks
- Renewable Fuels Standard Program, a national policy that requires a certain volume of renewable fuel to replace petroleum-based transportation fuel
- Passed a rule phasing down the U.S. production and consumption of HFCs by 85% over the next 15 years
- Implementing CO₂ emission standards for airplanes used in commercial aviation and for large business jets
- Proposed emission standards for greenhouse gas emissions from new fossil fuel-fired utility boilers and natural gas-fired stationary combustion turbines

Who Regulates Air Quality?

U.S. EPA

- Carries out enforcement of the Clean Air Act: limits certain pollutants
- Works with state agencies to ensure compliance with federal laws
- Develops & updates new federal pollutant standards



State, Tribal, Local Air Agencies

- Monitor & report pollution data
- Develop & update local pollution regulations
- Enforce EPA & state-adopted regulations



Transportation Agencies

- Manage the highway system
- Make large-scale transportation decisions



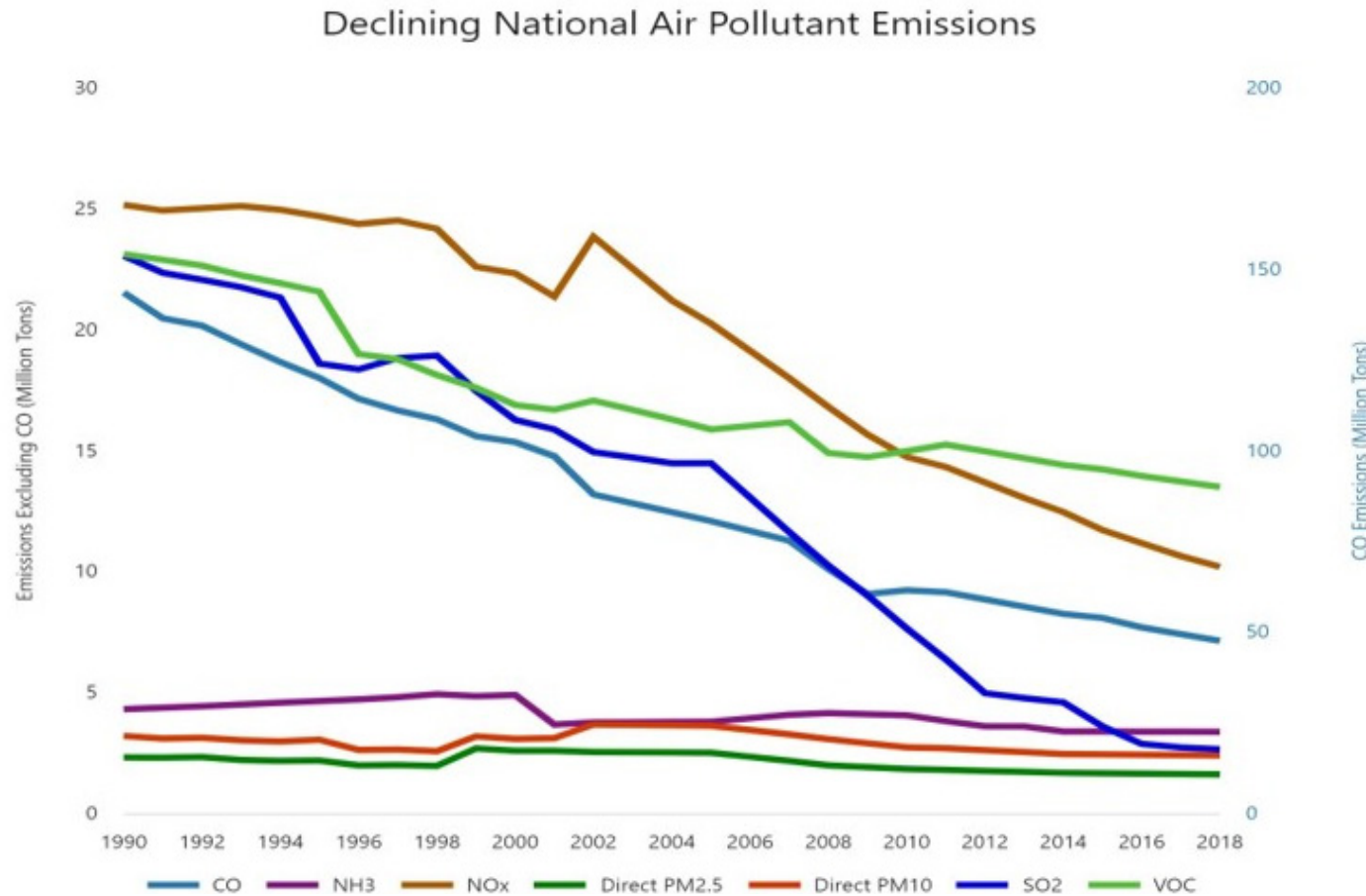
Land Use Decision Makers

- Plan and monitor local development
- Issue building permits



Do Regulations Work?

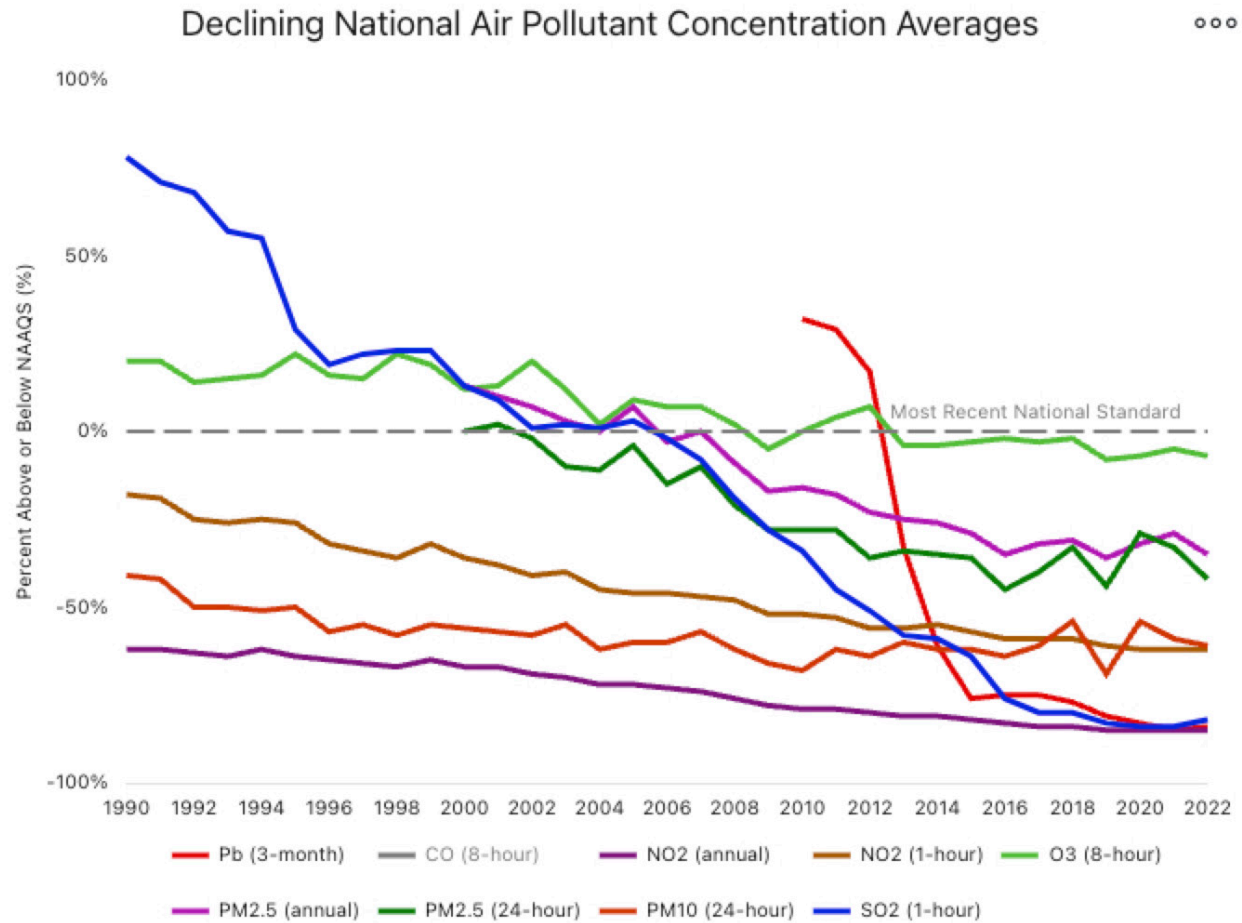
Regulations reduce emissions of pollutants going into the atmosphere



Since 1990, there has been approximately a 50% decline in emissions of key air pollutant emissions

Do Regulations Work?

Measurements show air quality improves as emissions are reduced



Nationally, concentrations of air pollutants have dropped significantly since 1990

Air Monitoring Regulations

DEFINITION

Air Monitoring

Detection of pollutant levels by measuring the quantity and types of certain pollutants in the outdoor air.



Source: EPA

Air Quality Regulations

Limits on air pollutants, including limits on how much air pollution can be released from a source or on how much can be in the air anywhere in the United States.

Air Monitoring Regulations

Ensure air monitoring data are high quality, complete, and comparable nationwide.

Air monitoring regulations dictate:

- The equipment to use
- The requirements for operating it and reporting the data (e.g., QA)

Who Monitors Air Quality?

U.S. EPA

- Compiles regulatory air quality data
- Conducts air quality monitoring studies
- Establishes air monitoring policy and regulations

State, Tribal, Local Air Agency

- Monitor & report pollution data to the EPA and residents
- Work with communities on air quality issues

City Air Quality/Environmental Departments

- May monitor & publish pollution data
- Work with communities on local air quality issues

Community Groups Monitoring Air Quality

- May monitor & publish pollution data
- Work with residents on local air quality issues

Industry

- Depending on permits, required to monitor & publish pollution data

Two Important Aspects to Monitoring:

What Equipment Are You Using?

- Certified
- Accurate
- Reliable
- Sensitive
- Durable

How Are You Operating It?

- Location
- Maintenance
- Quality Assurance
- Data handling & security
- Independent verification
- Quality control
- Data reporting

Monitoring Requirements

Regulatory Monitoring

- Uses EPA-certified equipment: Meet strict operating and performance requirements
 - Federal Reference Method (FRM)
 - Federal Equivalent Method (FEM)
- Follows precise operation, siting, and quality assurance and quality control (QA/QC) rules to ensure that monitors produce accurate data
- Performed by regulatory air quality agencies
- Data used to make sure NAAQS are being met and for health research

Non-Regulatory Monitoring

- All monitoring that is not done for regulatory reporting purposes
- Uses a wide range of devices: high to lower-quality
- No federal operating procedures to follow
- Can be taken by anyone: air agencies, community groups, researchers, businesses
- Cannot be legally used to make sure air quality standards are met
- This type of monitoring is also called non-regulatory supplemental and informational monitoring (NSIM)

How are data used? Guest Speaker

Dr. Kate Hoag, BAAQMD



Recap

- Air Quality Concepts
- Sources and Emissions
- Pollutants
- Why We Care
- Air Quality Regulations
- Air Monitoring Regulations

Interactive End-of-Session Feedback

What's the most useful thing you learned today?

What's up next

Webinar 2

Introduction to Air Monitoring and Measurements

What is air monitoring, measurement devices, important concepts for making measurements, what to do with measurement data