AIR QUALITY MONITORING
Part 2 – Air Quality & Health

Community Action to Promote Healthy Environments (CAPHE)

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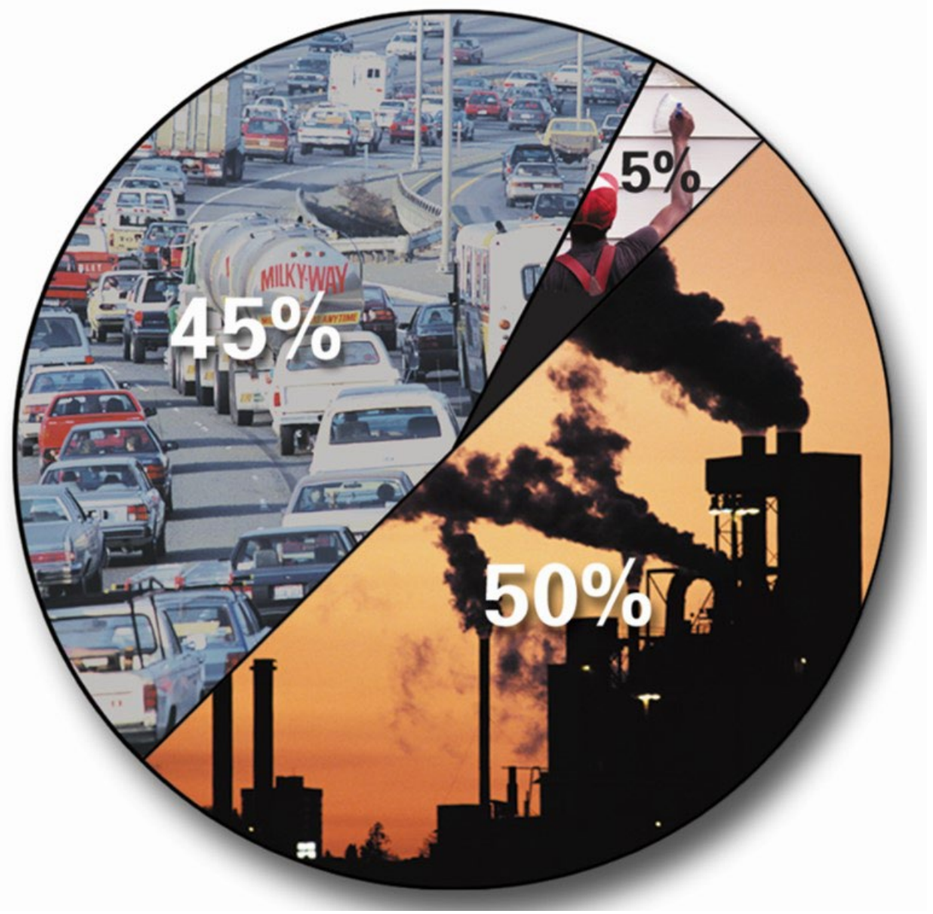
https://www.gordiehoweinternationalbridge.com/en/gallery

Air quality and health

The estimated six million children in the United States with asthma are especially vulnerable to air pollution.

https://www.epa.gov/sciencematters/links-between-air-pollution-and-childhood-asthma



Estimate of typical source contributions of volatile organic compounds (VOCs)

https://www.airnow.gov/download-images/

Air quality and health

Air pollutants can cause and aggravate health problems like cancer, asthma and other respiratory diseases, and have been linked to many other health issues, e.g., adverse birth outcomes and dementia.

Air pollution causes other effects too, like acid rain, thinning of the protective ozone layer in the upper atmosphere, damage to vegetation and crops, and climate change.

What we will cover:

- Pollutants
- Health effects
- Emission sources
- What you breath … concentrations
- National Ambient Air Quality Standards (NAAQS)
- Air Quality Index (AQI)

Pollutants

Most attention focuses on the six so-called “criteria pollutants” that have national Ambient Air Quality Standards (NAAQS), but other pollutants are also important. The US Clean Act defines 6 criteria pollutants and 189 different hazardous air pollutants. The main types of air pollutants are listed below:

Criteria pollutants

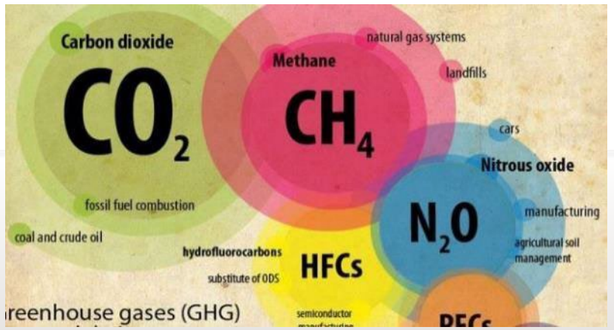
- **Sulfur dioxide** (SO_2), **nitrogen dioxide** (NO_2), **lead, ozone** (O_3), **carbon monoxide** (CO), **particulate matter** ($PM_{2.5}$, PM_{10})

Toxic pollutants *(toxics, hazardous air pollutants)*

- **Local** – benzene, hydrogen sulfide, formaldehyde, diesel exhaust
- **Regional** – mercury, PCBs, PBDEs
- **Global** – Chlorofluorocarbons (CFCs)

Greenhouse gas pollutants *(GHGs, short-lived are toxic)*

- **Long lived** – carbon dioxide (CO_2), nitrous oxide, halocarbons (N_2O, F11, F12, etc)
- **Medium lived** – methane (CH_4)
- **Short lived** – carbon monoxide (CO), non-methane VOC (NMVOCs)



Indoor pollutants, occupational pollutants

Health effects

Health effects for the six criteria pollutants (ozone, lead, nitrogen oxide, particulate matter, carbon monoxide, sulfur dioxide) are shown in the table – from US EPA's Integrated Science Assessments.

- Air pollution is one of the top environmental factors affecting health.
- Globally, about 7 million people die each year from exposure to both outdoor and indoor air pollutants, mostly from cardiovascular disease and chronic respiratory disease associated with exposure to particulate matter (PM2.5).
- $PM_{2.5}$ and ozone tend to be the most widespread and damaging pollutants.
- Thousands of epidemiological and toxicological studies have investigated the link between exposure to air pollutant and health effects.
- These studies also form the basis of air quality standards.

	Ozone	Lead	NO_x	$PM_{2.5}$	CO	SO_2
Respiratory Effects						
Lung diseases (COPD, chronic bronchitis, emphysema, and/or cancer)	X		X			X
Asthma incidences, attacks, hospitalizations, and aggravations	X			X		
Aggravation of bronchitis	X					
Impaired lung growth				X		
Decreased lung function			X	X		
Difficulty breathing	X			X	X	X
Lung irritation (airway hyper responsiveness and inflammation)			X	X		X
Lung related emergency visits	X		X			
Irritation of the nose and throat; coughing	X			X		X
Cardiovascular Effects						
Coronary heart disease		X				
Heart attacks				X		
Hypertension or increases in blood pressure		X		X		
Reduce oxygen carrying capacity of the blood		X			X	
Aggravation of existing heart disease					X	X
Reproductive Effects						
Decreased fertility (men and women)		X				X
Birth Outcomes & Childhood Development						
Adverse birth outcomes (premature birth, low birth weight, or miscarriage)	X	X	X	X	X	
Brain damage and other birth defects	X	X				
Behavioral and emotional problems		X				
Cognitive impairments		X			X	
Other						
Cancer		X		X		
Increased risk of premature death	X	X	X	X	X	X
Fever, convulsions, dizziness						X
Headaches, nausea, vomiting		X			X	X
Inhibition of thyroid functions						X
Kidney damage		X				
Loss of Smell						X
Visual impairment					X	
Cognitive decrements in adults		X			X	
Immune system impairments		X				

Table from: https://caphedetroit.sph.umich.edu/wp-content/uploads/2016/10/Resource-Manual-3.0-Air-Quality-Health-Environmental-Justice-Website-Version-10-4-16.pdf

Whose is most affected?

Health burden of ambient air pollution in Wayne County Michigan: 7.3% of annual deaths due to criteria pollutants and air toxics

Susceptibility

- Both young and old
- Individuals with pre-existing disease, including obesity, diabetes, and asthma
- Asthma prevalence among children: 11.3%
  - Hospitalizations and deaths 2x and 3x the state rates

Vulnerability

- 39% of Detroit residents live below the poverty line
- Largely minority population
  - 85% Black
  - 7% Hispanic or Latino
- Exposed to multiple point, area and mobile sources
- Occupational exposure in many trades

Sources: DeGuire et al. 2016; Fann et al. (2015); MDHHS (2015) MDEQ (2015); SEMCOG (2013); US Census Bureau (2015).

Emission sources

Air pollution has many sources. Some sources are obvious – like coal-fired boilers, municipal waste incinerators, automobiles, trucks, and buses. Others are not so obvious – like gasoline stations; dry cleaners; outboard boating equipment; lawn, garden, farm, and construction equipment engines; certain paints, coatings, and varnishes; and various household products.

Emission sources are classified into the following types:

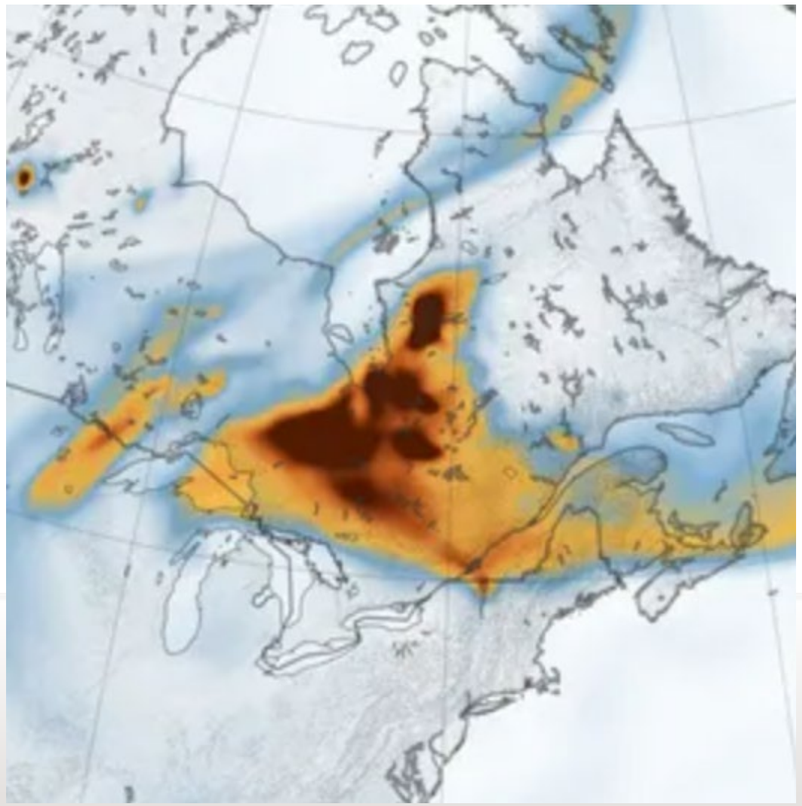
- **Point sources** – typically industry with smokestacks – power plants, boilers, incinerators
- **On-road mobile sources** – cars, trucks, buses
- **Off-road mobile sources** – trains, ships, construction equipment
- **Area sources** – construction sites, bulk storage areas, smaller building boilers/furnaces
- **Event sources** – wildland fires, structure fires, explosions
- **Regional sources** – from distant sources, called background
- **Secondary sources** – produced from atmospheric chemistry

Scale of air pollution

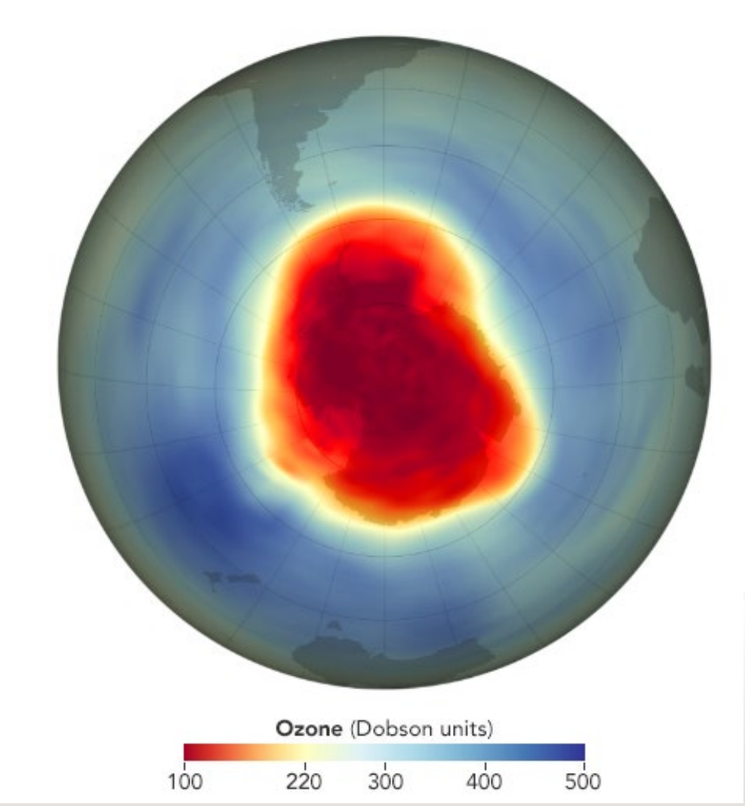
Hyperlocal → Local → Urban → Regional → Continental → Global

Modeled increases in SO_2 around Zug Island, maximum 1 hour level. J. Haywood, Mich EGLE, 2021

Satellite image of Canadian wildfire smoke moving east, late June 2023.
https://earthobservatory.nasa.gov/



Worst year for ozone “hole” (1994) from NASA Tropomi satellite.
https://earthobservatory.nasa.gov/world-of-change/Ozone/show-all



What you breath - concentrations and AQI

In air, pollutants are measured as a **concentration:**

- For particulate matter – like $PM_{2.5}$ – concentrations are measured as **micrograms per cubic meter or µg/m³**
- For gases like SO_2 or O_3 concentrations can be measured as either **micrograms per cubic meter, parts per million (ppm) or parts per billion (ppb)**

This differs from emission rates, which are expressed as **tons per year** (t/yr) or grams per second (g/s)

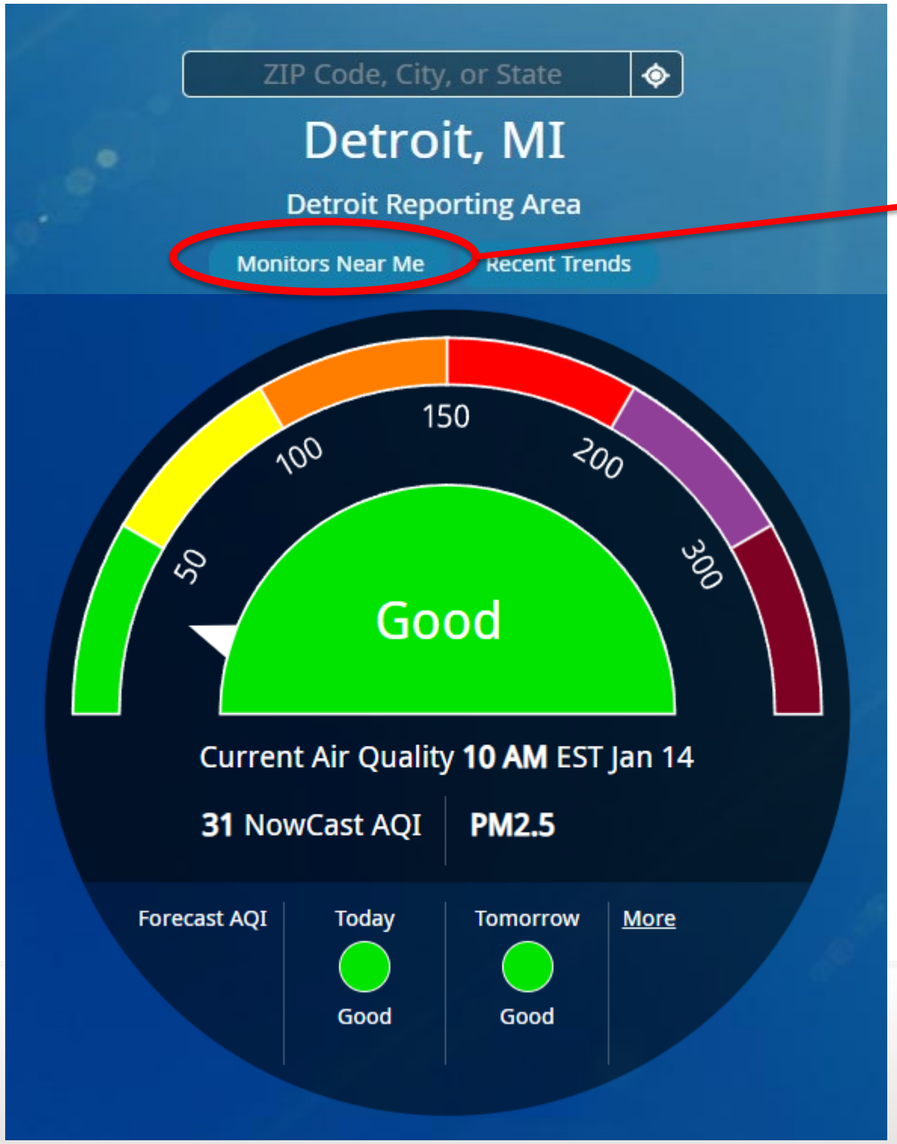
Air Quality Index or AQI helps account for the different concentration scales

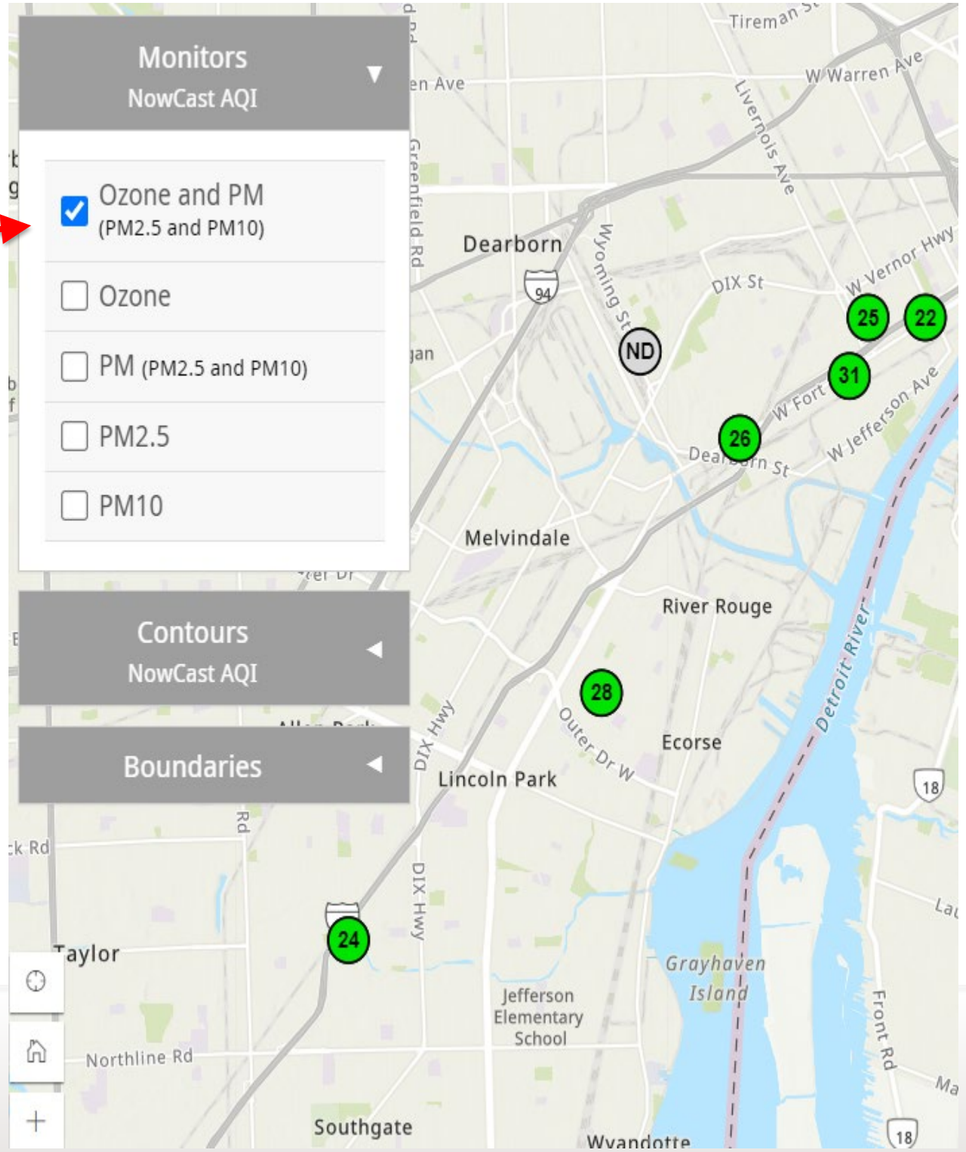
- AQI = 100 corresponds to short-term air quality standard:
  - 35 µg/m³ for $PM_{2.5}$
  - 70 ppb for O_3
- Must use appropriate averaging time
- AQI typically considers only two pollutants (O_3 and $PM_{2.5}$) and takes the maximum

Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

https://www.airnow.gov/

Try it!





Enter **ZIP Code or City**

Click on **monitors near me**

Select **PM** or ozone

Select **monitor** (circle)

Select **Plot Data** (shows last few hours)

Select **Loops** (top menu) for hour-by-hour

All is recent data, using AQI and ozone and PM, displayed using color coding

Select **Archive** for past data (top menu)

Set archive date to **July 25, 2023**

Contours (left menu) – can select pollutant

Air quality standards

The **National Ambient Air Quality Standards** (NAAQS) apply to the six criteria pollutants. These set maximum short- and long-term levels designed to protect health. Legal requirement, enforced using monitoring and modeling. Applies to all locations outside the fence line

EPA considering 8-10 µg/m^3

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 (1)	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 (2)	Annual Mean
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	Primary	1 year	12.0 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 (4)	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

Questions and key points

Which pollutants cause the greatest threats to human health in the US?

$PM_{2.5}$ and ozone

Why?

More people affected by these two criteria pollutants

$PM_{2.5}$ can be inhaled deep into the lungs and cause many health impacts

Ozone affects lung health and asthma

Large areas affected, often with levels near or above standards

Scientific evidence suggests the standards should be strengthened

Questions?