

AIR POLLUTION:

SOURCES, POLLUTANTS, SMOG
CHEMISTRY, AQI, & SOLUTIONS
HIGH SCHOOL READING

Improve students'
literacy skills

Sub Plan

Science Applicability



SCROLL
to take a look inside!

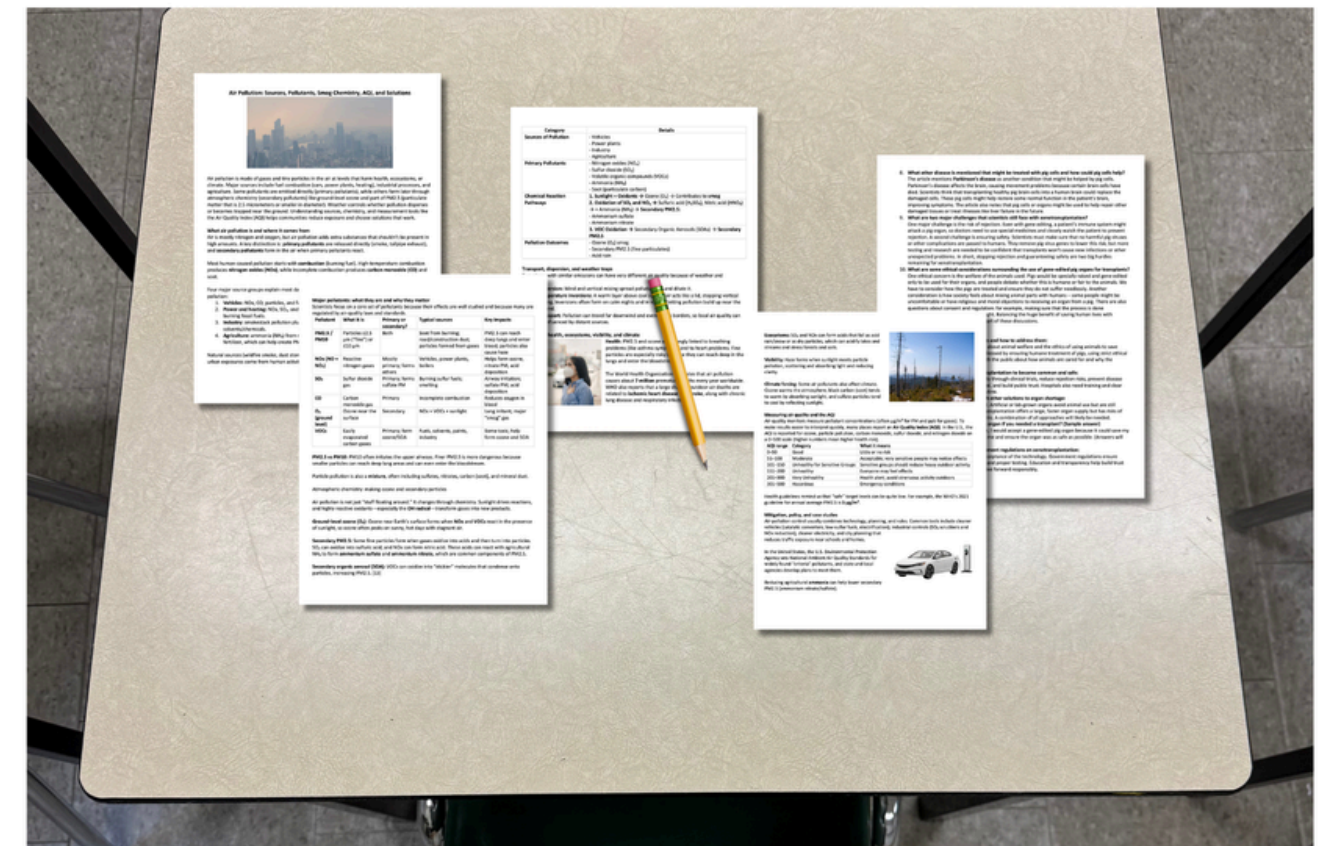


THE PROBLEMS YOU FACE

- Limited time to teach scientific literacy and strengthen students' reading and analysis skills.
- Need meaningful extension activities to engage fast-moving learners.
- Difficulty creating effective last-minute sub plans that still support student learning.

CLASSROOM READY

- Questions and Answer Key
- **No Prep, Ready-to-Use:** Print or assign digitally with Google Docs, Microsoft Word, and PDF formats for flexible classroom use
- **Includes Varied Question Types:** Knowledge, thinking, connecting, application, and open-ended questions.



What Will Your Students Learn?

READING COMPREHENSION ARTICLE & QUESTION BUNDLE

Article with
Comprehension
Questions

Grade 9 and Up

Print & Digital

- What Air Pollution Is
- Primary vs. Secondary Pollutants
- Major Human Sources
- Particulate Matter (PM2.5 vs PM10)
- Nitrogen Oxides, Sulfur Dioxide, VOCs, and Carbon Monoxide
- Ground-Level Ozone Formation
- Secondary Organic Aerosols
- Temperature Inversions and Pollution Trapping
- Health Impacts and WHO Estimates
- Ecosystem Damage and Acid Deposition
- Visibility and Haze
- The Air Quality Index (AQI)
- Mitigation Strategies and Policy Tools
- Real-World Case Studies

Comprehension Questions

1. What is the difference between a primary pollutant and a secondary pollutant?
2. Name the four major human source groups of air pollution described in the reading.
3. Which pollutant is produced by incomplete combustion, and what makes it dangerous?
4. What three ingredients are needed for ground-level ozone to form, according to the reading?
5. Why is PM2.5 generally more harmful than PM10?
6. What is a temperature inversion, and how does it affect pollution levels near the ground?
7. About how many premature deaths per year does the World Health Organization estimate are caused by air pollution worldwide?
8. Name two examples of air pollution from the reading (examples: ecosystems, visibility, climate change).
9. What is the main purpose of the Air Quality Index (AQI)?
10. Give one example of how air pollution affects human health.

Extension Questions

1. Check the "main idea" of the article.
2. Research the health effects of one of the pollutants mentioned in the article.
3. Research the effects of a temperature inversion on a city.
4. Compare the Air Quality Index (AQI) to the weather forecast for your city.

Air Pollution: Sources, Pollutants, Smog Chemistry, AQI, and Solutions



Air pollution is made of gases and tiny particles in the air at levels that harm health, ecosystems, or agriculture. Major sources include fuel combustion (cars, power plants, heating), industrial processes, and atmospheric chemistry (secondary pollutants) like ground-level ozone and part of PM2.5 (particulate matter that is 2.5 micrometers or smaller in diameter). Weather controls whether pollution disperses or becomes trapped near the ground. Understanding sources, chemistry, and measurement tools like the Air Quality Index (AQI) helps communities reduce exposure and choose solutions that work.

What air pollution is and where it comes from
Air is mostly nitrogen and oxygen, but air pollution adds extra substances that shouldn't be present in high amounts. A key distinction is: **primary pollutants** are released directly (smoke, tailpipe exhaust), and **secondary pollutants** form in the air when primary pollutants react.

Most human-caused pollution starts with **combustion** (burning fuel). High-temperature combustion produces **nitrogen oxides (NOx)**, while incomplete combustion produces **carbon monoxide (CO)** and soot.

Four major source groups explain most day-to-day air pollution:

1. **Vehicles:** NOx, CO, particles, and fuel vapors (VOCs).
2. **Power and heating:** NOx, SO₂, and particulate matter.

Natural sources like forest fires, dust storms, and volcanic activity also contribute to air pollution.

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PDF



Your Reading

Air Pollution: Sources, Pollutants, Smog Chemistry, AQI, and Solutions



Air pollution is made of gases and tiny particles in the air at levels that harm health, ecosystems, or climate. Major sources include fuel combustion (cars, power plants, heating), industrial processes, and agriculture. Some pollutants are emitted directly (primary pollutants), while others form later through atmospheric chemistry (secondary pollutants) like ground-level ozone and part of PM2.5 (particulate matter that is 2.5 micrometers or smaller in diameter). Weather controls whether pollution disperses or becomes trapped near the ground. Understanding sources, chemistry, and measurement tools like the Air Quality Index (AQI) helps communities reduce exposure and choose solutions that work.

What air pollution is and where it comes from

Air is mostly nitrogen and oxygen, but air pollution adds extra substances that shouldn't be present in high amounts. A key distinction is: **primary pollutants** are released directly (smoke, tailpipe exhaust), and **secondary pollutants** form in the air when primary pollutants react.

Most human-caused pollution starts with **combustion** (burning fuel). High-temperature combustion produces **nitrogen oxides (NOx)**, while incomplete combustion produces **carbon monoxide (CO)** and soot.

Four major source groups explain most day-to-day air pollution:

1. **Vehicles:** NOx, CO, particles, and fuel vapors (VOCs).
2. **Power and heating:** NOx, SO₂, and particles from burning fossil fuels.
3. **Industry:** smokestack pollution plus VOCs from solvents/chemicals.
4. **Agriculture:** ammonia (NH₃) from manure and fertilizer, which can help create PM2.5



Natural sources (wildfire smoke, dust storms, volcanoes) can be important too, but many long-term urban exposures come from human activity.

Why they matter

because their effects are well studied and bad.

Why they matter or why?	Typical sources	Key impacts
	Soot from burning; road/construction dust; particles formed from gases	PM2.5 deep in blood, cause disease
forms	Vehicles, power plants, boilers	Helps nitrates deposit
forms	Burning sulfur fuels; smelting	Airway sulfate deposits
	Incomplete combustion	Reduced blood flow
ry	NOx + VOCs + sunlight	Lung irritation, "smog"
form	Fuels, solvents, paints, industry	Some form cancer

upper airways. Finer PM2.5 is more dangerous and can even enter the bloodstream.

including sulfates, nitrates, carbon (soot), and secondary particles

und." It changes through chemistry. Sunlight and the **OH radical**—transform gases into new products. For example, ground-level ozone forms when NOx and VOCs react with sunlight, hot days with stagnant air.

form when gases oxidize into acids and then turn into particles.

SO₂ can oxidize into sulfuric acid, and NOx can form nitric acid. These acids can react with agricultural NH₃ to form **ammonium sulfate** and **ammonium nitrate**, which are common components of PM2.5.

Secondary organic aerosol (SOA): VOCs can oxidize into "stickier" molecules that condense onto particles, increasing PM2.5. [13]

Category	Details
Sources of Pollution	- Vehicles - Power plants - Industry - Agriculture
Primary Pollutants	- Nitrogen oxides (NO _x) - Sulfur dioxide (SO ₂) - Volatile organic compounds (VOCs) - Ammonia (NH ₃) - Soot (particulate carbon)
Chemical Reaction Pathways	1. Sunlight + Oxidants → Ozone (O ₃) → Contributes to smog 2. Oxidation of SO₂ and NO_x → Sulfuric acid (H ₂ SO ₄), Nitric acid (HNO ₃) → + Ammonia (NH ₃) → Secondary PM2.5: - Ammonium sulfate - Ammonium nitrate 3. VOC Oxidation → Secondary Organic Aerosols (SOAs) → Secondary PM2.5
Pollution Outcomes	- Ozone (O ₃) smog - Secondary PM2.5 (fine particulates) - Acid rain

Transport, dispersion, and weather traps

Two places with similar emissions can have very different air quality because of weather and geography.

- **Dispersion:** Wind and vertical mixing spread pollution out and dilute it.
- **Temperature inversions:** A warm layer above cool surface air acts like a lid, stopping vertical mixing. Inversions often form on calm nights and in valleys, letting pollution build up near the ground.
- **Transport:** Pollution can travel far downwind and even across borders, so local air quality can be influenced by distant sources.

Impacts on health, ecosystems, visibility, and climate



Health: PM2.5 and ozone are strongly linked to breathing problems (like asthma symptoms) and to heart problems. Fine particles are especially risky because they can reach deep in the lungs and enter the bloodstream.

The World Health Organization estimates that air pollution causes about **7 million** premature deaths every year worldwide. WHO also reports that a large share of outdoor-air deaths are related to **ischemic heart disease and stroke**, along with chronic lung disease and respiratory infections.

can form acids that fall as acid rains, which can acidify lakes and forests and soils.

When sunlight meets particle pollution, it can absorb light and reduce visibility.

Some pollutants also affect climate. For example, black carbon (soot) tends to absorb light, and sulfate particles tend to reflect light.

Understanding the AQI

To ensure pollutant concentrations (often µg/m³ for PM) are interpreted quickly, many places report an **Air Quality Index (AQI)**, a number that summarizes air quality. Higher numbers mean higher health risk).

	What it means
0-50	Little or no risk
51-100	Acceptable; very little risk
101-150	Sensitive groups may experience health effects
151-200	Everyone may experience health effects
201-300	Health alert; everyone may experience more serious health effects
301-400	Emergency conditions

US EPA says that "safe" target levels can be quite low. For example, the **PM2.5** target is **5 µg/m³**.

Policy solutions

Policy solutions often combine technology, planning, and incentives, such as low-sulfur fuels, electrification, improved public transit, and city planning that reduces traffic near schools and homes.

U.S. Environmental Protection Agency's National Ambient Air Quality Standards for particulate matter, and state and local governments can help meet them.

Ammonia can help lower secondary particulate matter (sulfates).

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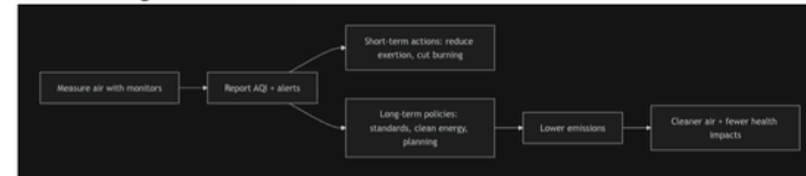
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Real-Life Examples:

- **London (1952):** Coal smoke plus a strong inversion created a deadly smog that killed thousands and drove major air-pollution reforms in the United Kingdom.
- **Beijing (2013):** An extreme winter haze episode showed how heavy emissions and stagnant air can combine into a crisis.
- **Delhi (modern episodes):** Severe winter smog can occur when traffic, industry, and seasonal burning combine with calm, trapping weather.
- **Los Angeles (1990s–present):** Tightening vehicle/fuel standards reduced ozone-forming VOCs and NOx, and regional data show a long-term decline in days that exceed ozone health standards (even though challenges remain).

Short and Long-Term Solutions



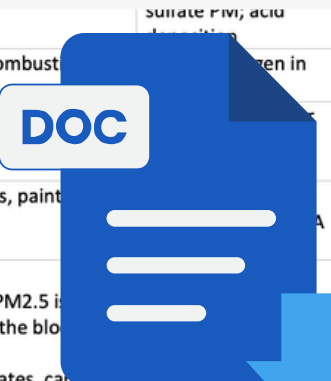
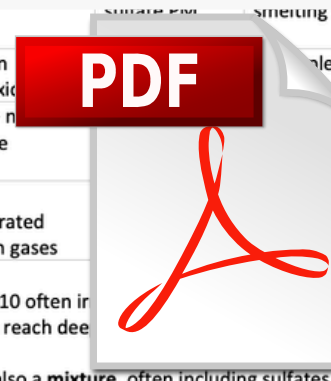
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Answer Key Included Office, Google, and PDF Versions



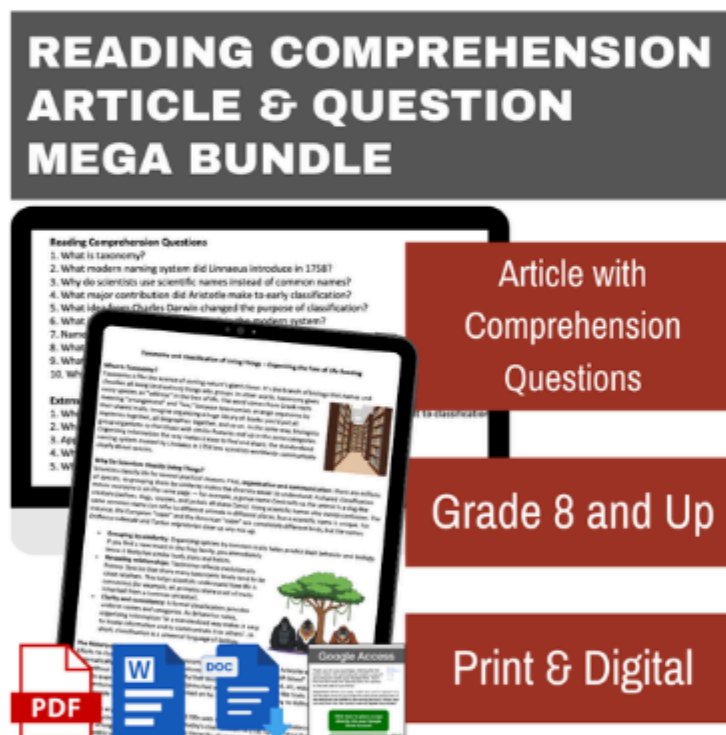
5. Choose one policy tool (low-emission zones, congestion pricing, electrifying buses, coal phase-out, industrial scrubbers). Find evidence for how it changed air pollution levels in one city or region.



Comprehension & Extension Questions

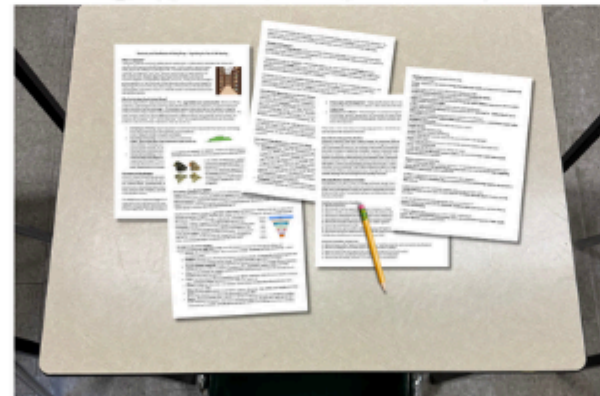
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★★★★★ Extremely satisfied - It is a good supplemental activity either for review and at the same time introducing some concept. I also use this for sub plan. It is well presented, organized and interesting.

★★★★★ Extremely satisfied - This a great resource. I used this for a sub plan. It was fun and engaging for my students.

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