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### Human sources of air pollution

Air pollution has become one of the most serious environmental challenges facing the modern world. While natural processes such as volcanic eruptions, wildfires, and dust storms contribute to the presence of pollutants in the atmosphere, human activities remain the dominant driver of air pollution on a global scale. Industrialization, rapid urbanization, and the ever-increasing demand for energy, transportation, and consumer goods have all intensified the emission of harmful substances into the air. These pollutants not only affect the environment but also pose severe risks to human health, leading to respiratory diseases, cardiovascular problems, and even premature deaths.

Human sources of air pollution can be categorized into several major sectors, including industry, transportation, agriculture, energy production, and household activities. Each of these sectors contributes differently, both in terms of the types of pollutants released and the scale of their impact.

### **1. Industrial Activities**

Industries are among the largest contributors to air pollution worldwide. Factories and manufacturing plants release significant amounts of gases and particulate matter into the atmosphere.

- **Combustion of Fossil Fuels:** Many industries rely heavily on coal, oil, and natural gas to power their operations. Burning these fuels releases carbon dioxide (CO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), and particulate matter.

- **Chemical Emissions:** The production of chemicals, plastics, fertilizers, and pharmaceuticals often results in the release of toxic compounds such as volatile organic compounds (VOCs), ammonia, and other hazardous air pollutants.

- **Metal Processing:** Smelting and refining metals like copper, lead, and zinc produce large amounts of heavy metals and particulates, which can persist in the atmosphere and contaminate soil and water.

- **Cement Production:** Cement factories are major sources of dust and CO<sub>2</sub>, contributing both to local air quality deterioration and global climate change.

Industrial emissions are especially concerning because they often occur in concentrated areas, leading to localized zones of severe pollution known as “industrial hotspots.”

### **2. Transportation**

The rapid growth of transportation systems has significantly increased air pollution in urban areas. Cars, trucks, buses, ships, and airplanes rely predominantly on fossil fuels such as gasoline, diesel, and jet fuel.

- **Vehicle Emissions:** Automobiles release carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), hydrocarbons, and particulate matter. These pollutants contribute to the formation of ground-level ozone and smog.

- **Diesel Engines:** Trucks and buses powered by diesel fuel emit high levels of fine particulate matter (PM<sub>2.5</sub>), which can penetrate deep into the lungs and cause chronic respiratory issues.

- **Aviation:** Aircraft engines emit CO<sub>2</sub>, NO<sub>x</sub>, and water vapor at high altitudes, contributing not only to local air pollution near airports but also to global climate impacts.

- **Shipping:** Cargo ships, often powered by heavy fuel oil, are a major source of sulfur oxides ( $\text{SO}_x$ ) and black carbon, especially in coastal and port areas. In cities with poor traffic management and outdated vehicle fleets, transportation is often the leading cause of poor air quality

### 3. Energy Production

Power generation is another major human source of air pollution, especially in countries that rely on fossil fuels.

- **Coal-Fired Power Plants:** Coal combustion produces large amounts of  $\text{CO}_2$ ,  $\text{SO}_2$ ,  $\text{NO}_x$ , and mercury. These plants are among the most polluting sources worldwide.

- **Oil and Gas Plants:** Burning petroleum products releases greenhouse gases and contributes to smog formation. Gas flaring in oil fields also adds methane ( $\text{CH}_4$ ), a highly potent greenhouse gas.

- **Biomass Burning:** In some regions, people burn wood, crop residues, or charcoal to produce energy. This practice emits large quantities of smoke, carbon monoxide, and particulates, especially in rural and developing areas.

Although renewable energy sources are growing, fossil fuels remain the dominant energy source, thus continuing to pollute the atmosphere.

### 4. Agricultural Activities

Agriculture, while essential for human survival, also contributes significantly to air pollution.

- **Livestock Farming:** Cattle, sheep, and goats emit methane ( $\text{CH}_4$ ) during digestion. Methane is a greenhouse gas far more potent than  $\text{CO}_2$ .

- **Fertilizers and Pesticides:** The application of nitrogen-based fertilizers releases nitrous oxide ( $\text{N}_2\text{O}$ ), another strong greenhouse gas. Spraying pesticides and herbicides can release harmful chemicals into the air.

- **Open Burning of Agricultural Waste:** Farmers in many regions burn leftover crop residues, producing smoke,  $\text{CO}$ , particulates, and polycyclic aromatic hydrocarbons (PAHs), which are harmful to both air quality and health. Agricultural emissions are often underestimated but are significant contributors to both local pollution and global warming.

### 5. Household and Urban Activities

On a smaller scale, daily human activities in households and cities contribute to air pollution.

- **Cooking and Heating:** In many developing regions, people rely on wood, charcoal, or kerosene for cooking and heating. This releases smoke,  $\text{CO}$ , and particulates indoors and outdoors.

- **Waste Burning:** Open burning of solid waste, including plastics, releases dioxins, furans, and other toxic compounds.
- **Construction and Demolition:** Dust, asbestos, and other particulates are released from construction sites, reducing air quality in rapidly growing urban centers.
- **Consumer Products:** Aerosols, paints, cleaning products, and cosmetics often release VOCs, which contribute to the formation of ground-level ozone. Although household contributions are smaller compared to industry or transportation, they have a direct impact on indoor air quality and health.

