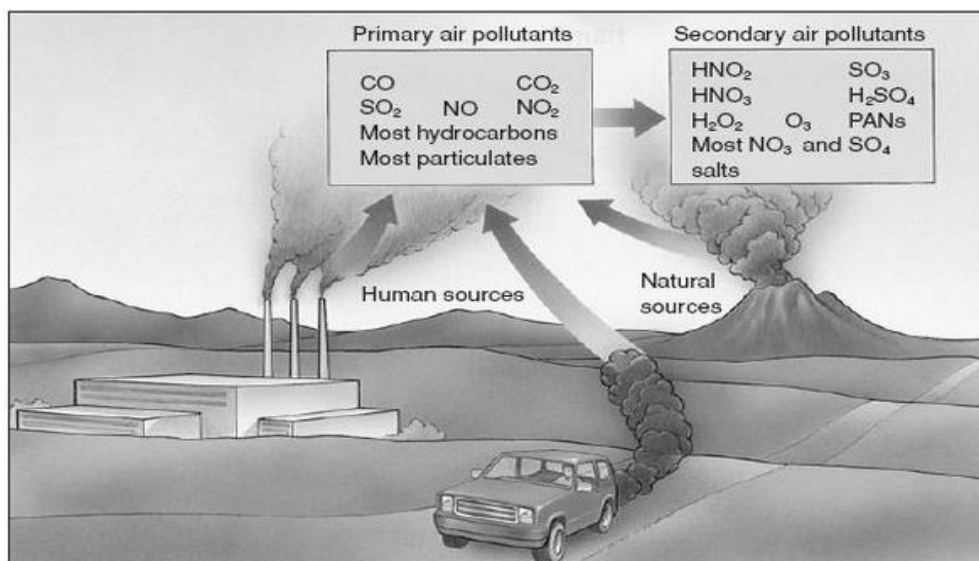


Motor vehicles are a major source of air pollution. In 2006, nationwide, motor vehicles (trucks, cars, and SUVs) were responsible for approximately 36% of nitrogen oxide emissions, 22% of volatile organic compound emissions, 8% of ammonia and particulate matter, and 53.8% of carbon monoxide emissions (US EPA, 2007). Motor vehicles also are a major source of carbon dioxide—a greenhouse gas. In 2003, the US transportation sector accounted for 23% of all greenhouse gases (EPA, 2008). As discussed below, air pollutants present a potentially significant direct risk to public health and the environment. And, as depicted in the following figure, the automobile contributes a number of secondary pollutants. In addition, the health and environmental effects of global climate change are becoming increasingly serious. Although emissions from an individual car are generally low, in numerous cities across the country, the personal automobile is the single greatest polluter—emissions from millions of vehicles add up. Driving a private car is probably a typical citizen's most "polluting" daily activity and is the most significant contribution to environmental degradation (US EPA, 1994).



The automobile is a major source of air pollution. Primary pollution refers to emitted or discharged pollutants when they react in the atmosphere. Secondary pollution is produced from chemical reactions involving the primary pollutants. PAN is peroxyacetyl nitrate.

Source: Raven, P. H., L. R. Berg and D. M. Hassenzahl. 2008. Environment. 6th ed. John Wiley & Sons, New York (p. 454).

HYDROCARBONS

Hydrocarbon emissions (or volatile organic compounds—VOCs) occur when fuel molecules in the internal combustion engine do not burn completely. Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground-level ozone—a major component of smog. Ozone irritates the eyes, damages the lungs, and aggravates respiratory problems (US EPA, 2007). It continues to be the nation's most widespread and intractable urban air pollution problem. A number of exhaust hydrocarbons are also toxic and carcinogenic. Hydrocarbon pollutants also escape into the air through fuel evaporation. Evaporation occurs primarily during refueling, while the engine is running and right after the engine is shut down (US EPA, 1994).

NITROGEN OXIDES

Under the high pressure and temperature conditions in an engine, nitrogen and oxygen atoms in the air react to form various nitrogen oxides, collectively known as NO_x. Nitrogen oxides, such as hydrocarbons, are precursors to the formation of ozone. Nitrogen oxides also contribute to the formation of acid rain (US EPA, 2007).

PARTICULATE MATTER

Particulate matter refers to solid or liquid particles found in the air. Some particles are large or dark enough to be seen as soot or smoke, but fine particulate matter is tiny and generally not visible to the naked eye. Particulate emissions from automobiles generally consist of very tiny particles, also known as PM_{2.5} because they are less than 2.5 microns in diameter. It is a health concern because very fine particles can reach and lodge in the deepest regions of the lungs. Health effects include asthma, difficult breathing, and chronic bronchitis, especially in children and the elderly. Fine particulate matter associated with diesel exhaust is a suspected carcinogen. Fine particulate matter can travel long distances and is a major cause of haze, which reduces visibility, affecting cities and scenic areas (US EPA, 2007).

CARBON MONOXIDE

Carbon monoxide (CO) is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidized rather than fully oxidized to carbon dioxide (CO₂). Carbon monoxide binds to hemoglobin in the blood (forming carboxyhemoglobin), taking the place used by oxygen, and thereby reducing the flow of

oxygen in the bloodstream. It is particularly dangerous to persons with heart disease (US EPA, 2007). The combustion of a typical gallon of gasoline releases 495 grams (1.091 pounds) of CO.

CARBON DIOXIDE

Carbon dioxide (CO₂) is a product of full or complete combustion. Although carbon dioxide does not directly impair human health, it is a greenhouse gas that traps the Earth's heat and is a major factor in global climate change (US EPA, 2007). The combustion of a typical gallon of gasoline releases 8.8 kilograms (19.4 pounds) of CO₂.

Source: Wagner, T., & Sanford, R. (2010). *Environmental science: Active learning laboratories and applied problem sets* (2nd ed.). Hoboken, NJ: Wiley.