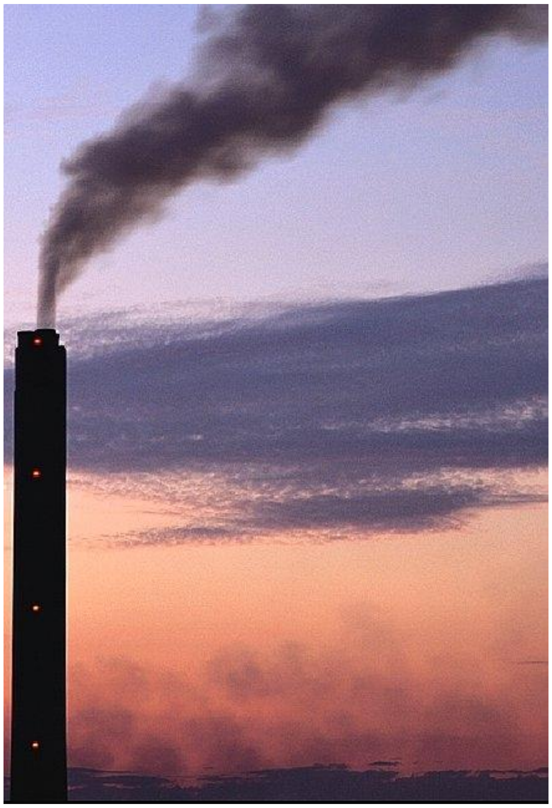
Air pollution



Air pollution is the introduction of chemicals, particulate matter, or microscopic organisms into theatmosphere; in particular, when concentrations of those substances cause adverse metabolic change to humans or other species. The most common and widespread air pollutants include carbon monoxide, sulfur dioxide, nitrogen oxides and particulate matter.

Presently, the greatest occurrences of air pollution are in China, India, Indonesia, South Africa, Brazil,Mexico and Argentina.[1] Each year air pollution is the cause of millions of human deaths, and even larger numbers of respiratory, circulatory, and cancer-related disease occurrences. Also, indoor air pollution is a significant source of human death and disease—mortality and morbidity—through indoor burning of wood and charcoal (especially in developing countries), tobacco smoking, radon and a host of chemical substances found in paints, printing supplies and cleaning products.

An increase of natural background concentrations to concentrations of a few micrograms per cubic meter of such common pollutants as sulfur dioxide, nitrogen oxides and ammonia may produce, for instance, increased growth of forests; however, higher levels of these chemicals produce such adverse effects on forests as decreased growth, greater susceptibility to diseases and pests, and ultimately to forest die-back.

History

Air pollution existed in prehistory in the form of volcanic eruptions, wildfires and duststorms and with their associated sulfur dioxide, carbon monoxide and particulate matter. In the Middle Ages coal burning was outlawed in London while Parliament was in session. However, the phenomenon of air pollution accelerated dramatically due to the increase of emissions since the Industrial Revolution.

In modern history, the first recognition that air pollution is more than a local problem arose with a dispute between the states of Tennessee and Georgia in the U.S. in the year 1907. A legal dispute arose that set the stage for a number of other similar interstate conflicts—that were not resolved fully until Federal legislation of 1955 and the Clean Air Act Amendments of 1970. The 1955 legislation only provided for research, but the 1970 Act enabled enforcement proceedings for industrial sources exceeding specific standards.[2]

Dispersal

Air pollutants are dispersed in the atmosphere through convective and turbulent movement. In addition, some pollutants undergo chemical reaction with others, particularly in the presence of sunlight, where photochemical oxidants are formed by combination of certain hydrocarbon molecules with oxides of nitrogen.

The transport of air pollutants is studied using mathematical models, that generally can be grouped as follows:

- Point source models, used chiefly for industrial sources;
- Line source models, applied mainly to roadway, train and aircraft sources;
- Area source models, used for such large, two dimensional sources as windblown dust or wildfires; and
- Photochemical models, invoked to study the combination of transport and chemical reactions that produce photochemical oxidants.

The earliest point source model was originated in the early twentieth century, invoking a Gaussian dispersion model for buoyant pollution plumes to predict movement of pollutants, with consideration given to wind velocity, source stack height, emission rate and atmospheric turbulence.[3][4] This model has been calibrated extensively with experimental data for a variety of atmospheric conditions.

A roadway air dispersion model was developed starting in the late 1950s and early 1960s in response to requirements of the National Environmental Policy Act and the U.S. Department of Transportation to understand impacts of proposed new highways upon air quality, especially in urban areas. Several research groups were active in this model development, among which were: the Environmental Research and Technology (ERT) group in Massachusetts, the ESL Inc. group in California and the California Air Resources Board group in California. The ESL group received a contract from the United States Environmental Protection Agency to validate a line source model using sulfur hexafluoride as a tracer gas. Some of the earliest uses of the model were in court cases involving highway air pollution at the Arlington, Virginia portion of Interstate 66 and the New Jersey Turnpike widening project through East Brunswick, New Jersey. Area source models were developed in 1971 through 1974 by the same groups pioneering the line source models, Similarly photochemical models were developed primarily in the 1960s and 1970s, but their use was more specialized and for such regional needs as understanding smog formation in the Livermore and Los Angeles air basins of California.

Emission sources

Air pollution emissions from an industrial complex. Source: Balázs Sudár

Air pollution emission sources are chiefly man-made, and can be divided into several main categories:

- Transportation sources including motor vehicles, aircraft, trains and ships, most of which burn fossil fuels and produce air pollution discharge;
- Agricultural sources that produce methane gases (from livestock and from rice farming) and particulate matter from land cultivation;
- Industrial sources that generate a variety of chemical waste gases (e.g. hydrocarbons, sulfur oxides,heavy metals) as by-products of their manufacturing processes;
- Construction activity that produces particulate and fossil fuel combustion products as well as a variety of paint and solvent off-gasses; and
- Landfills whose decaying organic matter produces methane gas.

Health effects

Air pollution causes deaths numbering in the millions of people per annum, worldwide. Chief causes of mortality are respiratory and circulatory disease, including a significant incidence of lung cancer. It is difficult to separate out the contributions of smoking and second hand smoke versus general ambient air quality, since all of these impacts are cumulative over the human lifespan. Heart disease is particularly strongly correlated with tobacco smoking and second hand derivatives, with the chief pathology being arterial plaque buildup through the customary mechanism of blood chemistry alteration due to depressed nitric oxide production. Respiratory diseases attributed to adverse air quality are chiefly lung cancer, emphysema and other obstructive lung disease.

The pathways of disease are not understood fully for a variety of carcinogenic air pollutants—since there is a vast array of airborne pesticides and other complex organic chemicals that can produce mutagenic as well as carcinogenic effects. In addition, the variety of impacts from heavy metals present in air pollution is not understood fully—due to the long time exposure required for many of the diseases to progress. Furthermore, the impacts of heavy metal pollutants are complex, since many of the locales of most acute impact have dual pathways of impact to the human body: most commonly being via water and via air exposure.

Indoor air quality

The interior of structures is a setting where airborne pollutants can be concentrated, especially in cases where ventilation is less than adequate. The most common pollutants involved in building interiors are: carbon monoxide, radon, volatile organic compounds, asbestos fibers, particulate matter and such biological agents as allergens, bacteria, molds—and a range of pathogens.[5]
Indoor air pollution exposure is responsible for millions of deaths per year, largely through respiratory disease from smoking exposure and indoor wood burning. Also, radon exposure in western countries is a major health risk, with the peril increasing in upscale, well insulated homes, where subsurface radium occurs or where interior stonework has imported a radon producing material (e.g., some granites). In most western countries, there are regulatory standards for many of the commonly occurring indoor air pollutants; however, the total array of chemicals utilized in paints, solvents and household cleaning products is sufficiently vast that all chemicals are not regulated.

Regulatory standards

Although England banned coal burning in London as early as the 13th century, and again responded to an air pollution episode in the same city in 1852—that killed over 8000 people in one season—substantial regulatory responses did not occur until the mid 1900s in the U.S. and UK. The first comprehensive legislation came from the United States in the form of the Clean Air Act of 1963 and Amendments of 1972. These set forth specific ambient air qualtiy standards for all major atmospheric pollutants (carbon monoxide, sulfur dioxide, oxides of nitrogen, total hydrocarbons and particulate matter). Furthermore mandates for national monitoring and an enforcement framework were established. Implementation of these standards was not only promulgated for ongoing emissions, but was integrated into the planning of new projects by coupling to the National Environmental Policy Act.

China established an initial framework for air quality standards in 1982 and added more substantive language in the decade following. That country has had a difficult time implementing air standards due to less than uniform enforcement, and a struggle with economic priorities versus environmental priorities. Consequently, over 40 percent of China's cities did not meet the national standards by the year 2005.[6]
In 1985, the Vienna Convention established an international framework for control of fluorocarbons and other pollutants that could damage the ozone layer. By the early 1990s the European Union had begun to establish air quality standards, but their approach relies heavily on vehicle emissions standards, and provides substantial latitude for industrial emitters, based upon regional economic

conditons.[7] By 1994 Australia had implemented a comprehensive air quality regulatory framework patterned after the USA and UK models, including provisions for nationwide ambient air monitoring.[8]

Natural occurrence

Many chemicals at low concentrations are essential nutrients for the structure and functioning of naturalecosystems. Several natural processes contribute to natural atmospheric air pollutants including forest fires, volcanic eruptions, windstorms, lightning and release of turpenes from conifers; however, the extent and damage from these natural sources is a minute portion of the air pollution emissions produced by the activiities of man.

Sulfur dioxide and particulate are produced by volcanoes. Nitrogen oxides are produced by lightning and by certain soil micro-organisms.

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