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Increasing Air Pollution and Its Associated Effects on Human Health

Nabanita De[1] and Tanmoy Das[2]
[1]Department of Chemistry, Krishnagar Women's College Krishnagar, Nadia 741101, WB India
[2]Department of Chemistry, University of Burdwan, 713104 WB India
Correspondence for materials should be addressed to TD (email: tdas@chem.buruniv.ac.in)

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Abstract
The growing menace of air pollution is becoming a matter of concern day by day. Pollution is the introduction of harmful substances or products into the environment. Air is getting polluted from the burning of fuel, industrial emissions, etc. There have been several fatal episodes since the early 1930s worldwide due to air pollution. Air pollution can adversely affect human health. There are many harmful diseases associated with such extreme air pollution including cardiovascular diseases and even cancer. In the present review paper, several sources of air pollution have been identified concerning their harmful effects. Both indoor and outdoor pollution have been taken into account. Considering the different agents responsible for such menace, some preventive measures have also been proposed regarding increasing pollution.

Keywords: Cardiovascular diseases; Pollutants; Industrial lung diseases; Particulate matter; Smog; PAN

Introduction
In the 1930s, 40s, and 50s, several episodes of extreme air pollution were observed all over the world. Events in the Meuse Valley, Belgium, in December 1930 (Firket, 1936) an episode in Donora, Pennsylvania in 1948 (Shrenk et al., 1949), and several episodes in London, England (Logan, 1953; Scott, 1963) are the examples of such extreme air pollutions. The sudden large increases in sickness and death that accompanied such episodes demonstrated that air pollution can adversely affect human health. The increased mortality associated with such episodes provided the first quantitative measure of the adverse effects of air pollution. The UK Act in 1956 (Arrow et al., 1995), led to a reduction in urban pollution. The causes of the excess deaths were never explained, but it was believed that the problem had been eliminated. Two facts make it necessary to question this assumption: the increase in motor vehicles on roads worldwide with the consequent rise in exhaust emissions, and evidence of continuing associations between air pollution and ill-health. The former has resulted in a change in the type of pollution in cities, and the latter has shown effects on health at levels of pollution previously considered harmless. There are many more harmful diseases associated with such extreme air pollution, as cancer which has various types, and out of them the most dangerous one is lung cancer. Lung cancer is one of the most common cancers and has a poor prognosis. Active smoking is the main cause, but occupational exposures, residential radon, and environmental tobacco smoke are also established risk factors. Furthermore, a lower socioeconomic position has been associated with a higher risk for lung cancer (Singh, 2022). Ambient air pollution, specifically particulate matter with absorbed polycyclic aromatic hydrocarbons and other genotoxic chemicals, is suspected to increase the risk of lung cancer (Dhau and Singh, 2023). Air pollution was responsible in 2015 for 21% of all cardiovascular deaths worldwide, 25% of ischaemic heart disease deaths, 24% of stroke deaths, and 27% of lung cancer deaths. Additionally, ambient air pollution appears to be an important although not yet quantified risk factor for neuro-developmental disorders in children and neurodegenerative diseases in adults.

The good news is that ambient air pollution can be controlled and the diseases it causes prevented. Ambient air pollution is not the unavoidable consequence of modern economic growth (Badman and Jaffe, 1996) but pollution is the release of noxious gases, such as sulphur dioxide, carbon monoxide, nitrogen oxides, and chemical vapours. These can take part in further chemical reactions once they are in the atmosphere, forming smog and acid rain.

Pollutant categories

The primary cause of the main alteration in the composition of the atmosphere is the burning of fossil fuels, which are utilized for transportation and energy production. There have been reports of several air pollutants with varying chemical compositions, reaction characteristics, emissions, environmental permanence, capacity to travel large or short distances, and potential health effects on humans and/or animals. However, they share some similarities and they can be grouped into four categories (Kaiser, 1997).

1. Gaseous pollutants (e.g. SO_2, NOx, CO, Ozone, Volatile Organic Compounds)
2. Persistent organic pollutants (e.g. dioxins)
3. Heavy metals (e.g. lead and mercury)
4. Particulate Matter

Gaseous pollutants contribute to a great extent in composition variations of the atmosphere and are mainly due to the combustion of fossil fuels (Mehra and Chadha, 2023; Katsouyanni, 2003). Nitrogen oxides are emitted as NO which rapidly reacts with ozone or radicals in the atmosphere forming NO_2. The main anthropogenic sources are mobile and stationary combustion sources. Moreover, ozone in the lower atmospheric layers is formed by a series of reactions involving NO_2 and volatile organic compounds, a process initiated by sunlight. CO is a byproduct of incomplete combustion, nevertheless. Road transport is another important source. Volcanoes and seas are the main natural sources of anthropogenic SO_2, which is produced when sulphur-containing fossil fuels (mostly coal and heavy oils) are burned and sulphur-containing ores are melted. The latter account for less than 2% of all emissions. Finally, a major class of compounds that fuel combustion and especially combustion processes for energy production and road transport are the major source of emission are the so-called volatile organic compounds (VOCs). This is a class of compounds, which includes chemical species of organic nature such as benzene. While most gaseous pollutants are breathed and primarily impact the respiratory system, they can also cause cancer and hematological issues (Vidal, 1997).

Hazardous chemicals are classified as persistent organic pollutants. They are long-lasting in the environment, and as they go up the food chain, their effects are stronger (a process known as bio-magnification). These consist of PCBs, dioxins, furans, and pesticides. Generally, the generic term "dioxins" is used to cover polychlorinated dibenzo-dioxins (PCDDs) and polychlorinated dibenzo-furans (PCDFs) while polychlorinated biphenyls (PCB) are called dioxin-like compounds (Dockery et al., 1993), and can act similarly in terms of dioxin-type toxicity. Dioxins are formed during incomplete combustion and whenever materials containing chlorine (plastics) are burned. Dioxins are airborne pollutants that tend to settle on land and in water, but because they are insoluble in water, they do not affect sources of groundwater. Due to their capacity to form stable bonds with lipids, dioxins are mostly found in plants and are absorbed down the food chain from sources such as pesticides, dust, and air.

Heavy metals include basic metal elements such as lead, mercury, cadmium silver nickel, vanadium, chromium and manganese. Being naturally occurring elements of the Earth's crust, they are impervious to deterioration or destruction, may be carried by air, and can find their way into water and human food supplies. Furthermore, they are released into the environment through a multitude of pathways, such as manufacturing facilities, wastewater discharges, and combustion. They inadvertently find their way into human bodies, where they function as trace elements and are vital to sustaining regular metabolic processes. But they can become harmful in larger amounts. Because they tend to bioaccumulate in the human body, most heavy metals are harmful. When a chemical's concentration in a biological organism rises over time relative to its concentration in the environment, this is referred to as bioaccumulation. Every time a compound is ingested and stored, it builds up in the system quicker than it can be metabolized or eliminated (Brunekreef and Holgate, 2002).

The general name for this class of air pollution is particulate matter (PM), which refers to complex and variable combinations of particles suspended in the breathing air that differ in size and content and are created by a wide range of anthropogenic and natural processes. Manufacturing facilities, power plants, waste incinerators, automobiles, building sites, wildfires, and naturally occurring wind-blown dust are the main causes of particle pollution. The size of the particles varies (PM2.5 and PM10 for aerodynamic diameter smaller than 2.5 mm and 10 mm respectively) and different categories have been defined: Ultrafine particles, smaller than 0.1 mm in aerodynamic diameter, Fine particles, smaller than 1 mm, and Coarse particles, larger than 1 mm. The size of the particles determines the site in the respiratory tract where they will deposit: PM10 particles deposit mainly in the upper respiratory tract while fine and ultra-fine particles can reach lung alveoli. So far, no single component has been identified that could explain most of the PM effects. The size, surface area, quantity, and makeup of the particles are some of the factors that are crucial in producing health impacts. Because PM may transport and absorb a wide range of contaminants, their makeup varies. Nonetheless, metals, organic substances, biologically derived material, ions, reactive gases, and the carbon core of the particle are their main constituents. Strong evidence suggests that small and ultra-fine particles provide a greater risk to human health than bigger (coarse) particles in terms of impacts on the heart, lungs, and other systems. Furthermore, the primary causes of PM toxicity include the amount of metals present, the existence of PAHs, and other organic components including endotoxins (Balmes et al., 1987).

Fig. 1. Air pollution due to vehicles on Road and due to industrial smoke

Exposures

Humans enter into contact with different air pollutants primarily via inhalation and ingestion, while dermal contact represents a minor route of exposure. Food and water contamination is largely caused by air pollution, making swallowing the primary method of pollutant absorption in many situations. Pollutants can be absorbed by the respiratory and digestive systems, and several harmful compounds can enter the bloodstream and settle in various body tissues. Elimination occurs to a certain degree by excretion (Bellinger, 2005).

Exposure to air pollution has been linked to several harmful respiratory outcomes, such as lung cancer and airway illnesses (Boffetta et al., 1993). Although environmental exposures can cause various kinds of interstitial lung disease (ILD), there has been limited research on the connection between air pollution and ILD. The long-term effect of exposure to air pollution on human health in Europe which included 36 European areas in which air pollution was measured, land-use regression models were developed, and cohort studies were located. The study included 17 cohort studies, located in 12 areas, from which information about incident lung cancer cases.

Indoor and outdoor air pollution

Indoors, where people spend most of their time, air pollution is concentrated due to inadequate ventilation. Certain places on Earth release radon (Rn) gas, a carcinogen that gets trapped within homes. Plywood and carpet are examples of building materials that release formaldehyde (H_2CO) gas. Volatile organic compounds (VOCs) are released by paints and solvents when they dry. Lead paint can break down into dust that might be breathed in. Using air fresheners, incense, and other scented products causes purposeful air pollution. Smoke particles from controlled wood fires in fireplaces and stoves can enter the house and contribute significantly to air pollution (Kaiser, 1997). Indoor pollution fatalities may be caused by using pesticides and other chemical sprays indoors without proper ventilation. Carbon monoxide poisoning and fatalities are often caused by faulty vents and chimneys, or by the burning of charcoal indoors or in a confined space, such as a tent (Vidal, 1997). Chronic carbon monoxide poisoning can result even from poorly adjusted pilot lights. Traps are built into all domestic plumbing to keep sewer gas and hydrogen sulphide, out of interiors. Clothing emits tetrachloroethylene, or other dry-cleaning fluids, for days after.

There is a large class of pollutants, generated by the buildings themselves or by indoor human activities, which typically have no concentrations of physiological significance in the outdoor air. These include the usage of indoor pesticides, radioactive gases coming from the subsurface, formaldehyde emissions from particle boards, and gases produced by human metabolism. The level of radon and its decay products inside conventional buildings is often higher than the ambient level outdoors, and inside poorly ventilated buildings these elements may accumulate to high levels due to the lack of diluting ventilation. Outdoor air pollution is a complex mixture of several pollutants. In 1970, Congress passed the Clean Air Act that established national air pollutant standards for 6 criteria pollutants: ozone, matter respirable particulate (PM), sulfur compounds, lead, carbon monoxide (CO), and nitrogen dioxide (NO2). Since 1970, levels of these pollutants have been regularly measured. Smog is a type of large-scale outdoor pollution. It is caused by chemical reactions between pollutants derived from different sources, primarily automobile exhaust and industrial emissions. Cities are often centers of these types of activities, and many suffer from the effects of smog, especially during the warm months of the year. The most important of these outdoor air pollutants in the U.S. today are ozone, PM, and SO_2. Almost all sources of outdoor air contain some pollutants, we are all probably exposed to some degree. The main route of exposure to outdoor air pollutants is through breathing. However, some of these substances can enter the local ecosystem through various ecological cycles and eventually become pollutants of water, soil, and plants. Children may receive more exposure to these pollutants than adults because of their intensity of exposure, the time course of exposure (minutes, days, years), and the individual's health status.

The National Academy of Sciences stated in its report on indoor pollutants: The constituents of tobacco smoke are well-documented as hazardous, the prevalence of population exposure is very high, and there is an increased incidence of respiratory tract symptoms and functional decrements (decreases) in children residing in homes with smokers, compared with those homes without smokers.

Sources of indoor air pollution

Unprocessed biomass used as cooking fuel causes major air pollution outdoors as well as indoors. Biomass is typically burned in poorly ventilated kitchens using inefficient traditional stoves causing pollution Biomass smoke contains PM, CO, dioxins, and many other toxins –PAHs, VOCs, and transitional metal During cooking with biomass the PM2.5 concentration near about 468g/ml.

Effects on Human Health

In 2012, air pollution in Europe was accountable for cutting short lives by an average of one year, contributing significantly to various pollution-related diseases such as respiratory infections, heart disease, COPD, stroke, and lung cancer (Dockery et al., 1993). Airborne pollutants exacerbate pre-existing respiratory and cardiac conditions, triggering symptoms like wheezing, coughing, asthma attacks, and breathing difficulties. Although the impacts of poor air quality on human health are vast, the respiratory and cardiovascular systems bear the brunt of the damage. Individual reactions to air pollutants depend on the type of pollutant, level of exposure, genetic predisposition, and current health status (Brunekreef and Holgate, 2002). Common air pollutants include ozone, nitrogen dioxide, sulfur dioxide, and particulate matter. Children under five in underdeveloped nations face the highest risk of mortality from indoor and outdoor air pollution (Balmes et al., 1987). An alarming 92 percent of the global population resides in areas with hazardous air pollution levels, contributing to an increased risk of cardiovascular issues and premature death, affecting approximately 7 million people worldwide (Birnbaum, 1994). India records the highest death toll from air pollution (Bellinger, 2005), with asthma being the leading cause of mortality, as reported by the World Health Organization. Estimates from December 2013 by Boffetta et al. (1993) suggest that air pollution claims 500,000 lives annually in China. Moreover, Bravo (1998) establishes a direct correlation between motor vehicle emissions and pneumonia-related mortality due to air pollution.

Fig. 2. Unprocessed biomass used as cooking fuel

Fig. 3. Air pollutants in biomass smoke

Approximately 430,000 premature deaths occur in Europe each year due to air pollution, with nitrogen dioxide and other nitrogen oxides (NOx) emitted primarily by automobiles and chemical plants playing a significant role (Krewsk et al., 2000). The UK government disclosed in a 2015 consultation that nitrogen dioxide contributes to 23,500 premature deaths annually in the UK. Air pollution is estimated to reduce life expectancy by more than nine months in the European Union, leading to deaths from strokes, heart disease, COPD, lung cancer, and lung infections (Katsouyanni, 2003).

Cardiovascular diseases

Cardiovascular diseases, including stroke, are exacerbated by air pollution, particularly in economically disadvantaged regions with high pollution levels. Research indicates that women's exposure to air pollution is linked to ischemic stroke rather than hemorrhagic stroke (Kelly, 2004). Additionally, a 2011 cohort study suggests a correlation between air pollution and increased incidence and mortality from myocardial infarction (Kelly, 2004). These associations are believed to be causative, with potential mediation through atherosclerosis, low-grade inflammation, and vasoconstriction (Rahman and MacNee, 2000). Imbalances in the autonomic nervous system represent another plausible mechanism.

Lung cancer

Lung cancer risk is also heightened by air pollution, as evidenced by studies conducted in London, where subjects exhibited exacerbated respiratory symptoms, reduced lung function, and increased sputum production and purulence, with air pollution being identified as the likely cause. Recent findings suggest that traffic-related air pollution inhibits lung function development in children, even at low concentrations, and increases the risk of lung cancer in nonsmokers. Living in proximity to busy traffic is associated with elevated risks of lung cancer, cardiovascular diseases, and overall non-accidental deaths. Furthermore, exposure to PM2.5 is positively correlated with mortality from coronary heart diseases, and exposure to SO_2 increases mortality from lung cancer, though conclusive evidence is lacking. Recommendations include avoiding strenuous outdoor activities in polluted areas to minimize exposure.

Nervous system

The nervous system is particularly vulnerable to heavy metal (such as lead, mercury, and arsenic) and dioxin exposure, leading to neuropathies and symptoms like memory disturbances, sleep disorders, fatigue, tremors, blurred vision, and impaired speech. Lead exposure, in particular, damages the dopamine and glutamate systems, impacting memory functions. Mercury is implicated in certain cases of neurological cancer. Dioxins hinder nerve conduction velocity and impede children's mental development.

Urinary system

Heavy metals can induce different types of health ailments (Riaz et al., 2023). It can lead to kidney damage, initially manifesting as tubular dysfunction characterized by increased excretion of low molecular weight proteins, which may progress to decreased glomerular filtration rate (GFR). Additionally, they heighten the risk of kidney stone formation, nephrocalcinosis, and renal cancer (Boffetta et al., 1993).

Natural protection

In our daily lives, we encounter various pollutants, each with its own potential health implications. These impacts hinge on factors such as the type of pollutant, its concentration, duration of exposure, presence of other pollutants, and individual susceptibility. Urban dwellers face heightened exposure due to increased industrial activity, energy demands, and vehicular traffic. Occupational settings also pose significant exposure risks. Over the past decade, developed nations have intensified research into the health effects of air pollution, yet more comprehensive environmental monitoring data are needed to establish safe thresholds. Furthermore, concerted efforts are required to mitigate human exposure to pollutants effectively.

The human body possesses drug-metabolizing enzymes (DMEs) or xenobiotic metabolizing enzymes (XMEs) to counter potential environmental threats. These enzymes, including cytochrome P450 (P450 or CYP), epoxide hydrolase, glutathione transferase, and others, play pivotal roles in metabolizing and detoxifying xenobiotics. They facilitate the conversion of foreign compounds into water-soluble metabolites for excretion, although some metabolites remain reactive and necessitate further detoxification. Consequently, the impact of compounds on detoxification enzyme systems varies depending on the metabolic pathways involved.

Certain dietary substances exhibit beneficial properties, supporting the body's natural detoxification mechanisms. These include antioxidants, herbs, minerals, essential amino acids, and fiber, all of which possess chelating properties. These substances aid in detoxification and overall health maintenance.

Conclusion

In summary, this review highlights the adverse health effects of air pollutants, ranging from household incense to large-scale industrial operations like sponge iron factories. Significant organ impairments are evident across various pollutants. The conclusion drawn underscores the importance of dietary interventions, particularly plant-rich diets, in mitigating the effects of pollutant exposure on human health. This conclusion finds support in numerous epidemiological studies demonstrating the beneficial impact of Mediterranean-style diets on overall well-being.

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