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PARTICULATE MATTER - SOURCES - IMPACT ON ENVIRONMENT AND HUMAN HEALTH

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Abstract

Air pollution is one of the major issues causing wide range of health issues and premature deaths. Out of various pollutants, particulate matter act as a major source. These particulate matters are the mixture of liquid and solid particles suspended in the atmosphere causing adverse effects to the environment and human health. Hence effective measures have to be taken to control the particulate matter pollution. PM are less than 10 micrometers enters through the respiratory tract and cause lung inflammation, cancer etc. but the ultrafine particulate matter can enter through the deeper regions of lungs (alveoli) and result in COPD and lung cancer. These particulate matters also influence the global climate and influence the rainfall pattern. Sources of particulate matter and their impact on environment and human health are discussed below.

Key words: Particulate matter-sources-effects

INTRODUCTION

Air pollution is of major concern these days owing to the tremendous development in the industrialization and urbanization. As per WHO (2018), outdoor air pollution results in 4 million and indoor air pollution results in about 3 to 4 million premature deaths annually, Air pollution is the reason for 1 in 9 deaths world-wide from heart disease, stroke, lung cancer, chronic lung disease and respiratory infections. The majority of the deaths were related to $PM_{2.5}$. This particulate matter can be directly released as dust or smoke or through chemical reactions such as sulfur dioxide, ammonia, nitrogen dioxide, etc. (gas to particle conversion).

According to, NASA, air quality observations from space state that $PM_{2.5}$ levels have decreased by about 30% over the eastern U.S., from 1998 to 2012 with the help of emission control measures. In addition to the U.S., few other places have been detected with dramatic changes in the NO_2 and SO_2 levels i.e., increase in levels over India and an decrease in levels over China in the last decade. Knowledge of both particulate matter and various pollutants is needed for the effective mitigation strategies. (6)

$PM_{2.5}$ exposure in India is about 75.7 µg/m3 in north and 29.8 µg/m3 in the south regions, mainly contributed by the residential combustion, industry, and power generation. Because of their smaller size

the particles less than 10 micrometers (PM_{10}) are easily inhaled through the respiratory tract, $PM_{2.5}$ can easily pass through the alveoli of the lungs, especially the ultrafine particles ie., $PM_{0.1}$ can pass through lungs and affect other organs. (6)

PARTICULATE MATTER

Atmospheric particulate matter are the heterogeneous mixture of microscopic particles that consist of either tiny solid particles or fine liquid droplets found suspended in the atmosphere. The particles or droplets have varying chemical constituents based on the sources of emission. Particulate matter can be PM_{10} (particulate matter of 10 mm or less), $PM_{2.5}$ (particulate matter of 2.5 mm or less).

Particulate matter is mainly composed of black carbon, polycyclic aromatic hydrocarbons, aryl hydrocarbons, heavy metals, organic compounds, minerals, inorganic compounds etc.

SOURCES OF $PM_{2.5}$

$PM_{2.5}$ is mainly emitted from the vehicles, fugitive emissions from automobile industries, combustions, construction sites, burning coal, unpaved roads, smokestacks, wild and land fires, tobacco smoking etc. The outdoor PM is the main source of Indoor PM pollution. The sources might be natural or artificial.

Biomass burning, sea salt, aerosol, coal, road dust, volcanic dust, wild and land fires are some of the natural sources. Diesel, petrol, oil burning; heavy metal industries, high temperature combustion, fertilizers, animal husbandry, and volatile organic carbon (VOC) emission are few of the anthropogenic sources which has been constantly emitting elements like K, Na, Al, Se, Co, As, V, Ni, Mn, Fe, Si, elemental carbon, organic carbon, formaldehydes, methylene chloride, tetrachloroethylene, toluene, and xylene.

Secondary pollutants are formed in the atmosphere by the chemical reactions of gaseous precursors such as sulfur dioxide, nitrogen oxides, and ammonia during transport process. Ozone and Secondary Organic Carbon (SOC) are some of the examples of secondary pollutants. Ozone is produced by the combination of CO with NO_2 and SOC (Secondary organic carbon) are produced by the photochemical reactions of POC (Primary organic carbon).

Diesel particulate matter:

Diesel engines emit a mixture of pollutants of both liquid and solid particles. Those solid particles from the diesel exhaust are called diesel particulate matter. Most of the DPM is less than 1 micrometers (subset of $PM_{2.5}$. DPM contributes about 8% of the outdoor air pollutants. In 1998, California air resources board identified the relation between DPM exposure and lung cancer and health effects. DPM constitutes carbon particles, organic compounds and 40 cancer causing agents, and volatile organic compounds, oxides of nitrogen. These particulate matters due to chemical reactions in the atmosphere forms $PM_{2.5}$ and ozone. DPM is mainly composed of Black Carbon (BC) which is the second largest contributor of global warming according to IPCC.

Agriculture as a source of PM:

Particulate matter is generated during the agricultural practices and operations. They include fine sold particles, pollen, spores, salt spray soil particles, organic and inorganic particles, chemicals in pesticides and fertilizers, farm equipment exhaust, flour, wood dust, cotton, exhaust from stubble burning, livestock particles like hair, feather and their excrement, etc. Agricultural field operations livestock management and agricultural industries are some of the main sources of indoor or

outdoor air pollution creating exposure to different kinds of dusts and pollutants. (Arslan and Aybek, 2012).

ENVIRONMENTAL EFFECTS

Climate effects:

Atmospheric aerosols affect the climate of earth by scattering the incoming radiation producing a cooling effect. Some aerosols absorb the outgoing longwave radiation and produce a warming effect. BC (black carbon), important on the later, OC (organic carbon), mineral dust are some aerosol particles that absorb the radiation. Aerosols are important for the cloud formation, suspension of these particulate matter in clouds increases the Cloud Condensation Nuclei (CCN) and ice nuclei (IN). Increase in CCN content results in the formation of more but small cloud droplets, these small droplets take time to coalesce and fall as precipitation producing cloud lifetime effect. (Myhre et al., 2013).

Ecological effects:

The deposition of particles on vegetation may cause radioactive heating and damage the photosynthetic tissues on the leaf surface. Acidic and alkaline materials may cause leaf injury like scorching of leaves. The toxic chemicals and heavy metals may cause phytotoxicity to the plants. The PM deposited in the soil alter the biogeochemical cycles. the presence of acidic and alkaline particles alters the pH and mineral composition of the soil. It also makes the lakes and streams acidic and changes the nutrient balance in coastal waters and large river basins. (Grantz et al., 2003)

HEALTH EFFECTS

Cardiovascular system:

Short term exposure to PM causes changes in the fibrinogen and TNF-a which results in coronary artery disease, ischemic heart disease, heart failure resulting in cardiac mortality. Long term exposure results in development of atherosclerosis through systemic inflammation, myocardial infraction. (Thangavel, et al., 2022). Exposure to $PM_{2.5}$ and traffic results in arterial stiffness. The translocated $PM_{2.5}$ causes systemic inflammation and sympathetic activation resulting in vasoconstriction, endothelial dysfunction and increased blood pressure.

Respiratory system:

The inhalable PM includes PM_{10} and $PM_{2.5}$. The PM_{10} can be inhaled and deposited at the nostrils, mucous membranes, surfaces of larger airways in the lungs and cause tissue damage and lung inflammation. $PM_{2.5}$ can enter through the deeper regions of the lungs (alveoli) and cause respiratory diseases like lung cancer (incidence of malignant tumors), COPD, bronchial asthma, pulmonary dysfunction, Idiopathic pulmonary fibrosis, and pneumonia (7). Incidence of pneumonia in children is increased by 1.5% for every 10mg/m3 increase in particulate matter concentration. (Thangavel et al., (2022)

Nervous system:

Air pollution can affect the central nervous system, the ultra-fine particles ($PM_{0.1}$) will enter the circulatory system and spread to brain and other organs. It may enter into the circulatory system directly or indirectly through the nasal and olfactory mucosa. Effects of heavy metals and dioxins have been constantly related to the neurological diseases in humans. Neurological damages such as lower IQ, attention impairment, encephalopathy, and memory loss has been associated with the chronic exposure to the fine particulate matter.

Carcinogenicity:

Presence of metals such as cadmium, mercury in PM have interferes the normal functioning of the cells and tissues. Metals

are more reactive in ion form and readily interact with the biological systems. For instance, cadmium ions can attach to the sulphur present in the proteins and can replace the zinc atoms. They also induce oxidative stress by the production of reactive oxygen species (ROS) which might induce the cancer cells.

CONTROL MEASURES:

- Stop smoking indoor.
- Implementing strict air quality and emission standards for industries and vehicles.
- encouraging the use of electrical car and bikes to reduce the emissions due to fuel burning.
- promoting effective pollution control measures in construction sites and mining areas.
- monitoring air quality in areas with high traffic and taking prompt action to address high pollution levels.
- Use of high-tech filtration systems to protect from air borne dust particles.

CONCLUSION

Atmospheric particulate matter is not a single pollutant, but a heterogeneous mixture of many chemical components. Being emitted from various sources it affects the environment and human health depending on the chemical composition of the particles present in the mixture. Estimated premature mortality due to $PM_{2.5}$ was 253 per 1,000,000 population and 587 per 1,000,000 for PM10 annually. Although various control measures and air quality standards have been set up special care has to be taken to reduce the emission of particulate matter and related health issues.

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