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Mini Review

Air Pollution - The Challenges Ahead

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Abstract

Air pollution is global environmental problem that influences mostly health of urban population. Over the past few decades, epidemiological studies have demonstrated adverse health effects due to higher ambient levels of air pollution. Studies have indicated that repeated exposures to ambient air pollutants over a prolonged period of time increases the risk of being susceptible to air borne diseases such as cardiovascular disease, respiratory disease, and lung cancer (WHO, 2009). Air pollution has been consistently linked to substantial burdens of ill-health in developed and developing countries. The growth of population, industry and number of vehicles and improper implementation of stringent emission standards had made the problem still worse. This mini review is an attempt to visualize what we are going to face due to air pollution in future.

Keywords: Air pollution; Pollutants; Global; Health effects; Air borne diseases

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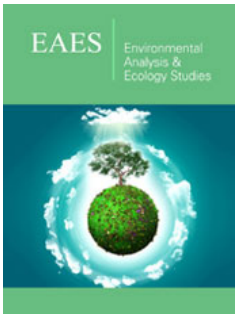

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Introduction

WHO/UNEP report 1992 reveals air pollution problems in metropolitan cities of India as they are heading the list of the most polluted cities of the world. There are 23 major cities of India over 1 million people where ambient air pollution levels exceed the WHO standards. Ambient air quality levels exceed the WHO levels in 36 major Indian cities and towns, resulting in 40 thousand premature deaths, around 19 million respiratory hospital admissions and sickness requiring medical treatment and 1.2 billion incidences of minor sickness annually. According to the 2014 WHO report, air pollution in 2012 caused the deaths of around 7 million people worldwide. In India, every year 11-12 lakh people die due to air pollution and 11% of diseases have the cause of pollution (Rajasthan Patrika 16.2.17 & 14.11.17).

The recent WHO Survey report done in 4300 cities of 108 countries of world, have listed Jodhpur at 14th position in list of most polluted cities (Newspaper Rajasthan Patrika 24.5.18). WHO reports that if pollution is reduced, human life expectancy can increase up to 4 years Despite the increasing evidence of negative impact of air quality on human health, not much data on ambient air quality, a prerequisite for health studies, is available for most of the medium size cities or towns in India, although a large population lives in these cities or towns. The reports quoted above paint a very grim picture we are facing today and may face more severe in future. A trailer of such situation we had already seen in Delhi, when the smog in winters of 2017 choked people of Delhi forcing them to remain indoors and suspending outdoor activities as much as possible.

WHO's fact sheet (01.10.2018) published by regional office South-East Asia mentions air pollution as modification in natural characteristics of air, due to contamination by a large range of solids and gases; of which key health harmful pollutants are particulate matter, black carbon, and gases like- CO, SO_2, NO_x, O_3. The health impacts due to particulate matter, depends on level of exposure (either short or long term); where short term exposure can cause irritation, wheezing and increased frequency of acute lower respiratory infections while long term exposure can cause increased risk of respiratory infections and premature death (due to utilization of non- conventional fuel, it's a particular concern in rural and peri urban settings). A section of society is vulnerable due to following situations: high concentrations of PM, use of non- conventional fuel, changing weather pattern etc which combine to create peaks of air pollution. Proximity to sources- from vehicles, mines, industries to burning biomass fuel and crackers; these activities generate high level of pollution, both gaseous and PM. In addition to above, factors like age, health status, pregnancy, socio-economic status, occupational

exposure and smoking of tobacco products also affect a person's vulnerability.

In addition to above, factors like age, health status, pregnancy, socio-economic status, occupational exposure and smoking of tobacco products also affect a person's vulnerability. Air pollutants, on basis of origin, can be classified into primary and secondary. Primary air pollutants are emitted directly into the air from the sources. They also serve as precursors of secondary air pollutants, along with certain meteorological factors. For example, gaseous pollutants like SO_2, NO_x, CO, VOC's etc. Sulfur dioxide (SO_2) a primary air pollutant, is a gas formed when sulfur is exposed to oxygen at high temperatures; in terms of ambient air pollution, sources of sulfur can be utilization of non- conventional fuel sources, burning of agricultural residues, industrial effluxes etc. SO_2 can be toxic at high concentrations in the air. SO_2 also results in formation of acid rain by reacting with water droplets in clouds to form sulfuric acid (H_2SO_4) and precipitate down; while reacting with moisture content of atmosphere can lead to formation of aerosols (sulfate aerosol particles).

Nitrogen oxides (NO and NO_2, referred together as NO_x) are highly reactive gases formed when oxygen and nitrogen react at high temperatures. Sources of nitrogen can be combustion of fossil fuels, biomass burning etc. Upon reaction of NO_x with VOCs and carbon monoxide in atmosphere, ground-level ozone is produced, by means of a chain reaction mechanism. NO_x just like SO_2, eventually oxidize to nitric acid (HNO_3) in atmosphere, thus forming acid rain and nitrogenous aerosol particles. Carbon Monoxide (CO) is an odorless, colorless gas formed by incomplete combustion of carbon in fuels, with sources as motor vehicle exhaust, industrial processes, biomass burning and causes formation of ground level ozone. It irreversibly binds to hemoglobin, causing reduction in the ability of RBC's to transport and release oxygen throughout the body. Hence, its low exposures can worsen cardiac ailments, while high exposures can result into CNS impairment or death.

Secondary air pollutants are formed when primary pollutants react in the atmosphere by either of reactions: Bimolecular (like forming of haze-aerosol absorb atmospheric humidity), three-body (formation of O_3 by: NO+ O_3 NO_2+ O_2), Photolysis, Thermal decomposition etc. Aerosols are also known as particulate matter (PM), which is contained by atmosphere in form of solid and liquid particles, which remain suspended in the air. US EPA, 1996 Ciencewicki & Jaspers [1] defined particulate matter as a mixture of particles and droplets in the air, consisting of a variety of components such as organic compounds, metals, acids, soil, and dust. They are removed from lower troposphere, when rain or snow carries them out of the atmosphere (washout effect) or when larger particles settle them down due to gravity (SPM). Large aerosol particles (usually 1 to 10μm in diameter or RSPM) are generated when winds blow sea salt, dust, and other debris into the atmosphere. PM of size> 0μm deposit in nasopharyngeal region (i.e. upper airway passage-nose, nasal cavity and throat); 4-10μm reach to trachea- bronchial region while 1-4μm reach to alveoli of lungs.

Fine aerosol particles with diameters <1μm are mainly produced when precursor gases condense in the atmosphere (they possess serious threats to health, because they are small enough to be absorbed deeply into the lungs, even into the bloodstream).

Discussion

Various researchers have studied the ambient air quality in different areas with diverse background. Said Munir et al characterized particulates (PM2.5, PM10) and meteorology in the arid climate of Makkah, Saudi Arabia [2]. They collected data hourly, for duration of 21 months at 15 stations. Most of the atmospheric PM in Makkah, came from re-suspended and windblown dust particles, generated from construction-demolition activities and surrounding sandy deserts. Verma et al assessed urban air quality for fine and respirable fraction of particulate matter in Lucknow city for a study period of 12 months, spanning across all 3 seasons (winter, summer and monsoon) [3]. Sampling for both the fractions was done for 24 hours per month at 4 monitoring sites, sorted as residential (A), residential /commercial (B), industrial (C) and ecologically sensitive area (D)- which served as a control. Trend suggests that the particulate levels were maximum in winters followed by summer and monsoon. Miyajan & Hemangi assessed AQI using parameters: RSPM, SPM (PM10), NO_x, SO_2, and CO at 12 sampling stations in the city of Surat, Gujarat during early morning hours for a duration of 4 months [4]. Results showed that the RSPM levels were high during the early morning hours. SPM & NOx were also beyond the prescribed limit in various areas. Srinivas et al evaluated status of ambient air quality index, in industrial area of Visakhapatnam, Andhra Pradesh, India for a study period of 12 months [5]. The sampling was done for 24 hours, every month for parameters $PM_{2.5}$, PM_{10}, SO_2 and NO_X whilst recording meteorological parameters like temperature, relative humidity, wind speed, wind direction and rain fall at 6 sampling sites in Visakhapatnam.

The PM_{10} concentration in ambient air was observed more than the specified standard values at sites 1 to 6; while annual NO_X and SO_2 concentrations at all monitoring stations were within maximum allowed limit as prescribed by NAAQS for different areas. Habeebullah analyzed air, for pollutants like: nitrogen oxides (NO_x)- NO_2 and NO, CO, SO_2, O_3 and PM10, to identify the major sources of air pollutants in Makkah, Saudi Arabia, near the Holy Mosque (Al-Haram) [6]. Temporal variations for level of NO_x follow daily traffic flow, thus higher during morning hours, lower during night and lowest during afternoon (combined effect of low traffic activities and atmospheric conditions). NO_x shows higher levels during January and February and gradually decrease from March onwards, reaching the lowest level in August (probably due to the variations in meteorological variables).

NO and NO_2 follow pattern alike NO_x, though NO_2 being a secondary pollutant lags an hour behind (as it is formed in atmosphere by reaction: $NO+O_3NO_2+O_2$). O_3 being a secondary pollutant (formed by photochemical reaction between VOC's and NO_x in presence of solar radiation) hence, O_3 concentrations are low during night, early morning and evening hours and higher in afternoon. O_3 levels during different seasons are more affected by meteorological variables and show weak association with NO_x. SO_2 and CO levels are generally higher during morning hours, lower during night and lowest during afternoon. PM_{10} levels show two

peaks in morning and evening; while highest concentrations are observed on Friday and Saturday. Prathipa & Sahaya analyzed air quality and AQI of Dindigul Town in Tamil Nadu, India with respect to following criteria: SO_2, NO_2, SPM, RSPM at three different locations, representing industrial, commercial cum traffic and residential site [7]. Results display a trend for maximum pollutant concentration during months of winter and minimizing in summer season.

This can be accredited to the fact that winters are calm than other months, facilitating stability to atmosphere and leading to slow dispersion of pollutants, causing its higher concentrations. Kaushik et al assessed air pollution due to anthropogenic activities in ambient air of urban centers in 8 districts of Haryana and health risks associated with it [8]. Sampling sites were categorized as-residential, sensitive, commercial and industrial in each district. TSPM concentrations were found more than the specific standards at almost all the sites. Amarendra & Chakraborti in their analysis of air quality at Jirania Brick Industries Cluster, Tripura; found seasonal variations of concentration of particulate matter and other gaseous pollutants [9]. The annual average concentration of PM_{10} of all the monitoring stations was higher than the permissible limit of 60μg/m^3. Cohen et al. in their study on estimating and finding 25-year trends of global burden of disease due to ambient air pollution, explored spatial and temporal trends in mortality and burden of disease; for a study period of 1990 to 2015 at global, regional, and country levels [10].

They evaluated following parameters: global population-weight age for mean concentrations of $PM_{2.5}$ and ozone were estimated using satellite-based estimates, chemical transport models, and ground-level measurements. Relative risk of mortality was estimated from ischemic heart disease, cerebrovascular disease, chronic obstructive pulmonary disease, lung cancer, and lower respiratory infections; using integrated exposure-response functions. These results supposed that toxicity due to ambient $PM_{2.5}$ depends only on the magnitude of concentration, not on the source. Short-term and long-term exposure, especially in the warmer seasons towards ozone exposure, resulted from mortality to adverse effects on the respiratory system, including chronic changes in lung structure and function in human beings and non-human primates and increased morbidity and mortality from COPD. Rai [11] Studied air quality, using AQI in 2 residential area of Jodhpur, Rajasthan for parameters PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO. AQI for Jalori gate area ranged from 194-273 hence exhibiting poor ambient air quality; while range of AQI at Kudi Housing Board Sector-3 area, was found between 118 to 129, illustrating moderate air quality.

The reason could be vehicular pollution and light sand storm, as Jodhpur zone is located in an arid zone. Majewski & Przewoźniczuk [12] studied Particulate Matter Pollution in Warsaw Area, Poland for a duration of 2 years (2004-2006) at 11 stations located in area. Results show that the permitted norm for the average annual PM_{10} concentration was exceeded at the stations located downtown, near traffic avenues and in densely populated quarters of Warsaw; while farther from the centre of Warsaw, the average yearly concentration values were found to be low. Sharma & Maloo [13] found Kanpur as most polluted city of India, much inferior to other cities in India and abroad. They pointed so on basis of a study with PM_{10}, $PM_{2.5}$, BSOF (Benzene-Soluble Organic Fraction) and heavy metals (Pb, Zn, Fe, Ni, Cd and Cr) as parameters, in three sampling locations: commercial site, residential site and a control site; for a duration of 5 months.

In a study conducted by Choudhary & Gupta [14] in the city of Kota, Rajasthan for assessing air pollution due to vehicles, parameters in terms of SPM, SO_2 and NO_X were monitored from month of August to November 2015. Major source of air pollution in Kota was exposed by the concentration of NO_X which is much higher than SO_2 levels and main source of NO_x emission is fuel combustion in vehicles. Environmental Monitoring Division of CSIR- IITR, Lucknow (2015) conducted a two month study, during pre-monsoon season for the parameters PM_{10}, $PM_{2.5}$, SO_2, NO_X, trace metals (Pb, Ni) at 9 representative locations of city Lucknow, categorized as residential (four), commercial (four) and industrial (one) areas. Results show that in residential areas, the 24 hours average concentrations of PM_{10} and $PM_{2.5}$ had an average of 182.5μg/m^3 and 90.0μg/m^3 respectively; for commercial areas, it was 212.4μg/m^3 and 104.8μg/m^3 respectively and in industrial area, 199.4μg/m^3 and 96.9μg/m^3 respectively. All the values of PM_{10} and $PM_{2.5}$ were above the prescribed NAAQS of 100μg/m^3 and 60μg/m^3 respectively, for industrial, residential, rural and other areas respectively (16).

Zhang YL & Cao F [15] obtained statistical summary of $PM_{2.5}$ concentrations, by monitoring 190 cities in China for a study period of 1 year. Diurnal pattern of $PM_{2.5}$ concentration show lowest levels in the afternoon hours, apparently due to the deeper boundary layer, while high levels are recorded at the evening hours of cold seasons due to above reasons. PM2.5 to CO ratio displays anotable peak during the afternoon periods, providing data that point towards contribution of secondary particle formation due to the relatively stronger solar irradiation and higher temperature.

Conclusion

The review of work done by various workers point towards a very dangerous situation we may face in coming years. It's high time to think and go back to nature because as Mahatma Gandhi once said, "The world has enough for everyone's need, but not enough for everyone's greed", which holds true even for air, because we care the least about it. The cities are in the race of becoming a smart city but in this race, we are jeopardizing our future. There is an immediate need to take measures, like planting big trees which are absorbents of most of pollutants, framing strict laws and policies and their proper implementation, otherwise we may land in the situation Delhi faced in November 2017.

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