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Effect of Atmospheric Aerosol Particles and Pollutants on Regional Air Quality: A Review in Reference to Chhattisgarh State of India

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ABSTRACT

Poor air quality in India is considered as one of the critical issues resulting largely by industrial emissions, burning of agricultural wastes, automobile emissions etc. Also, particularly in north India, a practice of crop residue burning is followed particularly in autumn and winter months as a low cost alternative to mechanical tilling. This results in large amount of smoke, smog and particulate matter thereby impacting the air quality of nearby regions. So far as the emission of greenhouse gases is concerned, India ranks low however is the third largest emitter of particulate matter only behind China and United States. This article reviews the air quality of Chhattisgarh in India, an important industrial state, effect of poor air quality and presence of aerosols.

Keywords: Air pollution, World health organization, Aerosol, Particulate matter

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INTRODUCTION

Air quality poses an important challenge to humanity and not only affects the climate but also have considerable impact on human health. Due to poor air quality, morbidity and mortality rate has considerably increased particularly due to increased rate of respiratory diseases. Many pollutants present in air are characterized by their harmful effects. For instance, particulate matter (PM) of various sizes enter the human system through respiration and results in various diseases such as respiratory, cardiovascular, nervous system dysfunction and cancer to name a few. Not only this, the effect on ozone layer due to chloro fluoro carbon (CFC's) emission also results in earth getting exposed to harmful ultraviolet radiations. In addition to this, nitrogen oxide, sulfur dioxide, volatile organic compounds (VOCs), dioxins, and polycyclic aromatic hydrocarbons (PAHs) are all considered to be harmful air pollutants to humans. Exposure to higher level of carbon monoxide can result in severe toxicity. Depending on the amount of exposure, heavy metals such as lead, results in poisoning or chronic intoxication to human beings.

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To name a few, Chronic Obstructive Pulmonary Disease (COPD), asthma, bronchiolitis, and lung cancer, cardiac events, nervous system dysfunction, and short-term illnesses are result of exposure to poor air quality [1]. Therefore it can be concluded that air quality is vital to human existence and poor air quality results in several diseases. Now a days several campaign are run both at Government level and by non-governmental organizations (NGO) to make people aware of various methods to control

air quality. At the same time, it is important to provide sustainable low cost alternative to methods such as crop residue burning so as to prevent the detoriation of air quality.

One of the major initiatives taken by the Indian Government is a launch of a major Clean India (Swachh Bharat) mission aiming to clean roads, slums in the cities, villages and adjoining areas and major rivers of the country such as Ganges which are polluted by industrial and other wastes. Also, simultaneous focus is to provide access to important sanitary facilities to rural India particularly women and address their energy (such as fuel) and health needs in particular sanitary needs [2]. Currently, citizen are more aware about air quality particularly in northern belt of India and serious effort is being taken by all institutions such as legislative, judiciary, citizen organizations etc. Inspired by the current initiatives, researchers have also analyzed and proposed solutions to control air pollution [3]. Firstly, a compilation of the possible sources of air pollution is done, its long term impact on human health, climate and food production is analyzed. Finally, effective solutions were proposed to control the air quality by reducing the effect of these reasons. These solutions if implemented will significantly improve the air quality of the region. Particularly, the air quality of northern regions such as Delhi and Uttar Pradesh if can be controlled during the winter months, it can significantly result in the overall significant improvement in the average air quality, considering the entire year. [4].

AIR POLLUTION IN CHHATTISGARH

India is currently growing at a significant rate and is placed in the list of world's fastest growing economies. India is a mineral rich state and one of the most important contributors to India's economy is the mining and metal extraction industry. To mention it in figures, overall contribution of mining industry in India's gross domestic product (GDP) is somewhere between 2.2% to 2.5%. However, considering the GDP of industrial sector only, mining industry contributes around 10 to 11% of overall figure. Since coal mining is one of the significant mining industry India, this study focuses on the impact on air quality in coal fueled industrial region of India which is also a major producer of coal. Chhattisgarh is one of the mineral rich states in India and is a major producer and user of coal in the country. Coal is mainly used to run the coal fired steel and power generations plants of the region [5].

So far as population is concerned, Chhattisgarh ranks almost at sixteenth level in the nation. One of major reason behind high population density of the region is it being one of the most mineral rich states with abundance of twenty eight major mineral resources. The state has got around sixteen percent of total mineral deposits present in India. Due to the abundance of coal in the region, it serves as an important industrial fuel and is used for running many industries particularly large number of steel and power plants spread throughout the state of Chhattisgarh. South Eastern Coalfields Limited (SECL), headquartered in Bilaspur, Chhattisgarh is recognized as the largest coal producing company in the country. It is one of the eight subsidiary of Coal India Limited (A Govt. of India Undertaking) under the ministry of Coal. SECL is fully operational in Chhattisgarh for coal production as SECL coal funding comes from five provinces namely Bilaspur, Korba, Raigarh, Surguja and Korea in Chhattisgarh and three counties Shahdol, Umaria, Anuppur in Madhya Pradesh region. This study therefore focuses to air quality in the region of SECL. The capital city of Chhattisgarh, Raipur has made significant rise in the list of most polluted cities in the world leaving Delhi behind at eleventh spot. However, air quality here is slightly better to other more critical Indian cities such as Gwalior, Patna and Prayagraj as reported by World Health Organization (WHO) [6-9]. WHO has placed Raipur in the list of most polluted cities in the world for consecutive years [6]. In 2014, WHO data reported Raipur as the third worst city in India in terms of air quality as the city found its way into the list of the twenty most polluted cities in the world. As reported, in Raipur organic (brown) and elemental (black) 30% of the combined carbon in the atmosphere is twice as much as in other cities and bringing it to a dangerous level of health hazards such as chronic asthma, respiratory and skin diseases [7]. Over a past few years, Chhattisgarh has been reporting almost a hundred percent increase in respiratory infections as a result of the high concentration of bacteria and allergens in the air besides high temperature and considerably less rainfall [8]. Korba is known as the power capital of Chhattisgarh and is a hub to major power producing plants such as National Thermal Power Corporation (NTPC). Air quality index in Korba has been severely hit in recent years. Currently, Korba hosts around

ten coal fired thermal power stations with a total produce of around 6000 mega-watts (MW) [9].

Recently, Chhattisgarh Health Center, in association with the local communities, collected air quality samples in around nine sites in Korba, Champa and Raipur in January and February 2020 [10]. The intention was to identify the level of air pollution and the potential health hazards it poses to residents [11]. The sampling locations were - MP Nagar, Chimney Bhatta, Darri, District Hospital and Rani Dhanraj Kumar PHC in Korba; Maruti Township in Champa and Priyadarshini Nagar in Raipur. Public participation in sample site selection was done and sites were selected based on citizens' recommendations, their willingness to host the sample collection tool and based on the strategic value of sites. Sampling tools were placed at various places such as the roofs of health facilities, and in the homes of managers. Quality control and all modeling procedures were strictly followed while collecting the sample.

Samples were taken for a time period of twenty four hours at each of these places using Teflon filters. As a result particulate matter (PM) of less than 2.5 micrometer in size and presence of heavy metals were analyzed [12]. It was observed out of this study that the air quality in Korba region is seriously detoriated and can have serious impact on human health.

Disease From Air Pollution

Air pollution is one of the most severe kinds of pollutions in human existence and have both short and long term impact on human health. This is made worse by the fact that every age group is severely affected by air pollution due to natural breathing. One can choose the water he or she drinks, but can't do much about the air.

Effects of Air Pollution on Human Health

Air pollution have severe effect on human health resulting in large variety of health ailments starting from the simple irritation in eyes, nose, mouth and throat to more severe syndromes like headache, dizziness etc. Most common health hazards due to inhalation of poor quality air are respiratory and lung diseases namely [13]:

- Chronic Obstructive Pulmonary Disease (COPD)
- Reduced lung function
- Asthma attacks
- Pulmonary cancer – happens due to inhalation of carcinogen
- Mesothelioma – due to exposure to asbestos
- Pneumonia
- Leukemia – due to exposure to benzene vapours
- Birth defects and immune system defects
- Cardiovascular problems, heart disease and stroke (mainly due to exposure to particulate matter)
- Neurobehavioral disorders – due to exposure to air toxins
- Liver and other types of cancer – due to carcinogenic volatile chemicals

Due to this several cases of premature death are recorded.

Aerosol Particles

Aerosols are small particles (solid or liquid) present in the air. Some aerosols are so small that they are made up of only a few molecules and are invisible, others are visible but very small. The smaller and brighter the particles, the longer they stay in the air. Larger aerosol particles gradually settle to ground due to gravity effect however, smaller particles can stay in air sufficiently larger periods [14]. Aerosols are found in nature normally sea salt, wild fires, dust. At the same time, human activity also contribute significantly to the overall volume of aerosol mainly it is released to atmosphere in burning of fuel, pollution by automobiles etc. [15]. At the same time aerosols are also produced in atmosphere, for instance, sulphur aerosols are produced itself in atmosphere from the sulphur dioxide released from the power plants.

Source and Composition of Aerosols

Aerosols in atmosphere are formed in solids or liquids or in mixed state and occur in wide range of chemical composition and sizes. The diversity in size and composition is mainly due to the different sources of release of aerosols. It is generally categorized into two categories namely advanced aerosols (that emitted directly into the air) and secondary aerosols (produced from the atmosphere from pre-infiltration gases) [16].

Aerosols Effect on the Weather

Normally, all types of aerosols present in atmosphere transmits the sunlight however, a few type of aerosols can also receive the sunlight. Black carbon

(BC) is very important in the latter, but mineral dust and other organic carbon (OC) substances are also absorbers. Aerosols mainly disperse the sun's rays with a cooling effect, increasing the total number of rays from the Earth. The high absorption of aerosols has a warming effect [17]. In space, there is a mixture of the dispersion and absorption of aerosols, and their overall effect on the earth's energy budget depends on the elements of the earth and clouds. Distributing aerosols over dark areas and absorbing aerosols over light areas works best (see Figure 1). Distributing (absorbing) aerosol over a light (dark) area is less effective because the sun's rays are visible (absorbed) anyway. Adhesive aerosols work best when placed above the clouds, which contributes significantly to the full light of the sun's rays returning to space.

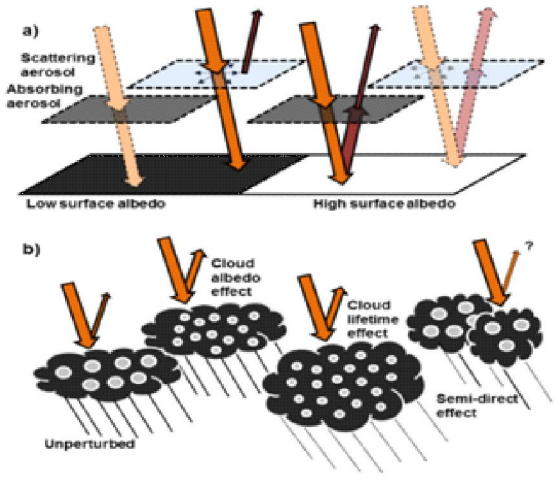

Figure 1: Figure shows the (a) effect of presence of aerosols (on absorption and scattering of radiations and (b) cloud albedo effect [16].

Table 1 represents the various solutions suggested to reduce the air pollution due to different applications.

Table-1: Technologies to reduce air pollution from different applications namely industrial, residential and transport.

S. No.	*Sector*	*Sub-sector*	*Technology*
1.	Transport	Vehicles	Diesel particulate filters; catalytic reduction; exhaust gas recirculation can be employed.
		Fuel	Hydro-desulfurization at refineries is suggested.
2.	Industries and power plants	Tail-pipe Control	Electrostatic precipitators; bag filters, flue gas desulphurization; wet scrubbers etc. to name a few can be used.
		Process improvement	Low NOx burners; efficient super critical combustion technologies etc. can be used to improve the process.
3.	Residential	Stove	Tier-4 cook stoves with higher thermal efficiencies (50% or more) and emissions conforming to WHO guidelines can be employed
4.	Open burning of agricultural residues	Agricultural Residues	Biomass gasifiers can be employed.
5.	Waste management	Waste	Methane recovery at landfills and sewage treatment plants.

The solutions suggested here are based on the studies done in the last decade [18-21].

CONCLUSION

This article concludes with identification of air pollutants that are hazardous to human health and in particular the particulate matter and aerosols found largely in coal fueled regions. The different types of particulate matter and aerosols are explained and their impact on human health is specified. Also the measures to reduce pollution in various applications are finally mentioned.

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