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A Review on Air Quality Parameters for Ambient Pollution Management Framework

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Abstract
Pollution is the addition of perilous substances in to the environment that creates harmful atmosphere to human and other living creatures. Pollutants are components of solids, liquids or gases specifically emitted beyond the normal threshold level of concentrations that affects the atmosphere's quality to a considerable extent. PM is one of the common air pollutants which is a combination of suspended solid and liquid particles in the air. $PM_{2.5}$ pollution is becoming a severe problem due to automation of industries and more energy consumption. Because of this, the people will be affected by breathing issues leading to in heating, ventilation, and air conditioning (HVAC) due to the requirement of air cleansing. This paper assesses and evaluates the foundations of indoor and outdoor $PM_{2.5}$ and the effect of $PM_{2.5}$ pollution on surrounding prominence, occupational health and residents conduct.$PM_{2.5}$ mainly creates heart disease, stroke, chronic obstructive pulmonary disease, lung cancer and other main health hazards. Inhaling SO_2 induces irritation to the nose, eyes, throat and lungs. When someone inhales NO_2, the gas rapidly dissolves into the blood stream and hits the brain within seconds. Low amounts of O_3 can cause chest pain, coughing and shortness of breath and throat infection. Further studies will forward us to a broad movement for the impact of $PM_{2.5}$ towards health issues.

Key-words: Air Pollution, Indoor, Outdoor, $PM_{2.5}$, PM_{10}, Sulfur Dioxide, Nitrogen Oxides.

1. Introduction

With reference to the air quality index report given by World Health Organization (WHO), air pollution is causing a huge damage to several developing nations and ambient air pollution (AAP) outburst with 4 million dying globally in 2012 and nearly 87 per cent about 0.68 million of these deaths occurs under the category of countries having low-and average economics [1]. Western Pacific and South East Asian countries account with 1.1 million and 0.79 million of death cases registered

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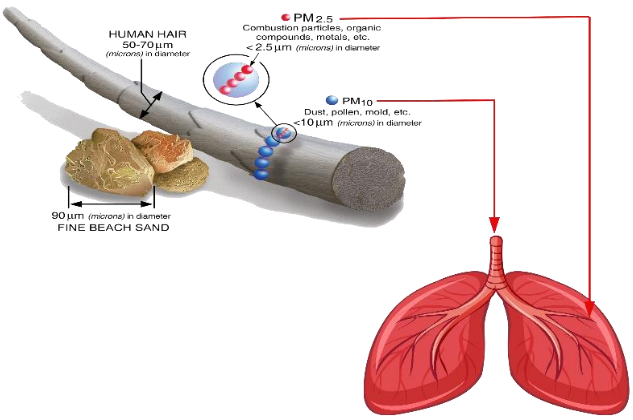
under air pollution. Two large countries that contribute a huge proportion to statistical data as well as death rates are China and India [2,1]. In Europe, US, the Western Pacific and the Eastern Mediterranean account for nearly 0.38 million [1]. Since India is inclined towards faster urbanisation, the condition of air pollution will get worsened. Smudgy environment creates an adverse impact in human eyesight. Figure 1 shows a comparison of $PM_{2.5}$ and PM_{10} sizes against with beach sand and human hair (with diameter of µm). A specialised cognitive area dealing with the framing, perceiving and assessing the various events happening to the human brain and body with respect to their residential environment is referred as Subjective Well-Being (SWB)[3]. The SWB evaluation is in preference to individual's favourable criteria than the external needs. A conventional technique to examine the air pollution effects is the survey instrument based on SWB and it is been broadly utilized by both sociologists and economists. SWB is presumably included by policy makers to plan and assess the impacts of policies. The Asian nation of Bhutan serves as a perfect instance to explain the above mentioned factor of SWB. National happiness index is being adopted by several nations. [2,3,4]. Due to this, several psychophysical methods are integrated in resolving the various problems associated with environment that includes landscape enchantments and necessary visual air quality needs. But the psychophysical procedure is not introduced in evaluating the impact of pollution on SWB.

Fig. 1 - Size comparison of $PM_{2.5}$ and PM_{10}



A. Atmospheric climate condition

In India, for a prolonged period of time, contaminants including PM_{10} and $PM_{2.5}$ serve as the most prevalent pollutants in creating hazy weather patterns. $PM_{2.5}$ was the chief polluting particle of particulate matter and contributes for 66.8% of the highly contaminated days[5]. It turns to be more toxic and dangerous component entering in to the human body due to its comparative smaller size, wider surface area and easy portability[6,7]. $PM_{2.5}$ has a major role in deciding the atmospheric climate condition as it is suspended in the environment for a prolong period and moves a hug distance. Also it induces higher impact on human[8].

B. Chemical components of PM

In US, fixed monitoring stations under the control of government agencies are used to calculate the chemical components of PM. There are two monitoring networks namely the U.S. EPA Chemical Speciation Network (CSN) and the US-sponsored Interagency Monitoring of Safe Visual Environment (IMPROVE) to measure chemical components of PM [9,10,11]. Nearly 250 PM part monitoring stations, with an average of 3 monitors for every urban area , compared to 2,000 $PM_{2.5}$ monitors across the country. A Chemical Species Network to measure and assess twenty-six PM chemical components is implemented by the Environmental Protection Department in Hong Kong. Six general monitoring stations and one roadside monitoring station are distributed throughout the region. Samples were collected every six days. Estimating the spatial and temporal variability is quite difficult with small number of monitors. PM components generally include nitrate (NO_3-), sulphate (SO_4^{2}-), aluminium (Al), calcium (Ca), copper (Cu), iron (Fe), manganese (Mn), lead (Pb), selenium (Se) and zinc(Zn)[12].

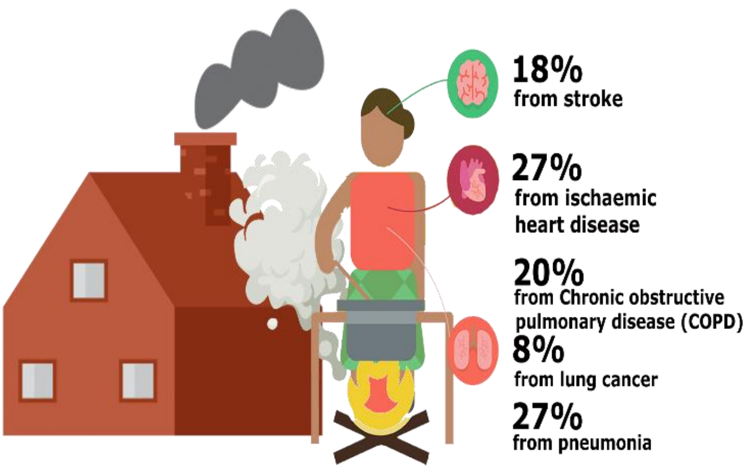
C. Predicting the mortality related to air pollution

The air pollutants have a direct impact in respiratory and cardiovascular systems leading to increased airway reactivity, pulmonary inflammation [13,14]. It is also inter related with increased danger of death and morbidity [15,16]. All of these results intimate that air pollution is a threat to public health, specifically in mega cities [17].Climatic conditions have an impact on concentrations of air pollutants by changing their emissions, aerosol photochemistry, transport and disposal. The temperature is directly proportional to O_3 concentrations due to the speeding up of photochemical reactions and higher biogenic volatile organic compound (VOC) emissions. As a result, given that climate change could get modified in the future, then there may be a growing interest in studying the way of air pollutants reaction with climate changes. Increased concentrations of air contaminants were expected by most, with high variability across regions. The Intergovernmental Panel on Climate Change (IPCC) concluded that climate change would modify a range of chemicals and processes that regulate air quality, and that net effects differ from region to region probably (IPCC , 2007). As air pollution levels tend to be up in the future[18,19], there is increasing check about its consequent effect on public health[20]. Two of them were released in 2008 and presented only a result overview of the studies. Several studies are also conducted due to the progress in climate-air quality prediction model systems, that result in exploring more issues. Another study is centred around the methods in measuring the way of future climate change and impact in air pollution-related health effects [21], even though the results of these researches are not analysed and summarised completely. Hence, in order to fill these information gaps and make recommendations, we are quantifying the mortality prediction studies with respect to $PM_{2.5}$ and O_3 since the two air contaminants were the most explored. Also we have closely studied the various uncertainties in predicting the mortality related to air pollution.

2. Pollutants

There is a strong linkage between pollution and environmental change. Earth's quality can be disrupted by the changes in climate [22]. The various pollutants such as methane , carbon, aerosols and tropospheric(ground level) ozone influence the sunlight. As a consequence, the Earth's temperature is rising and ice, icebergs and glaciers are melting and leads to frequent occurrence of natural climatic disasters[23]. corona (COViD19) virus from the china to entire world, as outbreaks of the disease were reported in all over the world[24] and very severe in India [25].Figure 2. typic different disease ratio from the house hold activates.

Fig 2. Indoor Air pollution disease ratio



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A. Air pollutants

World Health Organisation has identified the major air pollutants as particulate pollution, carbon monoxide , Sulfur oxides and nitrogen oxides, Air pollution, such as groundwater, soil , and air, may have a drastic impact on all aspects of the ecosystem. In addition, it is a significant hazard to living creatures. Air pollution causes a noteworthy ecological imbalance through acid rain, environmental warming, greenhouse effects and frequent climate changes [26]. Our focus is primarily on these types of pollutants, as these are connected to more widespread and serious human health and environmental problems.

B. Particulate matter and Health

Studies of short-term acute and chronic PM exposure have shown an association between PM and SWB. As a result of chemical reactions between various contaminants, PM is commonly produced in the atmosphere. Particle penetration depends on its size [26]. The term particles are described by the United States Environmental Protection Agency [27] as PM. Particulate matter pollution involves particles with a diameter of 10 micrometres (μm) or smaller called PM_{10} and extremely fine particles with a diameter of 2.5 micrometres (μm) and smaller in general. Particulate matter contains tiny droplets of liquid or solids that can be inhaled and cause severe health effects. After inhalation, particles smaller than 10 μm in diameter PM_{10} can invade the lungs and even enter the bloodstream [28].Different epidemiological studies have been carried out on the health effects of PM [28]. There was a favourable correlation between both short-term and long-term exposure to $PM_{2.5}$ and acute nasopharyngitis [29]. Furthermore, long-term exposure to PM has been associated with cardiovascular disease and infant mortality for years. Such studies are focused on $PM_{2.5}$ in the study area or suburban area, monitors are limited due to the lack of spatially resolved daily $PM_{2.5}$ concentration data and it is not reflective of the entire population in this way. As $PM_{2.5}$ levels differ spatially, an exposure error (Berkson error) appears to be created after a recent epidemiological analysis by the Department of Environmental Health at Harvard School of Public Health(Boston, MA)[30] and the strong relative magnitude of the short and long term effects is not yet fully elucidated. To determine short- and long-term human exposure, the team developed a $PM_{2.5}$ exposure model based on remote sensing data. This model allows for short-term spatial resolution, as well as the estimation of long-term effects across the population. Respiratory disorders and weakening of the immune system are also reported as long-term chronic effects [31]. It should be noted that individuals with asthma, influenza, diabetes, respiratory and cardiovascular conditions are particularly susceptible and resistant to the effects of Particulate Matter . Different respiratory system diseases are closely correlated with $PM_{2.5}$ accompanied by PM_{10}[32].As their size allows interior spaces to be pierced by them [33].Gas contaminants includes Smog, Soot, Cigarette Smoke, Oil Smoke, Fly Ash, and Cement Dust, and Particulate Matters are classified into 4 major groups according to form and scale [34].Microorganisms (bacteria , viruses , fungi, mould and bacterial spores), pet allergens, house dust and allergens, pollen, are biological pollutants. Dust forms include Suspended Dust of the Atmosphere, Settling Dust, and Heavy Dust. Finally, because of their tiny measurements, PM_{10} and $PM_{2.5}$ particles' half-life in the atmosphere is extended; this enables their long-lasting suspension in the atmosphere and even their move and spread to distant destinations where people and the environment can be exposed to the same magnitude [22].In watery environments, they are able to alter the nutrient balance, destroy forests and crops and acidify water sources. As reported, $PM_{2.5}$ causes more serious health effects due to its small size. The key cause of the 'haze' formation in various metropolises [21] [22] is these aforementioned fine particles.

C. Environmental impact by Ozone

Ozone(O_3) is a gas formed under high-voltage electric discharge from oxygen[33]. It is a potent oxidant that is 52% stronger than chlorine. It occurs in the stratosphere, but it may also occur in the troposphere following chain reactions of photochemical smog [34]. With air masses, ozone may pass to distant areas from its initial source [35].In comparison to the higher amounts in urban areas, it is alarming that ozone levels over urban areas are low, posing a danger to cultures, forests and vegetation[36] as it decreases carbon assimilation [37].Ozone decreases growth and yield and affects the microflora of plants due to its antimicrobial potential [38][39]. To this degree, ozone affects the microflora of other natural habitats [40,41] and changes the composition of animal species [42].In epidermal keratinocytes, ozone increases harmful DNA and contributes to impaired cell function [43]. Ground level ozone (GLO) is produced from a chemical reaction released from natural sources and/or after anthropogenic activity between nitrogen oxides and VOCs. Usually, ozone uptake occurs through inhalation. The upper layers of the skin and tear ducts are damaged by ozone [44]. A analysis of short-term exposure of mice to high ozone levels showed the development of malondialdehyde in the upper skin (epidermis) but also vitamin C and E depletion. ozone levels are not likely to interfere with the role and integrity of the skin barrier for predispose to skin disease [45]. Inhaled ozone has the ability to penetrate deeply into the lungs due to the poor solubility of ozone in water[46].In urban areas worldwide, ozone-induced toxic effects are documented to cause biochemical, morphological, functional and immunological disorders [47,48].

D. Nitrogen oxide (NO_2) impact in the atmosphere

The reddish-brown gas with strong oxidant properties is nitrogen dioxide (NO_2). Compared to concentrations in urban regions, natural background concentrations are low. Annual mean concentrations of NO_2 range from 20 to 90µg/m3 in urban areas around the world. The highest average amount up to 1000µg/m3 .NO_2 is emitted from vehicle motor engines, nitrogen oxide is a traffic-related pollutant [49]. It is an irritant of the respiratory system when, when inhaled at high levels, it penetrates deep into the lung, causing respiratory disorders, coughing, wheezing, bronchospasm and even pulmonary edema. In humans, concentrations above 0.2 pm tend to cause these adverse effects, whereas concentrations above 2.0 ppm affect T-lymphocytes, particularly the CD8+ cells and NK cells that generate our immune response.[50]. High levels of nitrogen dioxide are detrimental to crops and vegetation, as a decrease in crop yield and efficiency of plant growth is observed. In addition, NO_2 can reduce visibility and fabric discoloration [50].It is observed that NO_2 is emitted in increased levels by the devices used in combustion at homes in the order of 200 which affects the air path and lungs analysed in various studies[51, 52] Usage of gasoline- powered ice resurfacing machines [53] also induces NO_2 exposure. Several proofs from animal toxicology experiments, controlled and epidemiological studies were reviewed by the World Health Organization [51] Exposure in controlled conditions were analysed by[53]. Indoor and outdoor exposure in accordance with epidemiological studies were concentrated by [54].

E. NO_2 impact in different location of the globe

The reactivity of bronchi is induced by NO_2 and it is evident from the response of normal and asthmatic patients subjected to pharma- ecological broncho constrictor agents at a non-affecting level of pulmonary functions in the absence of a broncho constrictor. In contrast to this, few cases exhibit increased receptiveness to broncho constrictors at lower NO_2 levels of 376 to 565µg/m3; A consistency in validating the health consequences of the increased receptiveness to broncho constrictors is still infeasible[l51]. The receptiveness is increased to natural allergens also in the same range. The consequences of monotonous exposures of those kinds of individuals, or the influence of single exposures on more serious asthmatics, are not analysable [51]. It is suggested from the metaanalysis conducted for school going children that the cooking gas exposure have 30μg/m^3 induces a minute but considerable 20% increase of gas for cooking with an equivalent exposure was associated with a slight, but significant, in the generality of disorders in respiration [55]. And also, various analyses prove that cooking gas has showed constancy in respiratory problems and aggravating the functioning of lungs with respect to asthma affected adults [58-60]. NO_2 in the order of 100μg/m^3 has a minute effect in airpath reactivity of asthma persons due to inspired allergens by three studies [64-66]. In Sweden, asthma is worsened due to the daily changes in NO_2[67]. Infant studies failed to prove the above-mentioned results. In contrary to this, the European Community Health Survey has shown the linkage between females involved in cooking and the lung disorders never had constancy [61]. In Australia, there is an association between children and their exposure to NO_2 had incidents of having cold, soreness in throats, asthma, wheezing and school absenteeism [62,63]. It is also found that the children with prolonged exposures to ambient NO_2 suffer with high levels of respiratory problems and lungs dis functioning [68] and also chronic cough, bronchitis and conjunctivitis [73,74]. Various study works have found about the exacerbation of chronic bronchitis and emphysema ΠM [68-70].

F. Evidence for health impact

Prolonged exposure of children with an annual mean value of 50 to 75μg/m^3or higher are vulnerable to respiratory disorders whereas there are no sufficient results to show the effect levels in adults [51]. As per the panel cohorts report, the relativity of outdoor NO_2 to respiratory problems and lung functioning decreases in children. In single pollutant analysis, increased cough and lower symptoms of respiratory problems were found by a study [61]. There are certain studies which reveal about connectivity restricted to lung functioning alone [76-79]. There are some linkage between ambient NO_2 and the hours having high-peak and the cardio vascular mortality rate [30, 32, 40; 85-87]; Some works prove that pollutants like SPM and CO shown greater connections than NO_2. In a nutshell, copious evidences are not present to denote the relativity of NO_2 to health hazards from epidemiological studies. It is concluded that NO_2 contributes to a considerable extent in affecting the health with the help of existing evidences.

G. Carbon monoxide (CO)

Improper combustion of carbonaceous components produces a colourless, odourless, tasteless and insoluble gas which is termed as carbon monoxide that gets the large proportion from internal

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combustion engine exhausts from petrol engine vehicles. CO emissions influence greatly in climate changes and global warming like occurrence of storms and increasing the soil and water temperature [78]. It leads to dizziness, Headache, nausea, fatigue, vomiting, and gradual loss of consciousness. The affinity towards carbon monoxide is greater than that of oxygen in haemoglobin and results in severe poisoning in blood veins for people having prolonged exposure to CO. Due to the less affinity towards oxygen, carbon monoxide is mixed with the haemoglobin successfully and creates diseases such as ischemia, hypoxia and cardio vascular disorders. In laboratories and field findings had increased growth in plants [79].The vehicle density has a major role in deciding the concentrations of CO. The maximum occurrence of concentration falls between the morning and evening rush hours in several cities. An eight hour concentration of CO in European cities vary between 1 and 20μg/m^3[80-81] and this is approximately 8 times higher than those measurements in ambient air [82]. Car models, traffic patterns, ventilations, car maintenance and climate also influence CO levels in car. [83-84]. High peak hour of CO exposures in urban areas is undervalued by monitoring stations. The presence of improper ventilation in places like tunnels and parking areas have the higher vulnerability to CO emission[85,86]. Severe poisoning has been observed in even icy regions [87, 88]. The CO concentrations can be raised to 50μg/m^3 from environmental tobacco smoke in indoor environments . CO spreads fast inside the lungs through alveolar, capillary and placental membranes as the lungs are the most suited route for CO intake. Carboxy haemoglobin (COHb) is formed after inhaled CO around 80 to 90% combines with haemoglobin thereby decreasing the o2 carrying capability of blood and distorts the oxygen release from blood. After the onset of exposure, the concentration of COHb rapidly elevates and within 6 to 8 hours, the concentrations of CO in outdoor air and alveolar breath remain equal. Coburn-Foster-Kane exponential equation is used to denote the intake and elimination of CO [89]. Benignus has shown about the devastated behavioural patterns of CO exposure like impairment of eyes and vision when the COHb levels are beyond 18% [90]. During pregnancy, Maternal COHb levels are normally about 20%higher in pregnancy period than the non-pregnant individual values; There are high rate of vulnerabilities imposed by CO to the pregnant mother, the fetes, and the infant . Endogenous production of CO results in COHb levels of 0.4% to 0.7% in healthy individuals. And this elevated endogenous production causes increased maternal COHb levels of 0.7% to 2.5% around 0.5% to 1.5% for non-smoking general individuals. These type of persons falls under the occupation categories of being an auto-mobile driver, policeman, firemen, traffic warden, garage and tunnel worker have possess the chances of long term COHb levels of 5%, and chain smokers having of 10% [90] . Individuals with heavy work outs can have the ability to increase the COHb levels by up to 10%to 20% when exposed to indoor environments.

H. Sulfur dioxide

Sulfur dioxide is a toxic gas that is emitted primarily from the use or manufacturing activities of fossil fuels. SO_2 's annual norm is 0.03 ppm [92]. It affects plants, animals and humans. Susceptible individuals, such as those with lung disease, are at greater risk of harm to older individuals and children. In most cities, the major health effects of Sulfur dioxide are concerned with irritations in respiratory system, bronchitis, production of mucus and bronchospasm as it can penetrate more into lungs due to its sensory irritant nature. Inside the lungs, it gets changed into bisulfide and leads to constriction of bronchus by interacting with receptors. It also extends in creating redness of skin, damaging the lachrymal glands and opacity of cornea and ultimately putting the cardiovascular system in high risk [51]. Sulfur dioxide emissions tend to be associated with acidification and acid rain [93]. SO_2 is a toxic, colorless and water soluble gas produced from both natural and anthropogenic activities like volcanoes and usage of fossil fuels containing Sulfur in domestic cooking, heating, generation of power respectively. The diurnal and annual mean concentrations of SO_2 are below 100μg/m^3 and 500μg/m^3 in several cities of America and Europe. The US based Committee reviewed about the perilous nature of SO_2 in 1996 from the American Thoracic Society[51]. Europe has updated and revised the guidelines through the toxicological and epidemiological studies on the health effects of SO_2 [93]. A research work stated about Sulfur dioxide's toxicology and health effects induced by SO2 emitted from traffic[94]. The severe effects of SO_2 rise from controlled chamber observation with volunteers exposed to SO_2 concentrations above 500μg/m^3 for periods of few minutes to hours[51]. From the experiments it was observed that healthy persons have exhibited upper respiratory symptoms and asthmatics and respiratory hyper receptiveness persons have shown acute responses immediately after the inhalation of SO_2. It causes reductions in forced vital capacity (FVC) and increases airpath resistance with symptoms of breath shortness or wheezing in balanced individuals. Exercise is a factor in increasing the mass of inhaled air since it permits the penetration of SO_2 in a deeper mode into the respiratory path. A review of Mumbai city of India exhibited SO_2 effects in a daily basis mortality resulting from cardiorespiratory diseases. The data were not sufficient in classifying the effects of SO_2 are separated or combined with SPM I2AI. Athens and France had conducted a time-series studies that denote SO_2 induces independent severe health effects in both genders of people on daily mortality having age group of 65yrs and above [96]. At winter season, a small amount of correlativity was observed by the study conducted by Poland Pollution control board with mortality of male at the age of 65 having exposure to PM_{10} and SO_2. PM_{20} induced no causes on mortality even after adjusting the levels of SO_2. An estimation was given by the authors that incrementing the SO_2 concentration for about 100μg/m^3 , resulted in an increment of 19% and 10% of fatal respiratory diseases and cardio vascular diseases respectively was estimated by the authors. Delhi has conducted a study [96] and inferred about the extreme serious linkage between Sulfur dioxide's logarithmic levels and the fatality rate per day. Diseases such as chronic bronchitis, chronic obstructive pulmonary disease, and colour pulmonale have shown higher fatality rates. It is unfortunate in using the results and inferences of all these research works in estimating the dose-response relations. A considerable amount of increase was observed in both respiratory and circulatory system disorders with increased exposure to SO_2. There are some studies which reviewed about the influence of other components in the mixture of air pollutants and meteorological compounds [96]. But multi pollutant mix is not used in the APHEA studies. A valid establishment is not presented in relating the SO_2 and other pollutants for deciding the mortality. In Netherlands, a multi- variate review was conducted that concludes in a way of relative lower concentrations of SO_2 concentrations did not have short term-based effects on mortality [98]. An increment in SO_2 was strongly connected with morbidity of hospital admissions due to cardio vascular and respiratory disorders. There were no sufficient results given by the studies within the APHEA work [51]. Lung disorders with long range of sensitivity was demonstrated for both normal adults and adults with asthma (for instance, Nowak et al. [93]). Asthma affected people are the most vulnerable group in the community.

I. Lead

It is a heavy metal emitted from petrol motor engines, batteries, radiators, waste incinerators and waste waters and sources of lead include metals, ores, aircrafts with piston engine models. It is used in various industrial plants [98]. The serious threat to all living creatures is poising from lead because of its detrimental effects specifically widespread in developing nations. The process of inhaling, ingesting and dermal absorbing are the sources through which lead is exposed into human. The inhalation of lead gets gathered in blood, liver, lungs, tissues, bones, nerves and reproductive parts. This results in passing of lead into the unencumbered placenta in the form of trans- placental transport mode. Consequently, the poisonous effects gets aggravated more for the younger foetus such as damaging the nervous system, brain swelling. Even a minute quantity of lead is a kind of toxicant affecting nervous system resulting in disabilities with learning, perception, memory and mental impairments, hyper sensitivity in new born and young children[100]. Similarly, adults also suffered from concentration and memory loss, muscular pain etc. [100]. Lead's poisonous effects are not limited to humans, but also extends in damaging the crops and inducing nerve related problems in animals especially vertebrates [101].

J. Dioxins

Natural disasters like volcanic outbursts and forest fires are some sources of dioxins and man-made industries also play a role in emitting dioxins. It is evident that consumption of fossil fuels reserves a substantial part in contaminating the air. And this kind of contamination may be due to man-made activities like agriculture, transport and industrial processes or some of the natural causes also. Sea food like fish, shellfish and eatables like meat, dairy items and animal tissues are components getting accumulated with lead [102]. Shortened and prolonged exposure to lead results in occurrence of lesions and dark spots over skin and growth-related problems. Immune underdevelopment and impairments in endocrine, reproductive and nervous systems respectively. Its elevated effects are tumour and infertility issues.[102]. It is interested in observing that European Air Quality Directive standards are far better to Who air quality guidelines[103].

3. Sources of pollution $PM_{2.5}$

Human induced and natural sources play a key role in discharging PM into the environment by two modes. The former being the direct release into the atmosphere and latter being the transfer of gaseous precursors such as Sulfur dioxide , nitrogen oxides, ammonia and non-methane volatile organic compounds [104]. Human induced processes ranging from combustion of coal, heavy oil, lignite and biomass to industrial and agricultural activities are variable in nature. It also includes road-traffic surface degradation, and brake and tyre abrasion. The primary source of PM is the traffic from which the wear of vehicle components such as brakes and tyres and road dust are suspended . In addition to this, tyre and brake matter can contain metals like copper (Cu), antimony (Sb), lead (Pb) , cadmium (Cd), and zinc (Zn) . Tyre abrasion induces the discharge of inorganic abrasive crustal material particles rich in silicone (Si), aluminium (Al), potassium (K), sodium (Na) and calcium (Ca).In contrast, the volcanoes, dust storms, forest fires, living plants, and sea spray are the natural sources of PM following Figure 3. shows the different sources of pollution activate

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Fig 3. Different sources of pollution

A. $PM_{2.5}$ possibility of moving in air

Due to their minute sizes, these kind of particles remain in air for a prolonged period of time and have the possibility of moving to hundreds of kilometers. The changes in wind patterns and atmospheric stability decide the fractions of different PM concentrations and that can vary drastically from one day to the other(or even from hour to hour) . It is common to find that PM concentrations in the indoor environment exceed the outdoor environment. Indoor activities such as cooking, pets, mooring, household goods manufacturing liquid aerosols (e.g., aerosol cans) and office equipment's (e.g., printers and photocopiers) constitute a considerable amount of PM[106]. The most important factors of exposure in households are fuel and stove types, cooking period and neighborhood smoke. Even candles and incense sticks emit PM at the range of 100 to 1,700µg/m^3 The several livelihood facilities possess indoor PM contamination compared to recognisable source activities[107]. In India, average PM_{10} concentrations of 128µg/m^3 were found in four hospitals in Delhi City. Concentrations of PM_{10} were found to be 77.0 ± 29.9, 74.0 ± 23.6, 93.5 ± 9.47, and 66.7 ± 15.8µg/m^3 respectively[108] in indoor environments like children's care facilities , medical facilities, postnatal care centres, and elementary schools. Mean concentrations of PM_{10} in elementary school were present in the range 66.7 to 77.9µg/m^3.

B. Sources of Indoor $PM_{2.5}$

Sources of indoor $PM_{2.5}$ is represented in Figure 2. Indoor $PM_{2.5}$ pollution sources are typically produced transiently and intermittently, resulting in wide variations in indoor particulate concentrations[109].There are several different forms of indoor $PM_{2.5}$ sources , primarily from fuel combustion, human activities, equipment operation, cleaning and cooking. Indoor combustion of fuels such as coal, natural gas, alcohol, and mosquito coils which lead to a rapid increase in indoor $PM_{2.5}$ concentration[110]. have shown that burning a mosquito coil ring is capable of delivering 626μg/m^3 of $PM_{2.5}$ − 8.3 times the concentration limit permitted for the indoor setting[111] concluded that the concentration of $PM_{2.5}$ in households using coal for cooking was substantially higher than in households using gas or electricity, and that if coal is converted to gas or electricity, the concentration of $PM_{2.5}$ in the kitchen could be reduced by 40–70%[112] suggested that human activities, such as walking, dressing and washing, could result in an increase of 33 per cent indoor $PM_{2.5}$[113] performed dry-weeping, wet-weeping and air-drying tests in the office.

C. Human made sources of $PM_{2.5}$

$PM_{2.5}$ emissions from road vehicles are an significant source India. As a result, $PM_{2.5}$ (and population exposure) levels along roadsides are often much higher than those in background areas. Industrial pollution may also be significant in some areas, such as the use of non-smoking fuels for heating purposes and other domestic sources of smoke, such as bonfires. Under certain weather conditions, air polluted with $PM_{2.5}$ from the mainland could circulate throughout the United Kingdom – a condition known as the long-range transport of air pollution. Long-range transport, along with pollution from local sources, can contribute to short-term episodes of high pollution that could have an effect on the health of those vulnerable to high pollution. In addition to these direct (i.e. primary) emissions of particulate matter, $PM_{2.5}$ can also be produced from chemical reactions of gases such as Sulfur dioxide (SO_2) and nitrogen oxides (NOx: nitric oxide, NO plus). Consequently, steps to minimize the emissions of these precursor gases are also helpful in decreasing the overall amount of $PM_{2.5}$[114].

D. Outdoor sources of $PM_{2.5}$

Combustion of fossil fuels Home Heating Electricity generation Motor vehicles Manufacturing processes Agricultural processes Waste incineration Natural processes Thunderstorms Volcanoes Manufacturing or agricultural operations Disposal of industrial effluents and domestic residues Traffic Solid waste management Chemical accidents and spills Ozone(O3).

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1. Nitrogen Oxides (NOx)
2. Carbon Monoxide (CO)
3. Sulfur Dioxide (SO_2)
4. Particulate Matter (PM_{10} and $PM_{2.5}$)

These imperceptible urban contaminants can be defended by adopting some effortless procedures. For instance, when a grey-sky day is encountered, it is necessary to:

- Reduce the outdoor activity;
- Sticking to air quality measures
- Wearing an appropriate pollutant mask blocking 95% or more of the particles

A big initiative towards protecting the air is to analyse the nature of air surrounding us and by periodical testing of air quality index in a respective station before moving outdoor.

4. Sources of pollution $PM_{2.5}$

A. Health impact by $PM_{2.5}$

A description of the health impacts examined in this part. A review research on $PM_{2.5}$ in India, including health effects, was recently conducted by [115]. Four $PM_{2.5}$ health effects studies in Delhi have been illustrated in this study and are summarised here. recorded substantial increases in overall mortality, cardiovascular mortality and respiratory mortality with a 10μg/m^3 rise in $PM_{2.5}$ concentrations between 2007 and 2008. In addition,[116] identified substantial associations between elevated $PM_{2.5}$ levels and emergency room visits to cardiovascular disease incidents between 2004 and 2006[117].During this analysis , the average daily concentration of $PM_{2.5}$ was 122μg/m^3. The average increase was 0.69 percent and 1.32 percent respectively, which are still important. This study showed that adverse effects of lags ranging from 0 to 8 days were observed and were still important after control for variables such as time trend, seasonality, and meteorological influences. The Figure 4. shows different cardiology disease by the pollution in percentage.

B. Impact on human lung and respiratory diseases

PM_{10} and $PM_{2.5}$ possess small and minute inhalable particles that can easily enter the thoracic portion of human's respiratory system. The health effects are due to short-term (hours, days) and long-term (months, years) exposure and include

i) Morbidity in respiratory and cardiovascular systems leading to exasperation in asthma and frequent admissions to hospitals.

ii) Cardiovascular, respiratory diseases and lung cancer showing high rates of mortality.

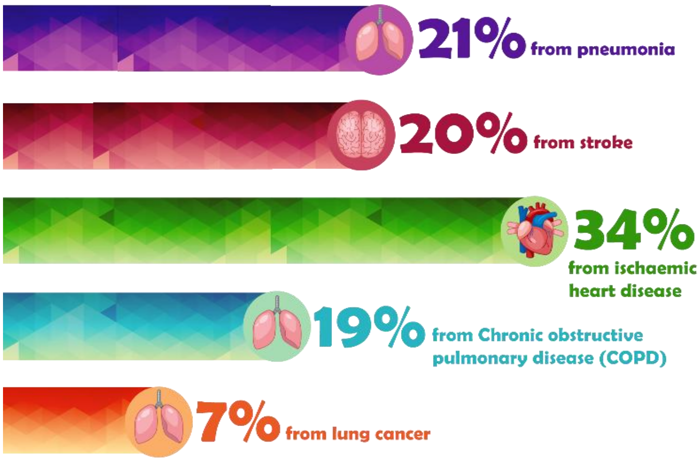
It is evident from the effects of short-term exposure to PM_{10} on respiratory system, but for mortality, and specifically as a result of long-term exposure, $PM_{2.5}$ is a huge risk factor than the gross component of PM_{10} (particles in the 2.5–10µg/m^3 range). It is calculated that all-cause daily mortality increases by 0.2–0.6 per cent per 10µg/m^3 of PM_{10}[130,122]. Long-term exposure to $PM_{2.5}$ is related to an improvement in the long-term risk of cardiopulmonary mortality by 6–13 per 10µg/$m^3$of $PM_{2.5}$ [123-125]. In particular, people already with lung or heart disease , elderly adults and children are the most vulnerable groups. Exposure to PM causes problems in lung development for children resulting in reversible lung function deficits and improper growth of lungs and a deficit in lung functioning for a long term [126]. There is no evidence of a normal level of exposure or a threshold at which there are no severe health effects. Exposure is prevalent and voluntary in nature leading to create awareness about this health determinant.

Minute particles having sizes smaller than 10 micrometres in diameter impose the human health under risk by getting deeper in to the lungs and its passages, heart while others enter in to the blood stream. Therefore the size is directly connected to the capability of particles in creating dangerous effects in human. Various scientific studies have shown that a variety of health hazards are directly resulted from exposure to particle pollution such as:

- More fatality in lung and heart diseases
- Frequent mild heart attacks
- Uneven heartbeat
- Exasperated asthma
- Improper functioning of lungs

Repetitive respiratory symptoms like airways irritation, coughing or breathing difficulties People already with heart or lung problems, children and elderly people are prone more to get affected by particle emissions.

Fig. 4 - Different kind of disease caused by pollution



C. Environmental Effects of air pollution

Polluted air creates hazardous effects to both human and environment [127]. The most crucial impact of environment is the outpour of acid rain having harmful proportions of nitric and sulfuric acid. It can be either in wet form (rain, fog, snow) or in rain form (particles and gas) It can acidify the aquatic and soil environment and can affect trees and crops, as well as damage to constructions and external carvings, statues. Industries, nuclear plants, heavy vehicles create smaller particles which get distributed in air in the form of hazes. The atmosphere‘s visibility is obscured during the occurrence of hazes. The presence of ozone at stratosphere shields the ultraviolet sunlight from harming the human whereas ground level ozone is detrimental in the form of a pollutant. Miserably, stratospheric ozone is being exhausted and destructed by chemicals, pesticides and aerosols from various types of industries and vehicles that causes disastrous consequences in human life [128] and crops[129] due to the thinning of ozone layer. The temperature of earth is stabilised by the greenhouse effect concept and Global climate change grows as a life threatening problem these years. This protection effect is destroyed by human induced activities by emitting huge volume of greenhouse gases. Global warming effects have the ruinous power over all living creatures, forests, biodiversity, agriculture and the water system. People living in poorly built buildings and houses in hot climate countries are most prone to risky life according to the report [130] when temperature rises. Sterility and pre mature birth problems have been reported. When the nutrient(nitrogenic) concentration elevates to a higher point, it induces the large volume of aquatic algae blooming which is termed as Eutrophication. It in turn puts fish and other aquatic species at risk. In accordance with Canada Acid Rain Program, it is evident that there is a serious concentration of contaminants with which the atmosphere can tolerate

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to some extent without being destructed and is connected with the system's capability to neutralise acidity. This load has been approximated at 20 kg /yr [131].People inhabiting the cities are comparatively facing greater exposure to PM as per the Global Health Observatory (GHO) data in 2016[24]. And it is around 90% greater than air quality guidelines given by WHO. It sets the Air Quality Guideline which is the annual mean concentration of particulate matter (PM). The guideline for $PM_{2.5}$ does not exceed 10μg/m^3 annual mean or 25 μg/m^3 for 24 hours average and PM10 does not exceed 20 μg/m^3 annual mean or 50 μg/m^3 for 24 hours average. Starting from India (68μg/m^3), Bangladesh (58.6μg/m^3), Bhutan (35.4μg/m^3), Myanmar (34.6 μg/m^3), the Democratic Citizens of the Republic of Korea (31.0μg/m^3), Thailand (26.6μg/m^3), Timor-Leste (18.2μg/m^3), Indonesia (16.4μg/m^3) and Sri Lanka (15.1μg/m^3) with the exception of the Maldives (7.7μg/m^3) showed that the annual mean concentration of fine particulate matter in urban areas surpassed.

D. Airway system impact

The health effects of air pollution on the airway system (lower airways) include acute and chronic changes in pulmonary function, increased frequency and prevalence of respiratory symptoms, allergen sensitization of airways, and exacerbation of respiratory infections such as rhinitis, sinusitis, pneumonia, alveolitis, and legion disease. The key agents for these health effects are the combustion products SO_2, NO_2, SPM with a mean aerodynamic diameter of less than 10μg and lower, and CO. Fine SPM, formaldehyde and infectious organisms may also serve as important agents in addition to indoor air contaminants.

E. Efficient Strategies for Pollution Avoidance

Pollution in air can be reduced by using some efficient strategies in transport, urban planning, power generation and manufacturing:

- Industry related: smoke stacks can be reduced by using appropriate cleaning technologies; urban and agricultural waste should be managed properly including methane gas from waste sites as an alternative approach to incineration (for use as biogas);
- Electricity: Activities like cooking, heating and lighting should be managed using economical and renewable household energy solutions
- Transport: electricity should be made to generate in sustainable modes; systematizing rapid mass transit, mass walking and cycling networks. Initiating inter urban rail freight and

passenger transport; moving towards cleaner heavy-duty diesel vehicles, low-emission vehicles and fuels and low-Sulfur fuels;

- Urban planning: The buildings should be constructed in a way to enhance the energy efficiency and cities are to be made greener and compact
- Low-emission fuels and non-combustion renewable energy sources should be promoted for usage like solar , wind or hydro power; co-generation of heat and power; and distributed generation of energy like mini-grids and rooftop solar power generation.
- Urban and agricultural waste management: adopting different methodologies for reducing and separating, recycling and re-use or reprocessing of wastes; Promoting anaerobic waste digestion for biogas production which is a refined as well as feasible biological waste management approach; replacing the open solid waste incineration with low cost alternatives. Combustion methodologies with severe emission controls are mandatory for unavoidable incinerations.

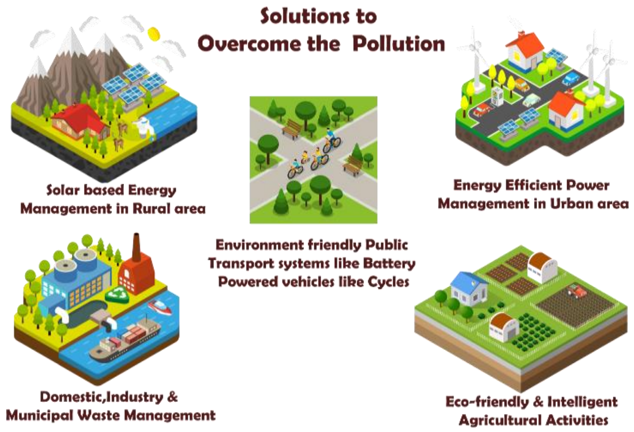
5. Indoor $PM_{2.5}$ Control

$PM_{2.5}$ avoidances strategies in indoor Figure 5 typic different solutions to overcome the pollution namely energy efficient power management, Solar based energy, Eco-friendly battery powered vehicles, intelligent waste management and smart agricultural activities.

A. Filters and Conditioner Recommendation

It becomes crucial to decrease the outcomes of $PM_{2.5}$ over the occupants health by regular monitoring of its indoor pollution level as short term elimination of $PM_{2.5}$ is impractical. Some research works have focussed on selecting a particular combination of air philtres, for instance, design of an a plan to reduce the $PM_{2.5}$ level in indoor [132] .A philtre efficiency test is conducted based on a particle size, counting system and a $PM_{2.5}$ weight filtration method for different air philtres with varying materials and particle removal efficiencies under the similar experimental factors. A preliminary standard is provided by the relativity between the above said two filtration efficiencies to select $PM_{2.5}$ air philtres specifically for air cooling and ventilation systems at indoor. The effectiveness with respect to filtration for varying categories of $PM_{2.5}$ philtres was examined by [133] and stated admissible philtre combination schemes depending on the pollution status of $PM_{2.5}$ in different places. Preliminary air conditioning systems are designed on a $PM_{2.5}$ concentration model for indoor is designed by [134] in accordance with the law of conservation of mass. The development in filtration and the flow rate of fresh air on indoor $PM_{2.5}$ is analysed with respect to primary, return and supply air sections. Since the split air conditioning systems are ductless systems, widely installed in most residential buildings for controlling the indoor environment in India. Evaporating and condensing units are separated from each other by indoor and outdoor heat exchangers respectively. Closing the doors and windows is the major step taken by the people of india in dealing with $PM_{2.5}$. Consequently, fresh air is not handled by air philtres and it's the point where $PM_{2.5}$ cracks. Maintaining an indoor atmosphere safely inside the buildings with isolated AC exists as an unsolved problem in India.

Fig. 5 - Solution to different kind of pollutions



B. New Material for $PM_{2.5}$ Air Filters

New philtre products production is being worked by the researchers. Electro spun polyvinylidene fluoride (PVDF) doped with negative ion powders (NIPs) provide an efficiency of 99.9% in purification when it is embedded with highly efficient and lower resistance air purifying components [135]. A highly effective polyimide nanofiber air philtre is devised by [136] with high-thermal-stability polyimide nanofibers and its performance efficiency rates to 99.5 % in eliminating the automotive exhaust at heavy temperatures. Polyether sulfone membrane is a reusable hollow fibre given by [137] which is highly permeable using single-jet wet-spinning technology. The capture capacity of $PM_{2.5}$ is higher in these above mentioned philtres and can be employed in Ac systems that eliminates the need of removing the $PM_{2.5}$ at indoor. It becomes impractical to implement this mode of philtres due to the heavy investment cost in the initial stage. Another mode of invention is that creating and adding the sensors to windows which permits the flow of air by reducing the costs of

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filtration. A new technique named blow-pinning that allows coating on a window screen with nanofiber transparent air philtre with an efficiency of > 99 per cent with 80 per cent optical clarity of $PM_{2.5}$ removal by [140]. The average value of the harmonic mean air exchange rate is better below the nationally fixed norms when there are open windows analysed by[141]. Natural ventilation can be improved by reducing the resistance of philtres and that needs further research activities.

C. Anti-Haze Based AC

The Existing AC's are needed to be customized for purifying $PM_{2.5}$ because of the frequent occurrence of hazy weather that reminding about the importance and essentiality of air quality improvement to people. Familiar air conditioning companies provides AC products enhanced with $PM_{2.5}$ purification functionalities. A novel Cleanable $PM_{2.5}$ purification technic is used in Midea 's air conditioner (AC) products that generate an electrical field to capture the $PM_{2.5}$ emitting charged particles in the dust collection system with the help of an electrical generator. A visualization functionality to acquire the $PM_{2.5}$ by providing a 5-colour indicator in every AC unit is devised by Haier's air conditioning firm. The indicator turns into red for denoting the high level of $PM_{2.5}$ at indoor and suggests the occupants to turn on the $PM_{2.5}$ removal mode. It turns into blue to indicate the normal level of $PM_{2.5}$. A highly efficient electric field is formed to capture the $PM_{2.5}$ by Panasonic air conditioners. It works by emitting negatively charged "nanoe-G" that is absorbed by $PM_{2.5}$ present in the air, and that results in negatively charged $PM_{2.5}$ which is easily captured by the electric field. $PM_{2.5}$ is purified by thee combination of three different techniques in Kelon air conditioning products such as stripping, packaging and melting technologies .

D. $PM_{2.5}$ Control strategies in outdoor

A variety of recommendations are needed to carry out since the issue of outdoor air pollution persist to be undetermined. The suggestions are as follows;

- Logical usage of energy.
- Adapting to less-polluting fossil fuels.
- Expanding the usage of non-fossil energy sources.
- Adoption of latest eco friendly combustion techniques
- Framing stern standards over the emissions from air pollutants.

The research works conducted world wide are aiming to bring an in depth perception of atmosphere and its associated problems with air pollution especially to human society. Nevertheless, newer methodologies for combustion of fossil fuels and controlling the pollution should be developed. The accessibility and stability in data regarding the air pollutant emissions should be increased and also it should entice the guidelines which are being the most principal part of recommendations in framing the control policies on air pollution.

6. Cities based pollutants impact in India

The pollutants parameters like $PM_{2.5}$,PM_{10},$SO_2$and NO_2 is observed in various cities located in India. Based on the air quality index the colour coding is used to visualize the above parameter. The non marked parameter value is still analysing phase(due data collection human error).Figure 6. Depicts $PM_{2.5}$,Figure 7. Depicts PM_{10} ,Figure 8. Depicts SO_2 and Figure 9. Depicts NO_2.The references AQI is listed in Table 1.

Table 1. AQI Scale 0-500 (units: μg/m^3)

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	SO_2 24-hr
Good (0-50)	0-50	0-30	0-40	0-40
Satisfactory (51-100)	51-100	31-60	41-80	41-80
Moderate (101-200)	101-250	61-90	81-180	81-380
Poor (201-300)	251-350	91-120	181-280	381-800
Very poor (301-400)	351-430	121-250	281-400	801-1600
Severe (401-500)	430+	250+	400+	1600+

Fig 6. Depicts $PM_{2.5}$

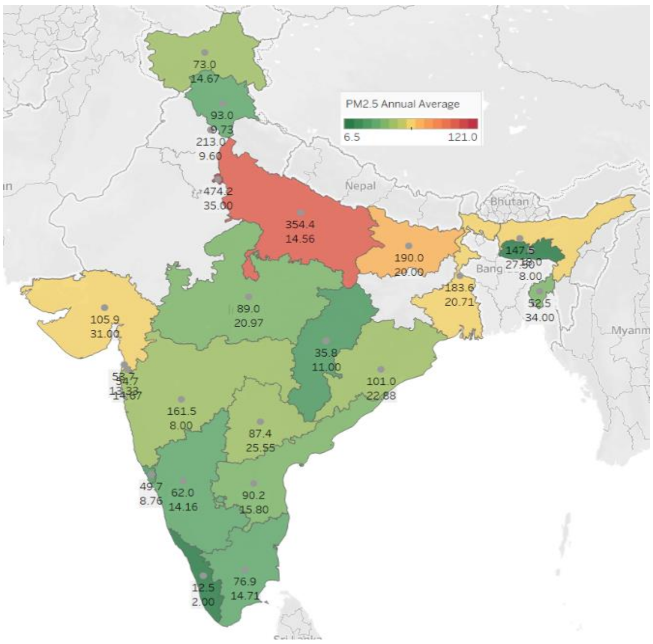

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Fig. 7 - Depicts PM_{10}

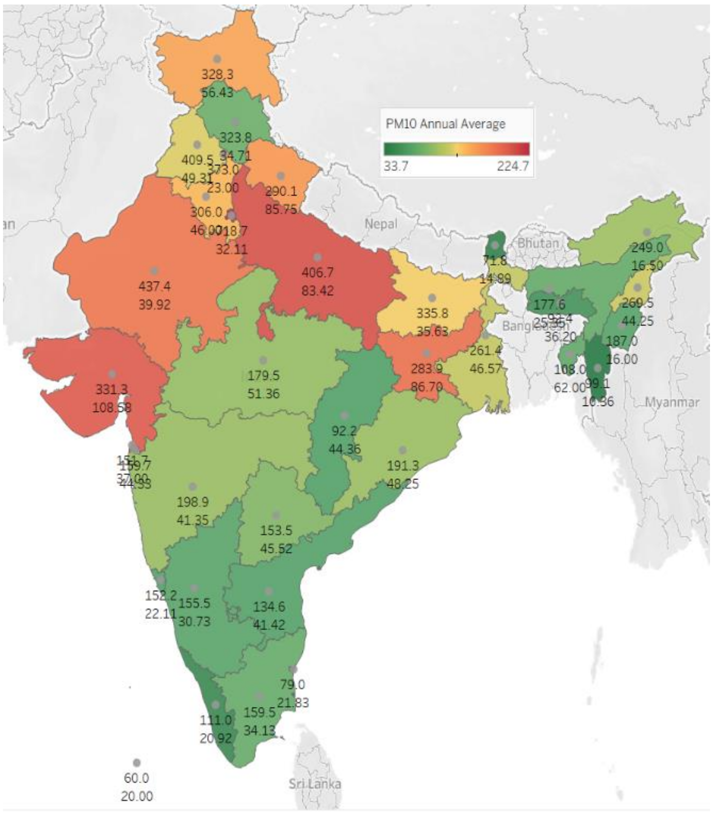

Fig. 8 - Depicts SO_2

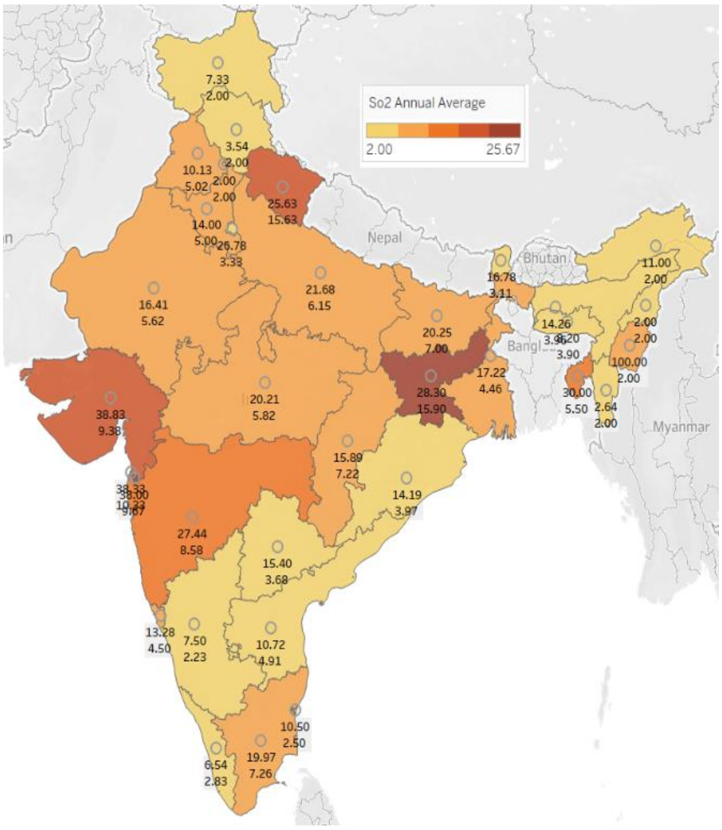

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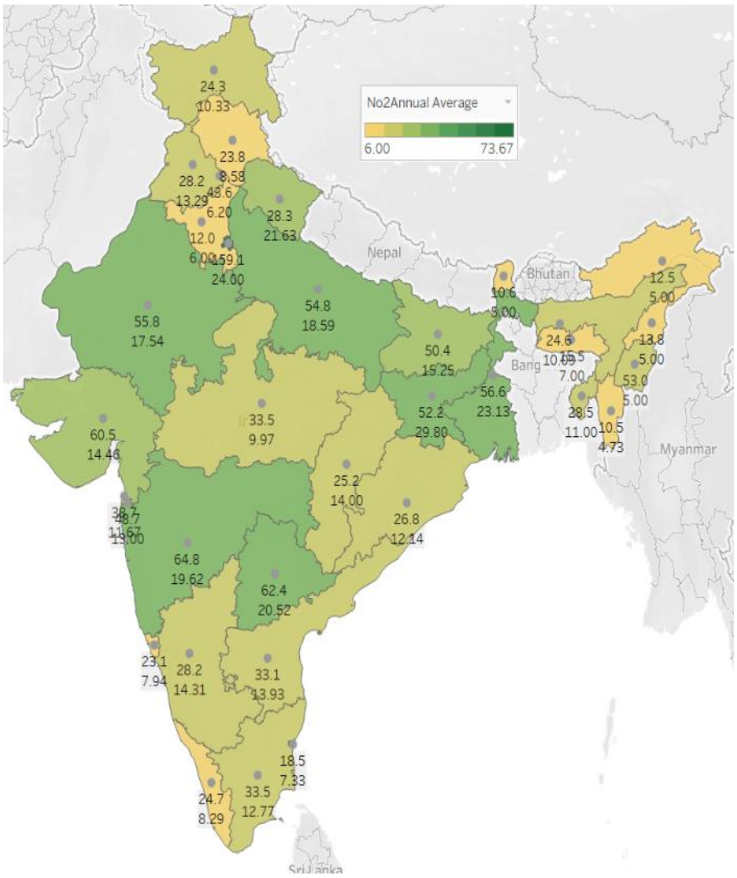
Fig. 9 - Depicts NO_2



7. Summary

It is clearly evident from recent researches that the concentrations of $PM_{2.5}$ in cities like Mumbai and Delhi has affected the health adversely with increased rate of risks. Prolonged exposure to $PM_{2.5}$ causes mortalities in blood circulation, respiration, hyper tension, lung diseases, COPD and advent of virus in respiratory tract like influenza and these effects in association with $PM_{2.5}$ are assured by latest literature survey. People in Delhi are prone to these hazardous diseases as the city has higher concentrations of $PM_{2.5}$. The $PM_{2.5}$ air quality standards were published in 2012 and that created a considerable drop of 36% in annual proportion of $PM_{2.5}$ from 90μg/m 3 in 2012 to 58μg/m3 in 2017[62], but above Indian and International standards (Table 1). The systematic analysis of previous studies established the following targets for future works on $PM_{2.5}$ health effects in India. Organising studies for a prolonged period of years to validate the connections between exposure and health effects. Obtaining finer exposure results with accurate spatial resolutions by deploying high density sampling drives and utilizing satellite based remote sensing techniques. Analysing the mechanisms causing severe health effects, specifically in a multipollutant scenario;

- Recognising the seasonal patterns and sub-population vulnerabilities;
- validating the health effects in order to find the impact of PM's chemical compounds;
- Constant monitoring of ambient $PM_{2.5}$;
- Investigating the conclusion of ultrafine PM exposure impacts.

Guidelines used in public health need to balance safety measures from hazardous effects and feasibility. The outcomes of this analysis need to demonstrate the arising and alarming need for tightening and revising the public health and environmental policies. Even though some milestones are reached, India has a long way to proceed further for optimising and controlling economic and energy formation. Focusing on these suggestions for future research works and regulations, this review will contribute for achieving a stability between growth and protection with respect to economics and environment.

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