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Emerging Urban Air Pollution- A serious threat

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ABSTRACT:
Air pollution in cities and urban sectors are increasing significantly on a time scale at global level. This alarming fact is substantiated with its gravity in the sense that more than 80% of people living in urban areas are exposed to air quality levels that exceed the World Health Organization (WHO) limits. The situation world over is more critical to populations in low-income cities which are most impacted. According to the urban air quality database, 98% of cities in low- and middle income countries with more than 100 000 inhabitants do not meet WHO air quality guidelines. However, the cities in high-income countries this percentage decreases to 56%. The WHO reveals the fact that around 3000 cities in 103 countries have started measuring air pollution levels and recognizing the associated health impacts. With declines of urban air quality , the risk of stroke, heart disease, lung cancer, chronic and acute respiratory diseases, including asthma, increases for the people who live in these cities.
An effort has therefore been made in this paper by the authors to briefly to explain some of the relevant factors responsible for urban air pollution such as heat island effect, albedo effect, urban planning with environmental inputs, climate change, urban environment policy parameters, sustainable urban transport, environmental sustainability etc. These issues need to be addressed globally on high scientific scale for effective reduction of urban air pollution.
KEYWORDS: *Air pollution, urban areas, indoor and outdoor air pollution, health impacts, air pollution episodes*

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I. INTRODUCTION:

Urban air pollution is a significant environmental problem in the developing and developed countries of the world. WHO and UNEP established an air pollution monitoring network as part of the Global Environment Monitoring System. Despite the very high levels observed, the countries have not taken serious steps to control urban air pollution. Millions of people reported serious health effects and experiencing discomfort. With the rapid increase of urban population on a time scale and lack of air pollution control mechanism, there will be a serious threat in urban areas and the people living therein. Such a problem would become much more gigantic if adequate steps are not taken on all the issues responsible to urban air pollution in an integrated manner. Figure 1 tends to indicate the extent of most polluted cities in India(1).

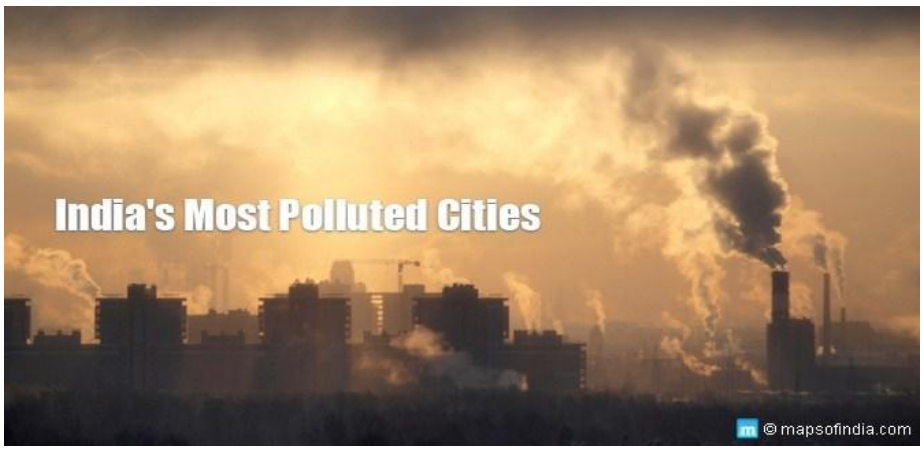


Figure 1: India's most polluted cities

II. OUTDOOR AND INDOOR AIR POLLUTION:

Air pollution is usually man-made and originates from poor combustion of fossil or biomass fuels in the form of. exhaust fumes from vehicles, furnaces or wood stoves, industries, household fuel burning and waste disposal or burning. Urban outdoor air pollution refers to the air pollution experienced by populations living in and around urban areas. Indoor air pollution refers to the pollutants found in indoors. The main cause of indoor air pollution is inefficient fuel combustion from technologies used for cooking, heating and lighting. There are also natural indoor air pollutants, like radon, chemical pollutants from building materials and cleaning products which also impact health. Urban outdoor air pollution can be an important contributor to the indoor air quality, especially in homes near pollution sources. Similarly, indoor air pollution sources may also be important causes of urban outdoor air pollution, especially in cities where many homes use biomass fuels or coal for heating and cooking.

Ambient air pollution is a broader term used to describe air pollution in outdoor environments whereas urban outdoor air pollution is a more specific term referring to the outdoor air pollution experienced by populations living in urban areas. The significant contributors to urban air pollution are in the form of mobile and stationery sources. Mobile sources are usually vehicles and trains whereas stationery sources are industries, house hold fuel burning, waste disposal or burning, D.G sets, construction activities, etc. Out of these sources, automobile emissions are the predominant sources of urban air pollution(2).

Health Impacts:

The World Health Organization (WHO) has revealed following alarming facts in respect of urban air pollution(3):

- Nine out of ten people in the world breathe polluted air
- More than 7 million people die every year as a result of air pollution.
- Ambient air pollution alone caused some 4.2 million deaths in 2016, while household air pollution from cooking with polluting fuels and technologies caused an estimated 3.8 million deaths in the same period.
- Toxic particles such as sulphate, nitrate and soot are responsible for 25 percent of all deaths from heart disease and stroke whereas 30 percent from lung cancers and almost 50 percent from chronic obstructive pulmonary diseases
- The risk of heart attacks, lung cancer and chronic breathing diseases is increasing particularly in poor countries.
- Majority of deaths are caused in low-income countries such as in Asia and Africa, where cooking is still more common on open fires, kerosene or wood burning.
- Overall 3 billion people, more than 40 per cent of the world's population, have no access to safe technological equipment thereby breathe dirty air into their homes every day.
- "Air pollution is one of the main causes of disease and death,"

Urban air pollution episodes:

There are many episodes on account of air pollution in which many deaths were caused , a list of such episodes are given hereunder(5):

- The Meuse Valley fog, 1930:
- The Donora smog, 1948:
- The St. Louis smog, 1939
- The Great Smog of London, 1952
- The Southeast Asian haze, 2006
- The Bhopal disaster, 1984

Air Pollution-Turning Silent Killer:

The world health organization (WHO) reveal the fact that air pollution levels are alarmingly high in many parts of the world in as much as that 9 out of 10 people breathe air containing high levels of pollutants. Besides, it has also been reported by WHO that an alarming death toll of 7 million people every year caused by ambient (outdoor) and household (Indoor) air pollution. Moreover, over 3 billion people out of whom mostly women and children are still breathing poisonous smoke every day from using polluting stoves and fuels in their homes. The WHO also reveal the fact that fine particles in polluted air penetrate deep into the lungs and cardiovascular system, causing diseases including stroke, heart disease, lung cancer, chronic obstructive pulmonary diseases and respiratory infections, including pneumonia. It has been reported that 21 percent death caused due to pneumonia, 20 percent from stroke, 34 percent from ischemic heart diseases, 19 percent from chronic obstructive pulmonary disease (COPD) and 7 percent from lung cancer [3] as shown in Figure 3.Moreover, as per WHO the Worldwide ambient air pollution accounts for(6)

- 25% of all deaths and disease from lung cancer
- 17% of all deaths and disease from acute lower respiratory infection
- 16% of all deaths from stroke
- 15% of all deaths and disease from ischemic heart disease
- 8% of all deaths and disease from chronic obstructive pulmonary disease

Effects of Air Pollutants:

The effects of air pollutants on human health are given hereunder:

- Sulphur compounds:

Flue gas desulphurization plants (FGD), coal power plant about 0.02-2% of emission, furnace oil (Sulphur content is generally 2.3 per cent by weight), paper mills, steel industry, refineries and sewage treatment plants, petroleum refinery and vehicles engines, burning rubber, crackers and match smoke emit sulphur compounds. Naturally sources such as volcanoes, marshes, bogs and swamps emit sulphur compounds. US, China and Russia are leading sulphur emitting countries. Found as SO_2, H_2S, CS_2, COS, Methyl mercaptan, Dimethyl sulphur, and Dimethyl disulphide. Health effects are generally wheezing, bronchoconstriction, chronic bronchitis, Chronic obstructive and lung disease(7).

- Nitrogen compounds:

Major source is combustion where NH_3 come from fertilizers, livestock & poultry wastes, and vegetation, burning of biomass and ocean spray, energy production, petroleum refinery, forest fire, volcanic activity, bacterial breakdown of organic nitrates. It promotes acidification in which NO2 favors photochemical smoke thereby reduce visibility. 77% of combustion gas of coal consist oxides of Nitrogen where high concentration causes pulmonary edema, airway injury, impaired lung defenses, dissolved atmospheric NO_x as in acid rain destroys fish and plant life and N_2O is a greenhouse gas causes global warming. Moreover, it causes leaf damage or affects the photosynthetic activities of plants and causes respiratory problems in mammals.

- Carbon monoxide:

CO is a colorless, odorless, toxic yet non-irritating gas. It is a product of combustion of fuel such as natural gas, coal or wood. Vehicular exhaust contributes to the majority of carbon monoxide which discharge into our atmosphere. It creates a smog type formation in the air which has been linked to many lung diseases and disruptions to the natural environment and animals. In 2013, more than half of the carbon monoxide emitted into our atmosphere was from vehicle traffic and burning one gallon of gas will often emit over 20 pounds of carbon monoxide into the air.[12] It causes difficulty in breathing as it compete with oxygen by forming carboxyhemoglobin, Asphyxia, damage to heart and nervous system. Moreover, it affects the respiratory activity as haemoglobin has more affinity for CO than for oxygen thereby combines with HB to reduce the oxygen-carrying capacity of blood. This also results in blurred vision, headache, unconsciousness and death due to asphyxiation (lack of oxygen).

- Carbon dioxide:

CO_2 is considered as an air pollutant as it is a greenhouse gas causing global warming. CO_2 emission is available from all kind of combustion both natural and manmade.

- Ground level Ozone:

Auto mobile emission, air craft cabins etc are Ozone generators. Ground level ozone (O_3) formed from NO_x and VOCs and Ozone (O_3) is a key constituent of the troposphere. It is also an important constituent of certain regions of the stratosphere commonly known as the Ozone layer. Photochemical and chemical reactions involving it drive many of the chemical processes that occur in the atmosphere by day and by night. At abnormally high concentrations brought about by human activities, it is a pollutant and a constituent of smog.

- Polycyclic aromatic hydrocarbon(PAH):

PAH are released from cigarette smoke and stove smoke, can cause lung cancer.

- Radon:

Released naturally from volcanic eruption, it is a radioactive material ionizes biological molecules, causes cell disruption and causing lung cancer. Radon is a colorless, odorless, naturally occurring,

radioactive noble gas which is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking.

- Asbestos:

Asbestos fiber dust released from building material, mines, mills and insulations causes Mesothelioma, lung cancer, Asbestosis.

- Arsenic:

Found in copper smelters and cigarette smoke causing in lung cancer.

- Allergens:

House dust, Pollen, animal dander causes Asthma and rhinitis.

- Particle matter SPM, PM10, PM 2.5:

Suspended particles are formed in every type of combustion and originated from various sources; PM 2.5 can even reach the blood circulation via the respiratory tract. Increased levels of fine particles in the air are linked to health hazards such as heart disease,[13] altered lung function and lung cancer. Particulates are related to respiratory infections and can be particularly harmful to those already suffering from conditions like asthama.[14]

- HCl:

Released naturally from volcanic activities, causes eye irritation and damages mucus membrane and affects respiratory system.

- Dioxin:

Dioxin is a toxic gas produced from burning of electronic wastes and plastic materials; it could cause cancer and affect the immune system and leads to developmental reproductive disorders.

- Furans:

Furans are released during the burning of plastic products such as nylon, containing various harmful compounds.

- Odour:

Odour also causes irritation causing nausea and headache.

- Mercury:

Gold refinery is the major source of Mercury and it is a known carcinogen. Moreover, mercury may also cause brain & kidney damage.

- Lead:

Lead particle found in petrol smoke and cause health issues such as affects respiratory system, blood and kidneys also cause dyslexia and hyperactivity in children, however currently it is completely banned from fuel as use of lead free gasoline. Burning of lead containing electronic wastes causes the adverse effect to the atmosphere.

- Compounds of Cadmium, Antimony, Arsenic, Zinc and Copper:

These metallic elements often toxic and irritating smoke causes adverse health effects, generally found in pesticides and fumes and gas emission during the burning of plastic and electronic wastes.

- Volatile organic compounds (VOCs):

VOCs are xylene, ethyl benzene and tri-methyl benzene compounds commonly found in Air freshener, air cleaners (with ozone), cleaning and disinfecting chemicals, cosmetics, gasoline, fuel oil, moth balls and vehicle exhaust. There is an array of compounds listed in this category such as Acetone, Benzene, Ethyl glycol, Formaldehyde, Methylene chloride, Perchloro ethylene, Toluene, Xylene, 1, 3- butadiene. Short time exposure may result irritation in eye and nose, headache, nausea, vomiting, dizziness and asthma. Continues exposure damages central nervous system, kidney and liver, some are carcinogens causing cancer.

- Persistent Organic Pollutants (POPs):

These substances could persist in the environment, causing bioaccumulation via the food chain, they are found in chemicals which transport for long range by air current to countries that even not produce them. Main sources are industrial products such as Poly chlorinated biphenyl (PCB), pesticides such as DDT, industrial by products and burning of waste products such as dioxins and furans. (European commission,' 2014).

- Sulphur dioxide:

Sulphur dioxide is generated from industries, burning of fossil fuels, forest fires, electric generation plants, smelting plants, industrial boilers, petroleum refineries and volcanic eruptions which causes respiratory problems, severe headache, reduced productivity of plants, yellowing and reduced storage time for paper, yellowing and damage to limestone and marble, damage to leather, increased rate of corrosion of iron, steel, zinc and aluminum.

- Hydrocarbons:

Hydrocarbons are in the form of Poly-nuclear Aromatic Compounds (PAC) and Poly-nuclear Aromatic Hydrocarbons (PAH) which originate from automobile exhaust and industries, leaking fuel tanks, leaching from toxic waste dumping sites and coal tar lining of some water supply pipes. These are carcinogenic in nature and may cause leukemia.

- Silicon dioxide:

It originates from stone cutting, pottery, glass manufacturing and cement industries which causes silicosis and a cancerous disease.

- Ground level Ozone:

It is the major component of Fog and it is produced by the photochemical reaction between NO_x and Volatile Organic Compounds. Causes breathing difficulty and aggravates the lung diseases such as Emphysema and chronic bronchitis.

- Peroxyacetylnitrate (PAN):

PAN is formed due to photochemical reaction of NO_x with hydrocarbons in the sunlight, it is a component of photochemical smog, smog is a mixture of air pollutants such as gases and particles react with sun light. PAN often causes irritation to eye and together with Ozone it lowers the lung capacity and increases breathing rate. (Ron Brecher, 2003)

- CFC:

Chloro-fluoro carbons (CFCs) originates from refrigerators, air conditioners, foam shaving cream, spray cans and cleaning solvents which unfortunately destroy ozone layer leading to permitting harmful UV rays to enter the atmosphere. The ozone layer protects the earth from the ultraviolet rays sent down by the sun. If the ozone layer is depleted by human action, the effects on the planet could be catastrophic.

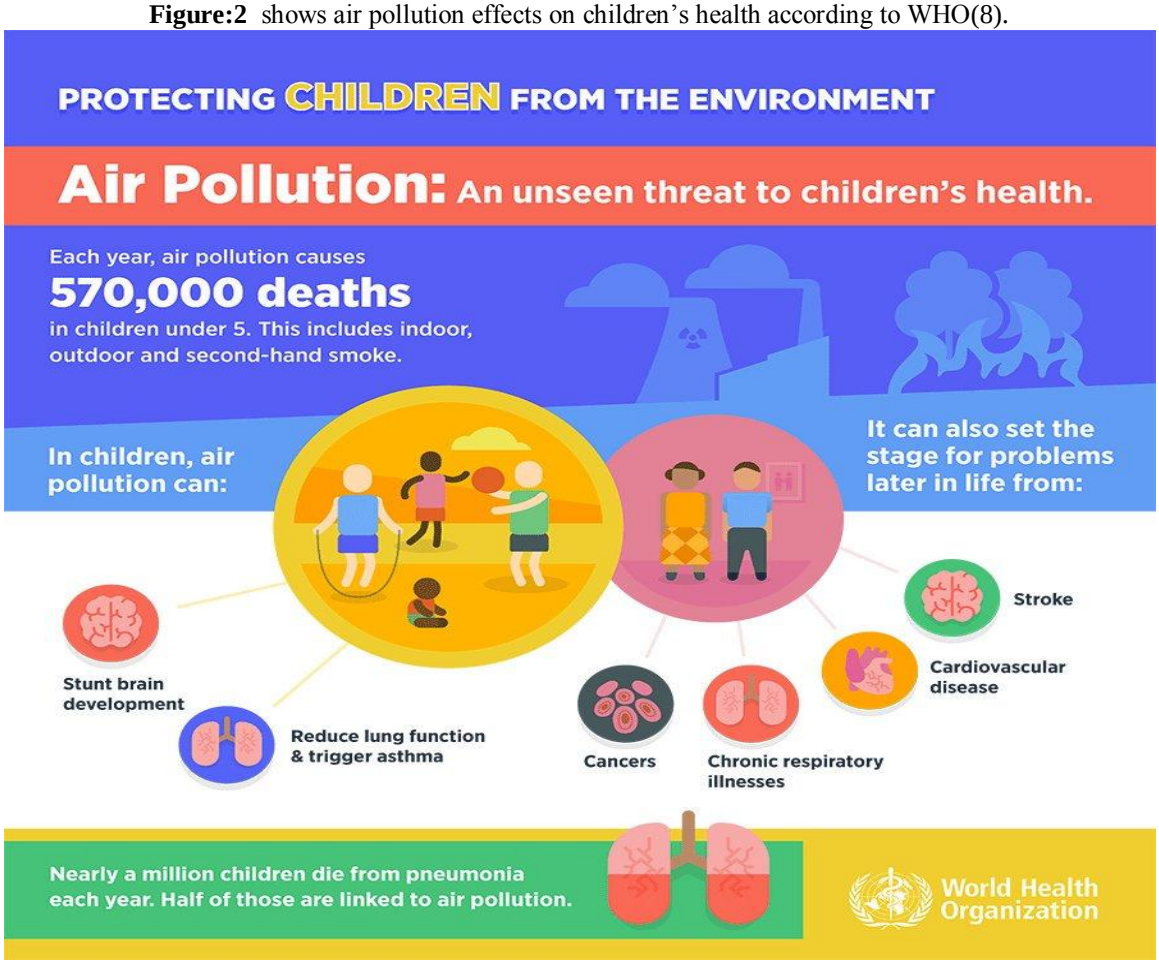
- Halons:

Brominated organic compounds used as fire retardant which is also an Ozone depleting compound.

- H_2SO_4:

Sulpuric acid formed due to the reaction of oxides of Sulphur with atmospheric water vapour, causes acid rain and respiratory problems.

Figure:2 shows air pollution effects on children's health according to WHO(8).



III. Air pollution control approach:

The present chapter high lights an integrated approach which inter-alia include Source Control, Pathway control, and Receptor control. Brief details are given hereunder:

- **Pathway Control:**

Pathway control is a control system through which the air pollutants are restricted or arrested between a source and receptor through the mechanism of scavenging and filtration .This can be achieved by having a green belt of suitable species between source and receptor. Such a green belt would be able to absorb the air pollution gases and would also act as filtering media for the particulate matter. Sometimes in certain situations, curtains in the form of high walls or other means are also provided between sources and receptor to restrict air pollutants to reach receptors.

- **Receptor Control:**

Receptor control is governed by an integrated urban and rural planning which should invariably incorporate environmental policy parameters in the form of following:

√ Atmospheric stability condition

√ Aerodynamic effects
√ Albedo-effect
√ Heat island effect
√ Ventilation coefficients
√ Optimization between concreting and non-concreting surface area
√ Optimization between vertical to horizontal expansion of urban area
√ Sustainable urban and industrial planning

If the above issues are adequately and scientifically addressed, the level of air pollution at the receptor urban area shall be significantly low.

- **Source Control:**

Main stress is usually laid on source control techniques with the focus on two fronts, one on "transformation of waste gasses / materials into usable products" and second on "end of the pipe treatment ". The first approach is gradually coming to fore front with the advancement of research and developmental activities and which has economic value addition. The second approach is cost intensive in which pollution control equipment or devices are installed to restrict air pollution into atmosphere. Source control is also associated with introduction of cleaner technologies, optimization of processes, controlled combustions, use of cleaner raw materials or fuels etc.

IV. URBAN PLANNING TOOLS PREVENT AIR POLLUTION:

The authors in the present paper have defined following environmental policy
parameters required to be infused into the process of urban planning in a more scientific and compatible manner to reduce or prevent urban air pollution.

- Optimization between concreting and non- concreting urban surface area
- Optimization between vertical to horizontal expansion of the city
- Ventilation coefficient
- Heat island effect
- Albedo effect
- Urban Atmospheric stability
- Temperature inversion
- Aerodynamics effects like wind rose and stability rose diagrams

4.1 Optimization between concreting and non- concreting urban surface area:

The urban areas are fast expanding looking to the needs of people, commercial activities and other amenities. These areas are becoming the jungle of concreting. In case of a concreting surface, the incoming solar radiation, reradiates back in to the lower urban atmosphere, making it more warmer as compare to rural or open area where absorption of incoming solar radiation are more than the re radiation. Once the urban atmosphere becomes warmer, the air pollutants released from automobiles, household fuel burning and commercial activities gets activated due to high heat. Once these pollutants became activated, they are more reactive and impinge on human body resulting in to skin problems. In case these reactive pollutants are inhaled by human beings, they cause multifarious complex diseases.

Moreover, the resulting warmer atmosphere leads to more energy consumption in the urban areas along with more consumption of water which is emerging as serious threat in big cities. Majority of states in India are facing water shortage, particularly in big cities and towns, where water is being supplied in tankers on comparatively high price. In order to address such an alarming issue presently and times to come, optimization between concreting and non-concreting urban surface area needs to be done on scientific scale by employing highly compatible mathematical and simulation models.

4.2 Optimization between vertical to horizontal expansion of the city:

With the fast growing of urban areas, vertical expansion is getting momentum which leads to high rise buildings and more concreting. These high rise buildings if not planned in a scientific manner, restrict the movement of air on the lower buildings located on leeward side. Moreover, it provides shadow to the lower buildings restricting the light. These restrictions lead to higher energy consumption in the lower buildings and also agglomeration of air pollutants on the leeward side to impart higher concentration and adverse health effects. Such a vertical expansion without scientific planning may also lead to poor urban ventilation, albedo and heat island effects. Moreover, vertical expansion leads to high energy and water consumption which necessitates scientific optimization between horizontal to vertical development of an urban area.

In order to incorporate this environmental parameter into the process of urban planning, mathematical and simulation models may be employed to address this important issue of optimization in the process of urban development.

4.3 Urban ventilation coefficient:

Air ventilation of an urban area is very important partly for the dispersion of air pollutants and partly to save energy during summer and monsoon seasons. The more is ventilated city; the least shall be air pollution levels in urban area due to higher dispersion and transportation of pollutants. Highly ventilated city consume less energy and provide better comfort. Presently this issue is being ignored in most of the cities resulting into elevated air pollution levels and consequently diseases.

The ventilation coefficients are to be considered at different heights of urban area with a maximum at the tallest building. A well defined scientific approach with the use of mathematical models would be able to address this parameter in the process of urban development.

4.4 Heat island effect:

The urban areas with higher concreting surface and higher degree of air pollutant emissions give rise to higher temperature which transform into island of heat. It can be easily witnessed that there is a significant difference between the temperature profile of urban and adjacent rural area. Such a difference has been reported to the magnitude of 3 to 8° c.

This heat island phenomenon would attribute to activation of air pollutants and subsequently these pollutants become reactive in nature. Once the air pollutants become reactive and inhaled by human beings, they cause serious health effects. The urban heat island is also attributed to high energy and water consumption...Presently such an environmental issue is not being addressed in the process of urban development and planning. This issue should also be addressed scientifically in order to minimize heat island effect during the process of urban planning.

4.5 Albedo effect:

Albedo is the ratio of incoming to outgoing solar radiation. This ratio is disturbed in case of urban area where concreting of urban surface is more predominant. This Albedo effect leads to heat island effect, the details of which have already been elaborated.

The use of mathematical models would be able to address this parameter in the process of urban planning by balancing the incoming and outgoing solar radiations. The urban planning should have sufficient open spaces in the form of non-concrete areas like green cover etc at appropriate and scientifically identified places.

4.6 Urban Atmospheric stability:

The atmospheric stability is defined as the ability of the atmosphere for the dispersion of air pollutants released from various air polluting sources. The atmospheric stability is further classified under six categories starting from category A to category F. The atmospheric category A represents highly unstable atmosphere followed by B as unstable, C as slightly unstable, D as neutral, E as stable and F as highly stable. Highly unstable atmosphere is good for dispersion of air pollutants where as highly stable is known to have poor dispersion ability.

The urban atmospheric stability should be considered while identifying the location of new urban area and expansion of existing city. Atmospheric stability should be worked out for each city on a time scale. Decisions of establishing new urban area or expansion of existing city should be taken after analyzing the atmospheric stability of that urban area or city.

4.7 Temperature inversion:

In an ideal atmosphere, temperature decreases with height. However, during winter conditions and where concrete surface in an urban area is more, the temperature increases with height. This phenomenon is known as temperature inversion. In such a situation the air above becomes heavier which restricts the air pollutants to disperse resulting into elevated ground level concentrations of air pollutants. Such a high concentration coupled with temperature inversion may lead to air pollution episodes or catastrophes. An example of such air pollution episode is London Smog where 4000 thousand people died.

Every urban authority or planner should work out the frequency of occurrence of temperature inversion over a period of time. This will help in taking scientific decisions for mitigation when the air pollution levels are very high. Moreover, in case where the frequency of temperature inversion in an urban area is significant, vertical expansion of city should be restricted to a desired level.

4.8 Aerodynamics effects like wind rose and stability rose diagrams:

The aerodynamics of an urban area is to be scientifically analyzed. Accordingly urban planning needs to be optimized in tune with urban aerodynamics. The wind roses are the important tools for overall spatial planning and addressing environmental to some extent. It provides the overall scenario of sectoral winds along with their speeds to facilitate the planners to identify the locations or areas for residential colonies, commercial activities, industrial areas & so on so forth.

These roses have the following applications.

1. Urban Planning
2. Siting of industrial locations including chimney & other air polluting source
3. Industrial zoning & industrial estate planning
4. Air pollution modelling.
5. Disaster Management
6. Street layout
7. Ventilation of urban, industrial and housing
8. Environmental Impact Assessment study.
9. Oceanography
10. Wind Energy
11. Agriculture Engineering
12. Ambient Air Monitoring
13. Noise Impact Modelling

Similarly, the atmospheric stability roses represent graphically the % frequency distribution of different stability classes in different directions for a specified period and location. The application of stability roses are mainly used in the air dispersion modelling which predict ground level air pollutant concentrations for a given air polluting source under different stability conditions.(9)

V. CONCLUSIONS:

Air Pollution is an area where integrated approach needs to be infused into the system of planning, strategy formulation, and technological advancement in the form of cleaner technology, transformation of waste into usable product, process optimization, and inter-linkage of pollution control devices with production. Significant focus needs to be given on Receptor Control coupled with Pathway Control. It can significantly reduce or prevent by incorporating environmentally policy parameters as explained in present paper.

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