

# Air Pollution in Delhi: An Analysis

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**Abstract:-** Air pollution generally happens when there are dangerous and extra quantity of substances which includes gases, particulate matter, and biological molecules are inserted into atmosphere of Earth. This can cause complex and severe diseases to humans; it may also cause harm and damage to other living organisms and food crops, and may destroy the natural and built ecology and environment. Human activities and natural processes both can generate air pollution to a great extent. Unfortunately, India is among those countries with maximum number of most polluted cities in the world with one of the worst Air Quality Index (AQI) especially, on the festival of Diwali; the air quality index of Delhi and NCR has reached to a new higher levels. Lately, the air pollution in Delhi and NCR has gone through many changes in terms of the level of pollutants and the control measures taken to control it.

**Keyword:-** Delhi NCR, Air Pollution, Air Quality Index (AQI).

## I. INTRODUCTION

Pollution is a term given to the adulteration of the earth's environment with that matter which damages and causes harm to human health, life quality and the ecosystems. The kinds of pollution involves water pollution, air pollution, noise pollution and soil pollution. Other less-known forms of pollution involves thermal pollution and radioactive pollutants. It is difficult and not right to point any one particular form of pollutant responsible for highest risk to human health and ecology; however, air and water pollution seems to be responsible the most for a large amount of health problems [1]. In 2012, air pollution was held responsible for premature deaths on average of 1 year in Europe, and was considered a serious risk factor for a large number of diseases caused by pollution, including respiratory diseases and infections, heart diseases, stroke and lung cancer [2]. The aftereffect on health caused by air pollution involves breathing difficulties, coughing, asthma and even deterioration of existing respiratory and cardiac health. Individual reactions and response towards air pollution is also dependent on the form of pollutant a person is subjected to, the degree of its exposure, and the ones past health and genetics of an individual [3]. The general forms of air pollutants includes particulate Matter (PM), Ozone, Nitrogen Dioxide, and Sulphur Dioxide. Children below five years of age who are from the developing countries are the most accessible and exposed towards it in terms of total number of deaths due to indoor and outdoor air pollution [4].

## II. AIR POLLUTANTS

An air pollutant means a matter present in air that can have harmful and severe effect on human beings and the ecosystem. These materials can be solid particles, liquid

droplets, or gases. An origin of pollutants can be natural or man-made. Pollutants are classified into primary and secondary pollutants. The Primary pollutants generally are having an origin of a process, such as ash evolving from a volcanic eruption. Other examples involve carbon monoxide (CO) gas from motor vehicles exhaustion, or the sulphur dioxide evolving from the factories. Secondary pollutants are not ejected directly but they are developed in air when primary pollutants react or interact with each other and form secondary products. Ozone at Ground level is an example of a secondary pollutant. Some pollutants are both primary and secondary type: they can both be ejected directly and also can be formed from other primary pollutants.

*Following are some of the common Air Pollutants:*

### A. Carbon Monoxide (CO)

CO is a colourless, odourless and a toxic gas. It is a non-irritating type of gas. Combustion of fuel such as natural gas, coal or wood generates this gas. Also the exhaustion from vehicles contributes majorly carbon monoxide into our earth's atmosphere. It causes reduction in the amount of oxygen availability to the humans in atmosphere, their organs and its tissues; increases the danger of heart diseases, which results in chest pain and other related symptoms and various cardiovascular problems. Infants, pregnant women, and elderly people are subjected to a high risk. In 2013, it was found that more than half of the carbon monoxide emitting into our atmosphere was evolved from vehicles and burning of one gallon of gas is emitting over 20 pounds of carbon monoxide into the Earth's atmosphere [5].

### B. Nitrogen oxides (NO<sub>x</sub>)

Nitrogen oxides, mainly nitrogen dioxide, developed from combustion at high temperature, and can also be generated during the thunderstorms by electric discharge. Nitrogen Oxides can be seen as a brown haze dome produced above or a cover of downwind of cities. NO<sub>2</sub> is a chemical compound with the formula of Nitrogen Dioxide. It is one of the dangerous and harmful of the nitrogen oxides. It is a reddish-brown toxic gas with a characteristic sharp, biting odour of its own.

### C. Sulphur oxides (SO<sub>x</sub>)

Among Sulphur Oxides, Sulphur Dioxide is the most dangerous among all as an air pollutant. Sulphur Dioxide is a chemical compound with the formula of SO<sub>2</sub>. SO<sub>2</sub> originates due to volcanoes and their activities and during various industrial processes. Coal and petroleum often have sulphur compounds, and their combustion emit sulphur dioxide. Furthermore oxidation of SO<sub>2</sub> in the presence of a catalyst such as NO<sub>2</sub>, generates H<sub>2</sub>SO<sub>4</sub> which is the main reason for acid rain [2]. This is one of the main reason for concern over the environmental impact with the use of these fuels as a power source towards the earth's environment.

#### D. Carbon dioxide (CO<sub>2</sub>)

Due to the huge role of Carbon Dioxide as a greenhouse gas it is called as "the leading pollutant"[6] and "the worst climate pollution"[7]. Carbon dioxide is a natural product in the atmosphere, significant for plant life and exhaled by the humans through their respiratory system [8]. CO<sub>2</sub> forms about 410 parts per million (ppm) of earth's atmosphere, compared to about 280 ppm in pre-industrial times [9] and billions of metric tons of CO<sub>2</sub> is emitted yearly by burning of fossil fuels [10].

#### E. Particulate matter (PM)

Particulate Matter is developed as a gaseous primary pollutant and compound in photochemical smog. Smog is also a kind of air pollution. Also the smog results due to large proportion of coal burning in an area resulted from a mixture of smoke and Sulfur Dioxide present at that area. Usually modern smog does not originates from coal but from vehicular and industrial exhausts that are acted upon in the atmosphere by ultraviolet light from the sun to form secondary pollutants that are also mixed with the primary emissions to form this photochemical smog. It is mostly windblown dust, pollen spores, and photo chemically generated particles. Its main causes is Vehicular emission, industrial, commercial and residential combustion, industries related to construction. It causes severe Respiratory Diseases, liver fibrosis, lung/liver cancer, heart stroke, bone related diseases and Visibility reduction. Particulate matter is the sum total of all solid and liquid particles suspended in atmosphere and which are hazardous to human health. This complex mixture involves both organic and inorganic particles, like dust, pollen, soot, smoke, and liquid droplets.

Total suspended particulate matter (TSPM): The density mixture of particulate matter in air that is obtained during a high volume bulk sampling is done on a filter substrate. It involves particles of all sizes.

- PM<sub>10</sub>: Diameter of these types of particles less than 10  $\mu\text{m}$ .
- PM<sub>2.5</sub>: Diameter of these types of particles less than 2.5  $\mu\text{m}$ .
- PM<sub>1.0</sub>: Diameter of these types of particles less than 1  $\mu\text{m}$ .

Diameter of particles which lie between 10 $\mu\text{m}$  to 2.5 $\mu\text{m}$  are known as 'coarse particles' whereas particles with diameter less than 2.5 $\mu\text{m}$  are known as 'fine particles'. Fine particles also includes ultra-fine particles of size less than 0.1  $\mu\text{m}$  (PM<sub>0.1</sub>).

#### F. Lead

Lead is a metal whose colour is blue-grey and is very toxic in nature which is found in many forms and locations on earth. Apart from it, lead comes from cars in areas where unleaded gasoline is not in use. Lead also originates from power plants and other industrial emissions. Lead paint is also a significant source of lead, particularly in houses where paint is peeling. Lead in pipes mainly in old pipes can also be a source of lead in drinking water. High amount of lead can be harmful for children and resulted into lower IQs and

kidney problems. Exposure to high amount of lead increases the chances of heart attacks or strokes for adults.

#### G. Ozone

Ozone is a gas that can be found in two places i.e. near the ground and upper atmosphere. Near the ground (i.e. in the troposphere), it is a big portion of a smog. The harmful ozone which also acts as a pollutant in the lower atmosphere must not be confused with the protective layer of ozone in the upper atmosphere (stratosphere), which protects the earth from harmful ultraviolet (UV) rays. Ozone is not formed primarily, but it is formed when nitrogen oxides and volatile organic compounds combine in the presence of the sunlight, due to which ozone is mainly found in the summer season. Nitrogen oxides generated from burning of gasoline, coal, and other fossil fuels. There are many forms of volatile organic compounds, and they originate from sources ranging from factories to trees. Ozone near the earth's ground level can cause a number of health problems and is considered as a pollutant. Ozone can lead to higher risk to asthma attacks in people having asthma and causes sore throats, coughs, and breathing difficulties and related problems. It even leads to premature deaths. Ozone can also cause damage to plants and crops.

#### H. Toxic Air Pollutants

There are a large number of chemicals that are known to cause cancer in humans. Some important Toxic pollutants involve arsenic, asbestos, benzene, and dioxin. Every different toxic air pollutant originates from a slightly different source, but many are generated chemical industries or are exhausted when fossil fuels are burned for power generation. Few toxic air pollutants, like asbestos and formaldehyde are found in building materials and thus results to indoor air problems. Many toxic air pollutants also enter the food and water supplies in the houses. Toxic air pollutants can cause cancer in humans. Some toxic air pollutants can also leads to birth defects in severe cases. Other effects depend on the type of pollutant and also involve skin, eye irritation and breathing problems.

#### Air Quality Index (AQI)

An air quality index (AQI) is a number which is created and used by government agencies [12] to indicate the public how polluted the atmospheric air presently is and to what level it will be polluted in near future [13][14]. With this AQI increment, our large portion of the population is likely to experience increased severe adverse health effects with as a trend.

The Air Quality Health Index gives a number from 1 to 10+ to show the level of risk on human health attached with local air quality index. At certain occasions, when the amount of air pollution is unusually high, the number may also exceed 10. The AQHI provides a local air quality value at present scenario and local air quality maxima forecast for today, tonight, and tomorrow, and gives associated health advices to people living at that particular area [15] which could be helpful at certain occasions.



Every health risk category has certain advice associated with it. At low and medium levels the public are advised to continue normal activities. At the high category occasions, children, the elderly and people suffering from heart or respiratory illnesses must reduce outdoor physical exposure or it should be at minimum level. On top of this (very high or serious) the general population is also advised to reduce or avoid outdoor exposure. Masks are highly recommended in these types of situations.

On 17 September 2014, The National Air Quality Index (AQI) was launched in New Delhi under the Swachh Bharat Abhiyan [16]. Taking into account the hazardous impacts caused by air pollutants, their effective management is a must. Therefore, to monitor and control of these air pollutants, Central Pollution Control Board (CPCB) has been set up by the government with various powers and functions under the Air (Prevention and Control of Pollution) Act, 1981.

Health risk category	AQHI
Low	1
	2
	3
Medium	4
	5
	6
High	7
	8
Very High	9
	10
Serious	10+

The Central Pollution Control Board along with State Pollution Control Boards is operating National Air Monitoring Program (NAMP) which covers more than 240 cities of the country having more than 342 stations which monitors its working [17]. An Expert Group consisting of medical professionals, air quality experts, academia, advocates and IIT Knapur has been awarded technical study. IIT Kanpur and the Group of experts suggested an AQI scheme in 2014 [18]. Whereas the earlier measuring index was limited to three indicators, the new index can measure upto eight parameters.[19] The continuous monitoring systems that provide data on near real-time basis i.e on daily basis, are installed in New Delhi, Mumbai, Pune and

Ahmedabad [20]. There are six AQI categories, i.e Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. The AQI generally consider into account eight pollutants i.e. PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub>, SO<sub>2</sub>, CO, O<sub>3</sub>, NH<sub>3</sub>, and Pb.

These are the pollutants which are taken into consideration.

*A. Air quality index (AQI) in Delhi*

The tool of Air quality index (AQI) is to check air quality majorly in urban cities across the country on a real – time basis which also increases public awareness and opinion and tends them to take steps which are in their hands. The AQI launched is based on human exposure and health effects and may not applicable to sensitive areas of eco system. Various pollutants which are considered for AQI determination are PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub>, O<sub>3</sub>, CO, SO<sub>2</sub>, NH<sub>3</sub>, and Pb [21]. The data obtained is available online at various air quality monitoring stations is the most suitable for the AQI determination as information on AQI can be generated on real time basis. For the ease of understanding, colour bands are used to represent various AQI bands which are shown as follows.

AQI	RANGE
GOOD	0-50
SATISFACTORY	51-100
MODERATELY POLLUTED	101-200
POOR	201-300
VERY POOR	301-400
SEVERE	401-500

According to AQI bulletin (January 2016), PM<sub>2.5</sub> is the significant pollutant in Delhi and neighbouring areas like NCR which continuously exceeds the standard mark [22]. In the months of May – October, the AQI seems that air quality is moderately polluted. However, after October, the situation is becoming worse and worse. The average AQI in the month of January was recorded from very poor to severe. Maximum value of recorded PM<sub>2.5</sub> was 296 µg/m<sup>3</sup> during January 2016 (at IHBAS, Dilshad Garden) which is above the prescribed standard limit (60 µg/m<sup>3</sup>). There is a number of sources which are responsible for the particulate matter sources such as transport, road dust, gaseous combustion etc. On top of that, the sources also get influenced by the meteorological conditions which are prevailing in the neighbouring areas.

As per the Central Pollution Control Board, Air Laboratory [23], PM<sub>10</sub>(µg/m<sup>3</sup>): is recorded 950 highest in Ghaziabad on 11 November 2017 and then 935 in RK Puram on 8 November 2017. Some other most polluted areas in Delhi were recorded as Pusa road (918), Lodhiroad(927), IGI Airport Terminal 3.

PM 2.5 ( $\mu\text{g}/\text{m}^3$ ): is recorded highest at CRRI Mathura Road as 827 on 8 November 2017 and on the same day as 789 at AnandVihar and 788 at Punjabi Bagh.

SO 2 ( $\mu\text{g}/\text{m}^3$ ): SO 2 is found to be highest at Ghaziabad on 9 November 2017 as 140 and 135 is recorded at Bhiwadi RICO industrial area 3 which is seen to be due to the industrial pollution at both the places, which also shows that industries are the main sources of this harmful and dangerous pollutant. At Non- Industrial areas Faridabad Sector 16 recorded highest SO 2 of 66 on 9 November 2017, Noida Sector 125 at 65 at 17 November and RK Puram at 50 on 25 November 2017.

NO<sub>2</sub>( $\mu\text{g}/\text{m}^3$ ): NO<sub>2</sub> is found to be all time high at 588 which is very dangerous at Punjabi Bagh On 28 November 2017 then 214 at RK Puram on 12 November 2017.

CO ( $\text{mg}/\text{m}^3$ ): CO is found to be highest at Ghaziabad upto 5.9 on 8 November 2017 and 5.7 at Punjabi Bagh on 8 November 2017.

Ozone ( $\mu\text{g}/\text{m}^3$ ): Ozone is found highest at North Campus on 1 November 2017 at a record high of 143, 133 at Ghaziabad on 30 November 2017, then comes Anand Vihar with 119 on 29 November 2017.

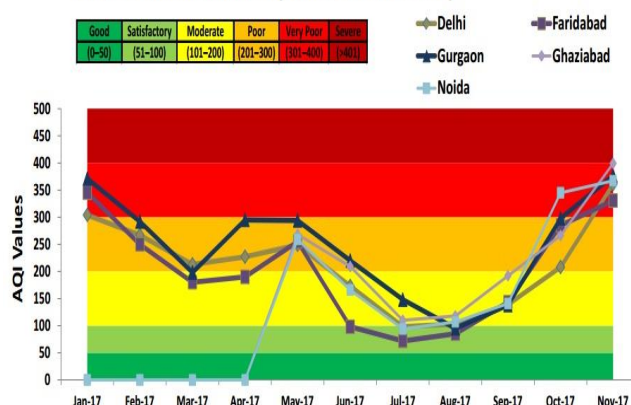
From the above discussion it is seen that the air pollution is getting worse year by year as we can see the readings of year 2016 and 2017 which are even worse and particularly the particulate matter. The increment in the Delhi's pollution levels particularly in the last few winters may be due to the meteorological conditions, which are not only escorting pollutants from north India due to stubble burning, but also trapping and accumulating in the capital — a study by Delhi Public School (RK Puram) has found in its studies [24].

The study which examined IMD's data between 2000 and 2017 found that there had been a small increment in relative humidity, aggravated by a drop in average wind speed in these past five years. Furthermore it has been spotted changes in wind direction over this period and founded that there was a shift in the direction from northwest in 2000 to north in winter months, which directly brought stubble burning pollutants from Punjab and Haryana toward the Delhi NCR. Also in wind direction, there had been a common change from northwest and north of northwest in 2000 to northern winds, which was first observed in 2010 and particularly in the past two years.

This Describes how high pollution is observed in October and November. Breezes and Winds from Punjab and Haryana were taking in particulate matter that accumulates in Delhi and its neighbouring areas as it acts as a sink. Firecrackers celebrations on Diwali and New Year celebrations further pile and increases its pollution levels according to the study. The research also found two other factors that helped this phenomenon — Local relative humidity and wind speed in the area.

Whereas between 2000 and 2017 there was a common rise in wind speeds till 2010 and after that a decline was seen. For the past five years the average wind speed in Delhi decreases from 3 m/s to less than 2m/s which shows that there is less movement of air and due to which the dispersion of pollutants also decreases. Talking about Relative Humidity, during the period of 2000-2017 there is a relative increase of 56% to 61% which also provides more and more moisture to the particulate matter to get trapped in this area which makes the situation more worse. Figure 1 shows the present trend in AQI.

AQI Trend Delhi-NCR (Jan. to Nov. 2017)



Current Trend in the AQI of Delhi NCR

On top of that with the increase in the number of vehicles coming to the streets of the capital has increased the concern for the air pollution in Delhi NCR. 2017 has shown the highest increase in the registered vehicles with a total of 681275 registered vehicles in capital city Delhi and NCR which is an all-time high. In 2016, there were 673932, 588349 in 2015, 529566 in 2014 [25], which is going on increasing with time and which has become the factor for increase in the AQI in Delhi and NCR.

With the number of vehicles increasing on which there is subsequent add up in AQI which is being studied in this study. Above that industrial pollution, Chloroform Carbon (CFC) also add carbon dioxide and other harmful gases which subsequently turn to the Green House Gases and further aggravating the temperature of the capital region.

Impact of CNG on vehicular pollution in Delhi is satisfactorily good and it is right now seems to be the most favourite option for the capital region. Daily ambient air quality data which we is taken in this study from the busiest crossing in Delhi do not shows an all-round improvement in AQI. The Nitrous Oxides (NO<sub>x</sub>) has risen after the conversion whereas SPM and PM<sub>10</sub> have shown only marginal fall; Carbon Monoxide (CO) has shown a significant decline [26].

### III. GEOGRAPHICAL ISSUES

In addition to the vehicular and industrial emissions, local climatic and seasonal factors also affect the air quality of Delhi. Delhi is a land-locked territory and is therefore unable to dilute its emission with the effects of sea unlike

other metropolitan cities like Mumbai, Kolkata, and Chennai. Delhi is also surrounded by the regions of variable climatic patterns. From west, there is Great Indian Desert (Thar desert) of Rajasthan while in the north and east direction there are cool hilly regions of Himalayas. At its south, there are plains which are relatively hot. Thus, Delhi is located in the subtropical region with extremely hot summers, moderate rainfall, and extremely cold winters. The winters are extremely important in Delhi as it is dominated by cold, dry air which add up with low wind conditions, these conditions are responsible for increasing the density of air and concentration of pollutants [27] into the atmosphere. High concentration of pollutants are literally trapped very close to earth's surface due to the layer of warm air acts as a lid which locks and covers it on top of this layer. Thus, dense smog which formed during winter months is being witnessed in Delhi in the past years, the reason of which is vehicular exhaust pollution as well as the prevailing geographical disadvantage with meteorological conditions in the months of December and January of the Delhi and NCR. In November 2017, in an event known as the Great smog of Delhi, the air pollution spiked far beyond acceptable levels. Levels of PM<sub>2.5</sub> and PM 10 particulate matter hit 999 micrograms per cubic meter, while the safe limits for those pollutants are 60 and 100 respectively [28].

#### IV. SUGGESTIONS AND RECOMMENDATIONS

- [1]. Control measures of pollution must be effective, and proper installation of air pollution control devices and their smooth functioning must be ensured before the launching and working of any industry.
- [2]. Exhaust and emission from construction industries / activities can be minimized by adopting best Practices.
- [3]. Old polluting vehicles should be strictly prohibited.
- [4]. Subsidies may be given on the vehicles installing fuel machinery.
- [5]. Up-gradation of public transport must be done compulsory by improving service quality, enhancing the number of buses, and better road management.
- [6]. Idea of working in different shifts for corporate firms / government offices to minimize traffic at peak hours can be introduced.
- [7]. Strict rules should be imposed and followed regarding proper dumping and disposal of solid waste, because unregulated burning of plastics and other dumps results in pile-up of smoke and particulate matter.
- [8]. Odd Even by the government should be seriously followed and pool system should be there for the employees heading towards the same or nearby place.
- [9]. More and more CNG vehicles should be opted by the government.

#### V. CONCLUSION AND REMARK

This Critical Study in this paper reveals that the condition of the national capital is deteriorating year by year. It is seen that the Pollutants are being increased in our capital due to the conditions that are evolved as per time, due to which the AQI along with the temperature of the capital is on the rise which must be controlled.

The study shows that due to increasing number of vehicles, industrial waste along with the winds from the neighbouring states pile up to the problem of high pollutants in the air of Delhi (especially in winter season). Specially in winters this pollution gets trapped with humidity and becomes smog which gets trapped in the capital due to its geographical constraints and the national capital becomes a smoke chamber which is very dangerous to the children, old people and patients suffering from respiratory diseases. This study shows that the recent trend of Particulate Matter is going beyond severe condition mark i.e 400-500. Especially PM<sub>2.5</sub> is becoming more severe as these Fine particles may come from various sources. These involve power plants, motor vehicles, airplanes, residential wood burning i.e Indian domestic *chulhas*, forest and irrigational fires, agricultural burning, dust storms and volcanic eruptions. Some are emitted directly into the air, while others are generated when gases and particles interact with one another in the atmospheric air. Because the size of these particles is so small and light, fine particles tend to stay for longer duration in the air than heavier particles. This increases the chances of humans and animals inhaling them into their bodies. Due to their micro size, particles smaller than 2.5 micrometres are able to enter the nostrils and throat and infiltrate deep into the lungs and eventually enter the circulatory system.

It is found that there is a close link between exposure to fine particles and premature deaths due to heart and lung problems. Fine particles are also known to exaggerate chronic disease such as asthma, bronchitis and other respiratory problems like heart attack. In this study we have found that places in Delhi NCR like Punjabi bagh, Ghaziabad, RK Puram are having largest Particulate Matter in it which is too beyond the severe mark. SO<sub>2</sub> which is a poisonous gas is also growing in industrial areas with large number of industries like Bhiwadi and Ghaziabad and less greenery which is disastrous to people's health. The study also shows the weather condition of the Delhi in winter season so the pollution during Diwali and New Year the use of fire crackers should also be checked by the government. Winter season Pollution should be checked by the government.

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