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Seasonal Air Pollution Variation in Delhi (2019): A Case Study using by the Geo-spatial Technology

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Abstract

Air Pollution is a mixture of solid particles in the air. The level of air Pollution is varying in every season according to weathering phenomena and human activities. This work has been on seasonal air Pollution in Delhi in 2019. The main aim of this study is to understand seasonal air Pollution variation in Delhi. Delhi is a union territory of India containing New Delhi the capital of India. The study area of this paper is Delhi and its 39 surrounding air Pollution monitoring stations. Due to the rapid growth of industries and vehicles, the air pollution rate is increasing day by day and it creates adverse effects on the environment and human health. This work is mainly based on six pollutants such as PM_{10}, $PM_{2.5}$, NO_2, SO_2, O_3, and CO. Through the Air Quality Index (AQI) formula, the concentration maps of these six pollutants have been prepared. The level of pollution is mainly high in the winter (December) season rather than the monsoon (July) season. The main reason for this is the weathering phenomena (fog, mist, dust, etc). It plays an important role in air pollution variation in Delhi.

Key Words: *Pollutants, Concentration, Air Quality Index, Weathering phenomena, Vulnerability*

1. Introduction

In the twenty-first century, one of the biggest challenges is air pollution, not only at global scale but also at local and regional levels (6).Air pollution occurs when gases, dust particles, fumes (or smoke) or odours are introduced into the atmosphere in a way that makes it harmful to humans, animals and plants (7).Air pollution is the presence of one or more substances at a concentration above their natural levels, with the potential to produce an adverse effect (45).Air Pollution is one of the serious problems in the world, especially in urban areas of developing countries due to rapid growth of population, increase in the number of vehicles and industrialization (19). The World Health Organisation (WHO) has recognised ambient air pollution as a class one carcinogen and the fourth highest risk factor for premature death worldwide(20).Worldwide, air pollution is a serious problem and it has harmful effects on human health. It is reported that >3 million deaths are attributed to air pollution every year. An aggregate of gases—such as carbon monoxide (CO), nitrogen dioxide (NO_2), nitrogen oxides (NO_X), ozone (O_3), and sulfur dioxide (SO_2)—particulate matter (PM), metals, and organic compounds are commonly discharged through industrial and vehicle combustions, especially in developed and rapidly developing countries(39).Patterns of human activity also change from season to season, so that a particular air pollution concentration in one season may lead to a different exposure in another season(35).According to the environmental monitoring database for the world-leading megacities encompassing 100 countries published in April 2018 by WHO for 2011 and 2016 Delhi ranks high in the list of PM_{10} pollution(WHO 2018)(28).Air pollution varies seasonally. In the study area, the air quality index is generally moderate level between January to September and then it drastically deteriorates to very poor, severe or hazardous levels from October to December. Due to stubble burning, road dust, vehicle pollution and cold weather in the winter season air pollution are more dangerous than monsoon season.The winters in megacity Delhi are harsh, smoggy, foggy, and highly polluted. The pollution levels are approximately two to three times those monitored in the summer months, and the severity is felt not only in the health department but also in the transportation department, with regular delays at airport operations and a series of minor and major accidents across the road corridors(16).Delhi is considered to be one of the most polluted cities in the world(2).Sharma,*et al*., (2001) have developed an AQI in the Indian context by considering three pollutants: sulphur dioxide (S02), nitrogen dioxide ($N0_2$) and Suspended Particulate Matter (SPM). Sharma,*et al*., (2003) have proposed an AQI for the city of Kanpur by using a maximum operator concept, which takes the maximum value of sub-indices of each pollutant.The air quality index has a comparative index function and supplies the public with a better indicator of air quality. Moreover, it is

investigated that there exists a relationship between pollutant concentrations Introduction and meteorological parameters (e.g. Mccollister and Wilson, 1975; Aron and Aron, 1978; Lin, 1982; Robenson and Steyn, 1990; Ziomas *et al*, 1995). Further, Cox and Chu (1993) and Kassomenos (1995) have examined the relationship between the AQI and meteorological conditions prevalent in the urban atmosphere. Therefore a concentrated effort is underway to develop an AQI coupled with meteorological parameters (8). The Air Quality Index (AQI) is an index for reporting daily air quality(31).According to WHO, six major air pollutants are PM_{10}, $PM_{2.5}$, O_3, SO_2, CO, and NO_2. The AQI values of these pollutants are used to determine the air condition.

1.2 Study Area:

Delhi is a union territory of India containing New Delhi the capital of India. Delhi is geographically located in north India, within the latitude 28°24′17′′N to 28°53′00′′N and longitude 77°45′30′′E to 77°21′30′′E. It is bounded on three sides by the state of Haryana and Uttar Pradesh bound the east portion. The NCT covers an area of 1,484 square kilometres (573 square miles). Delhi is located in the western part of the Yamuna River, 213-305 metres above the mean sea level. Its maximum length is 51.50 km and its width is 48.48 km.

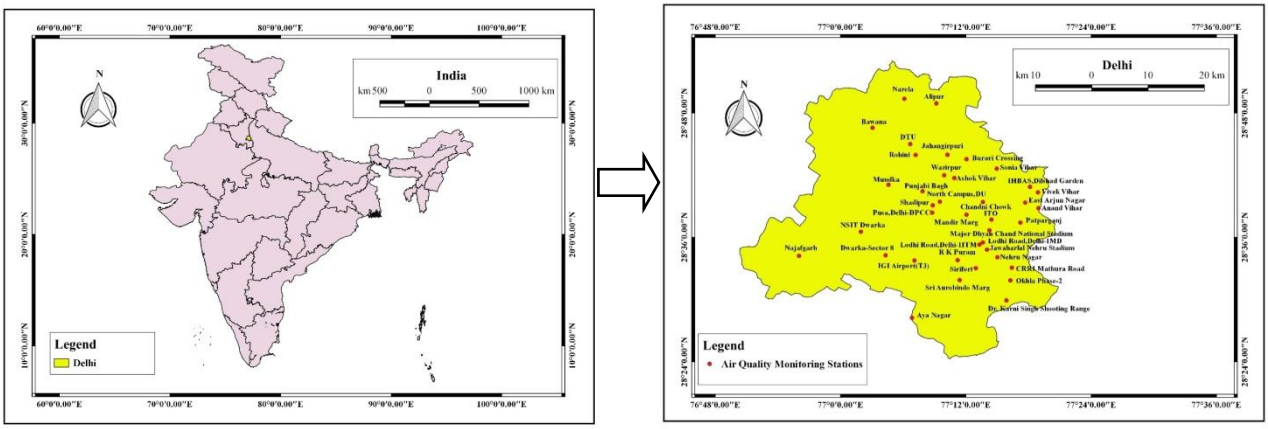


Figure No. 1 ***Location Map***

In Delhi, there are 39 air pollution stations under the control of the Central Pollution Control Board (CPCB), Delhi Pollution Control Committee (DPCC), Indian Meteorological Department (IMD) and Indian Institute of Tropical Meteorology (IITM). Stations are Alipur(DPCC), Anand Vihar(DPCC), Ashok Vihar(DPCC), Aya Nagar(IMD), Bawana(DPCC), Burarai Crossing(IMD), Chandni Chowk (IITM), CRRI Mathura Road (IMD), Dr Karni Singh Shooting Range (DPCC), DTU (CPCB), Dwarka-Sector8(DPCC), East Arjun Nagar (CPCB), IGI Airport(T3) (IMD), IHBAS Dilshad Garden(CPCB), ITO (CPCB), Jahangirpuri (CPCB), Jawaharlal Nehru Stadium (CPCB), Lodhi Road (IITM), Lodhi Road(IMD), Major Dhyan Chand National Stadium(DPCC), Mandir Marg(DPCC), Mundka (DPCC), NSIT- Dwarka(CPCB), Najafgarh(DPCC), Narela(CPCB), North Campus-DU (IMD), Nehru Nagar(DPCC), Okhla Phase 2(DPCC), Patparganj(DPCC), Punjabi Bagh (DPCC), Pusa (DPCC), R.K Puram-(DPCC), Rohini (DPCC), Shadipur (CPCB), Sirifort (CPCB), Sri Aurobindo Marg (DPCC), Sonia Vihar (DPCC), Vivek Vihar (DPCC), Wazirpur (DPCC).

1.3 Objective

To study the spatial and seasonal variations of air pollution and show the vulnerable zonation in Delhi, according to the present situation.

2. Methodology

The study has focused on season-wise air pollution variation in the Delhi National Capital Region (Delhi NCR), with the help of six parameters ($PM_{2.5}$, PM_{10}, NO2, SO_2, CO, O_3). As the study is based on secondary data, so all the work has been done by various sources on the internet. The Air Quality Index (AQI) is a quantitative tool that can be used to report air pollution, providing information on how clean or polluted the air is. AQI adopted in India in 2014, is a six-colour code with a scale (Good, Satisfactory, Moderately polluted, Poor, Very Poor, Severe) developed for easy understanding to know the pollution condition and easy to aware people for their health as well as for the environment.

Table No:-1**National AQI classes, range and health impact and health breakpoints for the six pollutants Scale (0-500).**

AQI Class (Range)	Health Impact	PM_{10} 24 hrs (µg/m³)	$PM_{2.5}$ 24 hrs (µg/m³)	SO_2 24 hrs (µg/m³)	NO_2 24 hrs (µg/m³)	O_3 24 hrs (µg/m³)	CO 24 hrs (µg/m³)
		Concentration Range					
Good (0-50)	Minimal Impact	0-50	0-30	0-40	0-40	0-50	0-1
Satisfactory (51-100)	Minor breathing discomfort in sensitive people	51-100	31-60	41-80	41-80	51-100	1.1-2
Moderately Polluted (101-200)	Breathing discomfort to people with lung	101-250	61-90	81-380	81-180	101-168	2.1-10
Poor (201-300)	Breathing discomfort to the people on prolonged exposure	251-350	91-120	381-800	181-280	169-208	10-17
Very Poor (301-400)	Respiratory illness the people with prolonged exposure	351-430	121-250	801-1600	281-400	209-748	17-34
Severe (401-500)	Respiratory illness the people with prolonged exposure	>430	>250	>1600	>400	>748	>34

Source: Central Pollution Control Board, 2019

All data has been collected from Central Pollution Control Board (CPCB) and then calculate the AQI value with the help of the AQI formula. Due to having a lot of data, all the data has been divided into three main shifts to facilitate the work of having multiple data. The shift is mainly based on the working time, like (00:00-08:00),(08:00-16:00),(16:00-00:00), as a result, it will be possible to know the level of pollution accurately. With the help of QGIS software, the IDW map of Delhi has been prepared to show the concentration zones of Delhi. Satellite images have been collected from USGS earth explorers between the years 1989 and 2019 to know the land use and land cover pattern. With the help of Semi-Automatic Classification Plugging in QGIS, supervised classification has been done. Climatic data from Palam weather station and Safdarjung weather station of Delhi has been collected by Indian Meteorological Department (IMD) to know the weathering phenomena.

Air Quality Index (after Pal, *et al.*, 2020**):**

$$I_i = [\{(I_{Hi} - I_{Lo})/(B_{Hi} - B_{Lo})\} \times (C_p - B_{Lo})] + I_{Lo}$$

Where,

I_i = *The Index for Pollutants*

C_p = *Pollutant concentration*

B_{Hi} = *Break point Concentration i.e. greater than or equal to* C_p

B_{Lo} = *Break point Concentration i.e. less than or equal to* C_p

I_{Hi} = *The AQI value equivalent to* B_{Hi}

I_{Lo} = *The AQI value equivalent to* B_{lo}

3. Result:

3.1 PM_{10}:

Respirable Suspended Particulate Matter or PM_{10} consists of particulates having a diameter of less than 10 μm. These are very small particles(18).Some particulates occurs naturally emitting from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray and some are emitted directly from anthropogenic sources, such as construction sites, unpaved roads fields, smokestacks of fires(1).

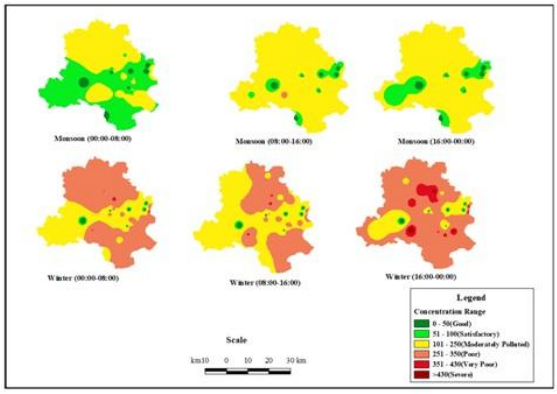
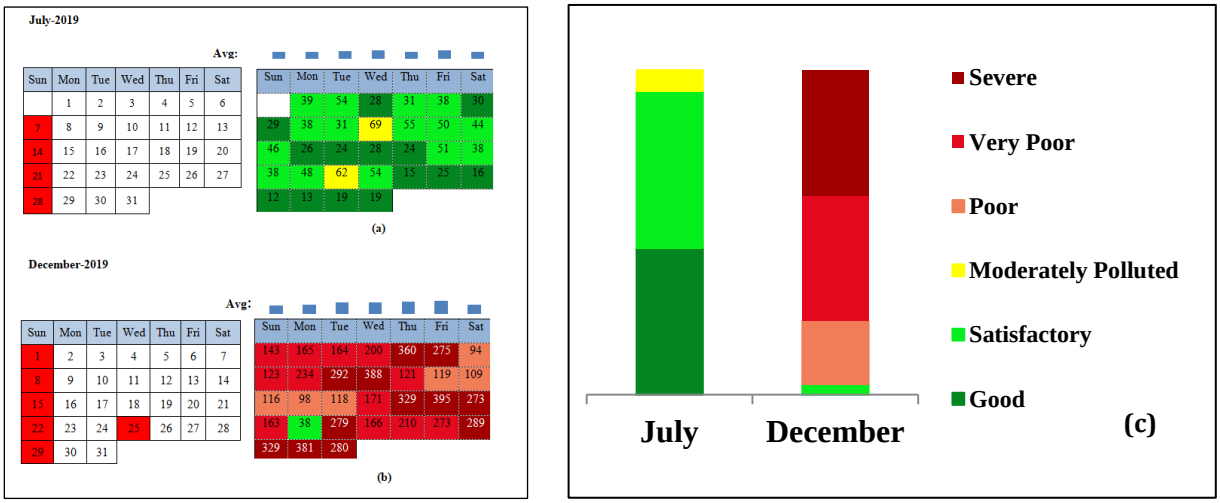


Figure 2 Concentration of PM_{10} in Monsoon and Winter of Different Time, 2019

Spatial Variation

In monsoon, the concentration range of PM_{10} mainly varies from good to satisfactory condition. In the morning to day shift (08:00-16:00) and afternoon to mid-night shift (16:00-00:00) moderately Polluted conditions are mainly seen. In those, time sections, industrial emissions and vehicle emissions are very high which is the main source of PM_{10} and most of the places are belongs in satisfactory condition duringthe midnight to morning shift because in this time vehicle emissions are comparatively low as well residential emission is also less. On the other hand concentration range of PM_{10} belongs from good to severe conditions in the winter season. Wazirpur station is an industrial area and many industries are found like chemical industries, consumer goods industries, etc. so industrial emissions mainly chemical industries are the main cause to occur pollution. For this reason, Wazirpur station falls in very poor condition in terms of pollution. During this season neighbour states such as Punjab, and Haryana burns agricultural stubble causing a layer of smoke to spread over the entire Delhi. For this reason, all the particles are stuck in this smoky layer and increase the level of pollution and weathering phenomena like mist, fog, etc. play a big role in this. The amount of fog and mist is very high during the night and morning shiftsand contamination of PM10 is also high in the morning and night shifts. Because fog creates a layer in the atmosphere that's why pollutants could not spread in the upper atmosphere. But in the day shift amount of fog and mist is comparatively low(Fig No:2).

About 32% and 42% (which is calculated) days are in satisfactory and moderately polluted conditions respectively.Contamination of PM_{10} has been found on Thursday and Friday because these days are working days(Fig No: 3a, 3b).About 3%, 35%, 16%, 19% and 26% (which is calculated) days are in satisfactory, moderately polluted, poor very poor and severe conditions respectively in December.Contamination of PM_{10} is high on Thursday and Friday. On Monday, Tuesday and Wednesday, the concentration of PM_{10} is also high, because these are working days. Therefore, vehicle and industrial emissions are high in those days (Fig No: 3a, 3c).



Source: Central Pollution Control Board

Figure No. 3 Status of daily (24hrs) average PM_{10} concentration during monsoon & winter (2019) in Ashok Vihar, Delhi

In Delhi, many people suffer many health problems as if nose block, wheezing cough, attacks of shortness of breath, etc. that are mainly caused by PM_{10} pollutants.Few people are suffering from lung cancer and COPD disease that are mainly caused by PM_{10}.

3.2 $PM_{2.5}$:

It refers to atmospheric particulate matter (PM) that has a diameter of fewer than 2.5 micrometres that is about 3% the diameter of a human hair(18). Natural sources of $PM_{2.5}$ are windblown dust, pollen, spores, photochemical, ally produced particles. Anthropogenic sources of $PM_{2.5}$ are vehicular emission, industrial combustion processes, commercial and residential combustion, and industries(1).

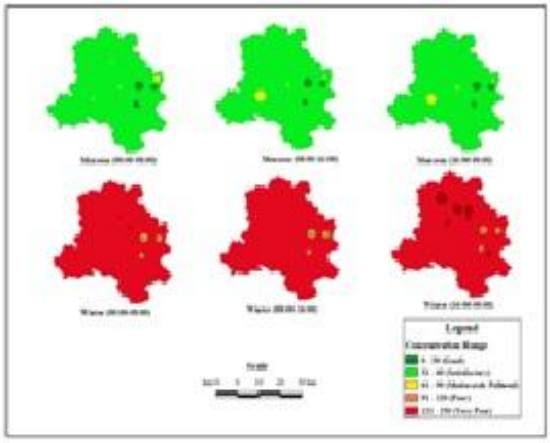
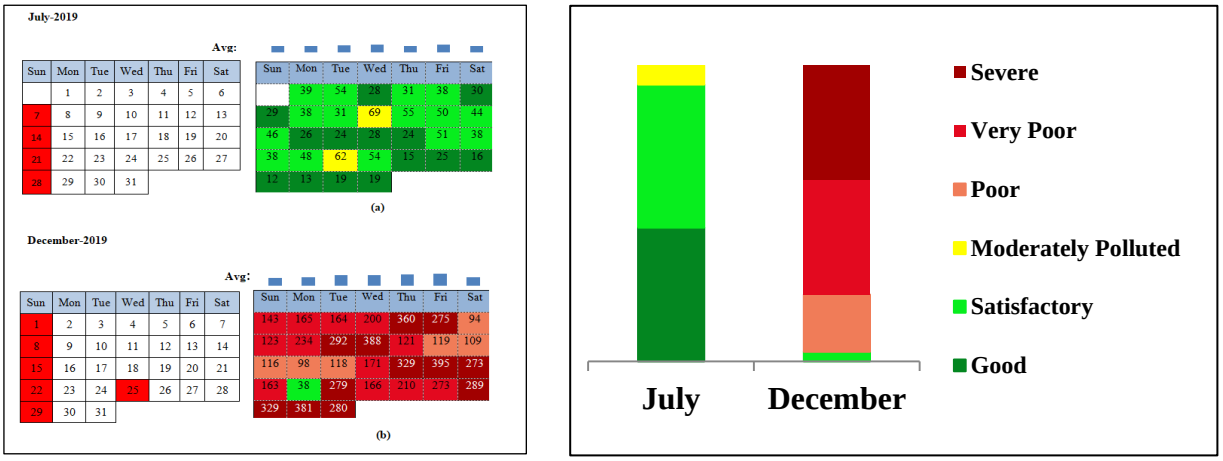


Figure No. 4 Concentration of $PM_{2.5}$ in monsoon and winter of a different time, 2019

In monsoon, the concentration pattern of $PM_{2.5}$ varies from good to moderately polluted conditions. The amount of fog and mist is very low at this time. However, in the winter season concentration of $PM_{2.5}$ is very unhealthy. Even severe condition is

found in some places, which create a bad impact on human health as well as the environment. Generally, the winter season is more dangerous than the monsoon and the main cause of this condition is weathering phenomena such as fog, mist, etc. Almost whole Delhi belongs in very poor condition in winter.**(Fig No: 4)**



Source: Central Pollution Control Board

Figure No. 5 Status of daily (24hrs) average $PM_{2.5}$ concentration during monsoon & winter (2019) in Ashok Vihar, Delhi

About 45%, 48% and 6% days (which are calculated) are in good, satisfactory and moderately polluted condition respectively in July (Fig No: 5a. 5c). About 3%, 19%, 39%, and 39% (which is calculated) days are in satisfactory, poor, very poor and severe condition respectively in December. Despite being a holiday, 25th December is in very poor condition in $PM_{2.5}$ concentration, because on that day vehicle emission rate is high(Fig No: 5b, 5c).

The diameter of $PM_{2.5}$ is very small so they are easily able to reach the lungs and obstruct the respiratory tract. These fine particles ($PM_{2.5}$) can cause lung nose, throat, and eye irritation, coughing, runny nose, and sneezing. The long-term effect of $PM_{2.5}$ is very harmful to children, decreased lung function, and premature death of those people who have lung or heart disease.

3.3 CO:

Carbon monoxide (CO) is one of the most common and widely circulated air pollutants. It is a colourless, odourless, tasteless and non–irritant toxic gas that is very less soluble in water. Incomplete combustion of carbon results in the production of carbon monoxide (CO). The anthropogenic sources of CO are motor vehicles, coal combustion, fuel oil combustion, industrial processes, solid waste disposal and refuse burning(18).

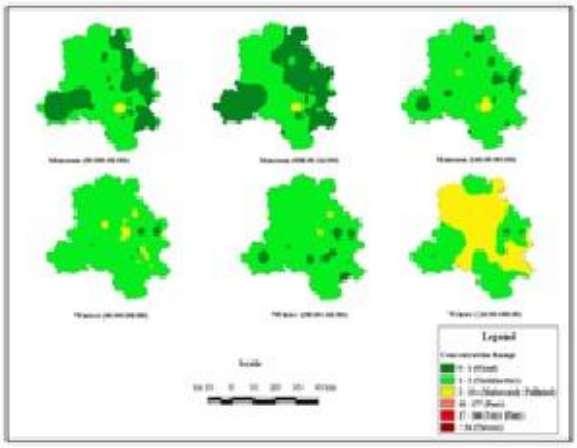
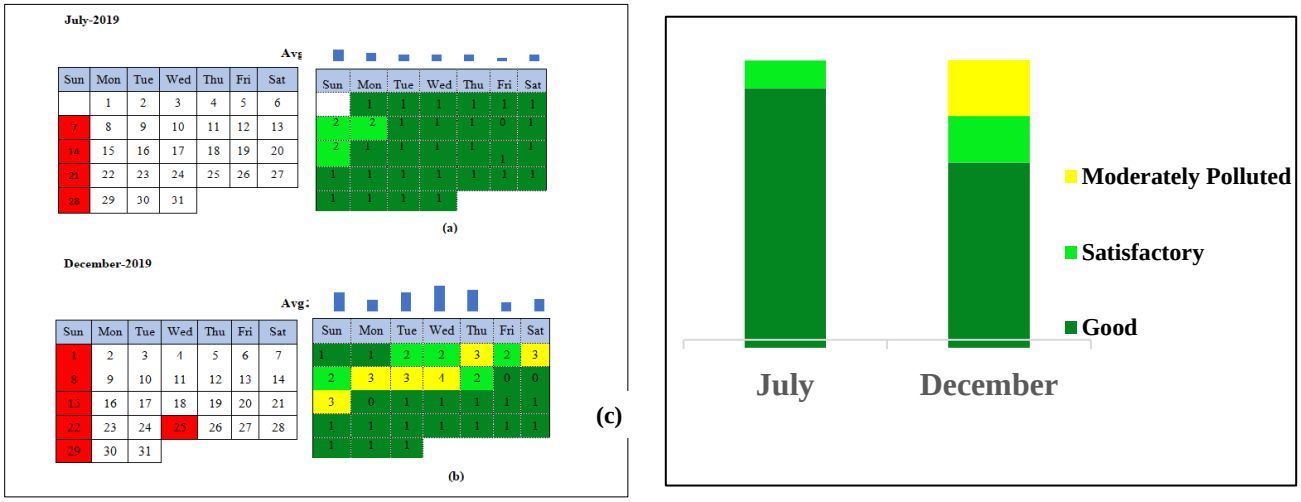


Figure No. 6 Concentration of CO in monsoon and winter at different times, 2019

Carbon monoxide (CO) is one of the most common and widely circulated air pollutants. In monsoon (July), the concentration range pattern mainly varies from good to moderately polluted conditions. In the night shift (16:00-00:00) mainly good condition is being observed, as the industrial emissions and residential emissions are low at this time. But some places like R.K. Puram, Lodhi Road, and Sirifort stations have fallen into this category, and the main reason is vehicle emissions and a high amount of industrial emissions, which create a bad impact on human health and the environment. In winter (December), the satisfactory condition was mainly observed all over Delhi. During the night shift (16:00-00:00) moderately polluted conditions are observed in most parts of Delhi. Due to the presence of many industries, and also weathering phenomena, the level of pollution has increased in all these areas. The amount of fog and mist is moderately high in these areas. In the winter season weathering phenomena have played an important role in Pollution.**(Fig No: 6)**



Source: Central Pollution Control Board

Figure No. 7 Status of daily (24hrs) average CO concentration during monsoon & winter (2019) in Ashok Vihar, Delhi

About 90.32% of days (which are calculated) are under good condition and 9.68% days of July are in satisfactory condition (Fig No: 7a, 7c). About 64.51%, 16.13%, and 19.34% days (which are calculated) are in good, satisfactory and moderately polluted condition respectively in December (Fig No: 7b, 7c).

3.4 NO_2:

Generally recognised as the sum of nitric oxide (NO) and nitrogen dioxide (NO_2),it is a reddish brown corrosive gas (18).Forest fire, lightning etc. are the natural sources of NO_2. It also comes into the air when fuels are burned. NO_2 emits from vehicles, trucks, buses, power stations and off-road equipment.(1)

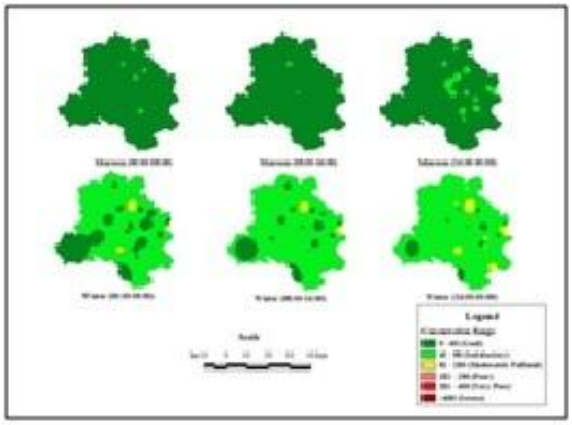
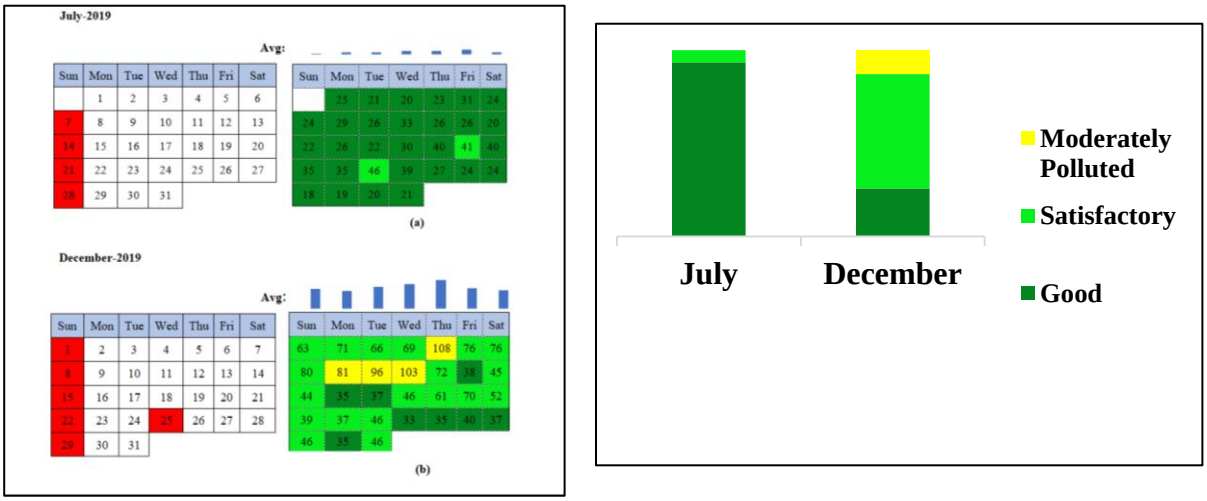


Figure No. 8 Concentration of NO_2 in monsoon and winter at different times, 2019

In monsoon (July), the concentration pattern varies from good to satisfactory condition in terms of pollution. The whole of Delhi except some places of north, north-east Delhi is fallen in this category. In the midnight shift (16:00-00:00) some places are in satisfactory condition. So in monsoon time, the pollution level of NO_2 is much lower than winter season. In winter (December), the whole of Delhi mainly falls in satisfactory condition, though some places are in moderately polluted conditions. The main reason for this type of condition is weathering phenomenon. In winter all the particles which are emitted from fuel burning, vehicles, residential uses, etc. are stacked in the upper layer. For this reason, the level of pollution is also very high at this time. For this reason, the atmosphere is also very unhealthy and dangerous for human health as well as the environment(Fig No: 8).



Source: Central Pollution Control Board

Figure No. 9 Status of daily (24hrs) average CO concentration during monsoon & winter (2019) in Ashok Vihar, Delhi

About 93.54% and 6.45% of days (which are calculated) are in good and satisfactory condition respectively in July(Fig No: 9a, 9c).About 61.29% of days (which are calculated) areunder satisfactory condition, 25.80% and 12.90% days are in good, moderately Polluted condition respectively in December(Fig No: 9b, 9c).

3.5 SO_2:

Sulphur dioxide (SO_2), a colourless, foul-smelling, toxic gas, is part of a larger group of chemicals known as sulphur oxide (SOX). It is a non-flammable gas. Naturally, SO_2 is emitted from volcanic eruptions, ocean and plant decaying matters and forest fires. Sulphur dioxide is formed in different ways- in the presence of oxygen when sulphur is burned. Oxidation of hydrogen sulphide, when fossil fuels are burned, biomass and high-temperature combustion process is occurring.

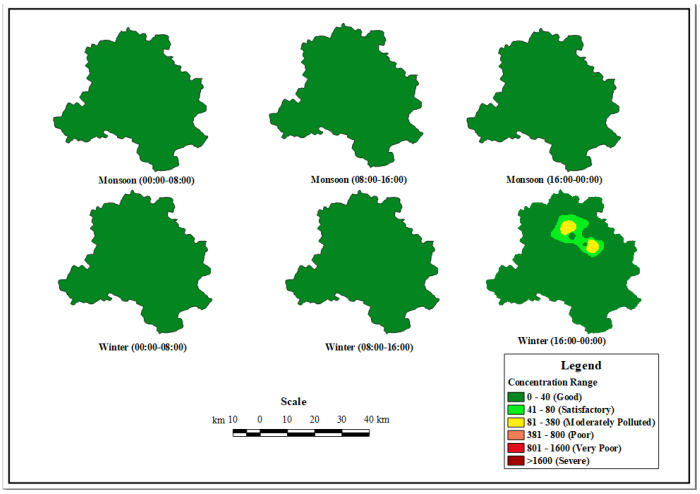
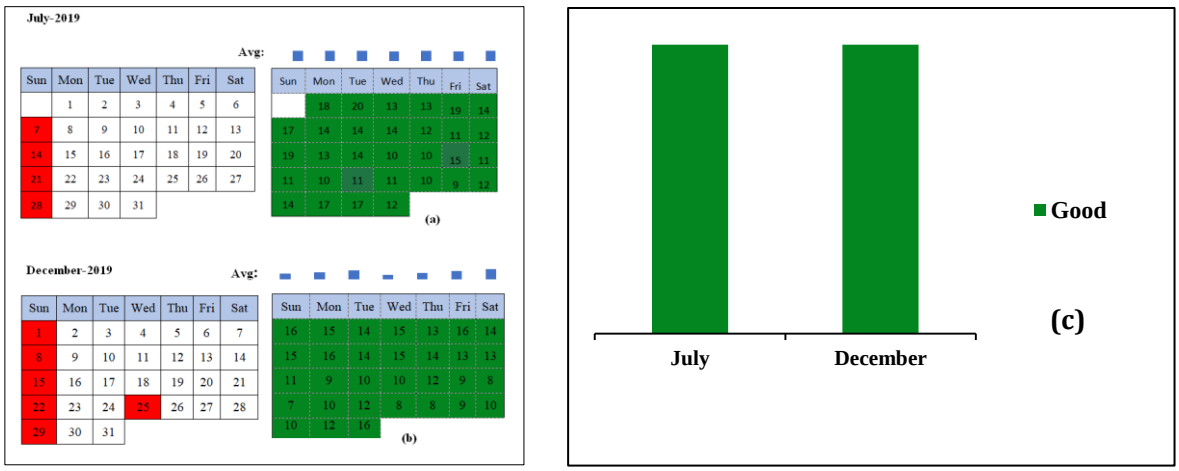


Figure No:10 Concentration of so_2 in monsoon and winter at different times, 2019

In monsoon, the concentration pattern of SO_2 is a good condition in terms of pollution concentration range in the whole area of Delhi. In Delhi, the amount of fog and mist is very less in July. Besides monsoon has already entered July. So, the SO_2 concentration level is relatively less. In Delhi, the main source of SO_2 is the combustion of fossil fuels. In winter, the concentration pattern of SO_2 varies from good to moderately polluted conditions. In mid-night to morning and morning to afternoon shifts, the SO_2 concentration pattern is good. But afternoon to night shift SO_2 concentration level is moderately polluted in some places because of the presents of fog, mist, etc. Some parts of North Delhi and North West Delhi districts mainly DTU and Wazirpur stations and their surrounding areas belong to moderately pollutant conditions. Wazirpur station is an industrial area, and there are so many industries found like chemical industries, consumer goods industries, etc. Badli Industrial Area is located near DTU. So, emissions of those industries mainly chemical industries caused pollution in those places. SO2 mainly affects the respiratory system, and lung function and makes breathing difficult.**(Fig No: 10)**



Source: Central Pollution Control Board

Figure No. 11 Status of daily (24 hrs) average SO_2 concentration during monsoon & winter (2019) in Ashok Vihar, Delhi

The whole month of July and December are in the good condition in terms of SO_2 concentration. **(Fig No: 11a, 11b, 11c)**

Excessive SO2 emissions have a detrimental effect on asthma patients and cause bronchitis. Sulpher dioxide emission has a bad effect on soil. It causes acid rain which makes the soil more acidic and also affects on Taj Mahal. Because it is completely made of marble. Marble reacts with acid rain and acid rain damages the beauty of the Taj Mahal.

3.6 Ozone:

Ozone is formed through the dissociation of nitrogen oxides (NO_2) by sunlight to yield the oxygen atoms, which then react with molecular oxygen to produce ozone molecules(18).

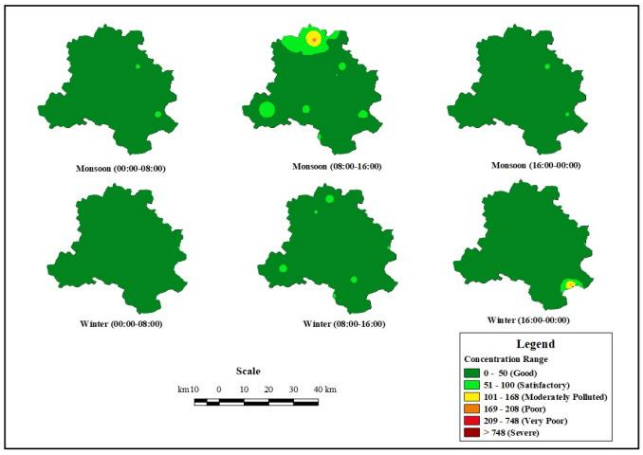
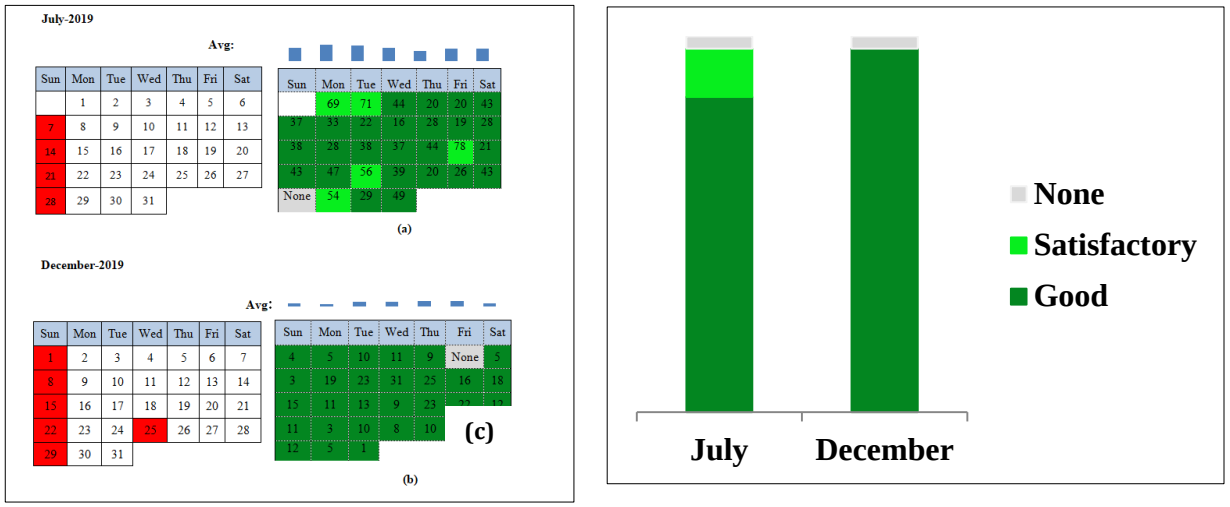


Figure No. 12 Concentration of Ozonein monsoon and winter at different times, 2019

In monsoon,(July) the concentration pattern of ozone mainly varies from good to poor condition. Mainly the level of pollution is lesser in the morning and the night time, because the rays of sunlight are less is this time and the industries also closed at night time. But in day time the level of pollution is high because of industrial emissions and as well as the sun's rays. In winter

(December) the concentration pattern varies from good to poor condition. Mainly in the afternoon to mid-night shift (16:00-00:00), the pollution is very high. Sometimes it reached poor condition. Dr Karni Singh Shooting Range is under this zone. The main reason is built-up areas and the weathering phenomena. In this area, the amount of fog is very high (14.8 mm). Fog does not mix pollutants in the upper atmosphere layer. For that reason ozone gas concentrates this area. For this reason, these areas and their surrounding areas are very unhealthy for human health. Breathing discomfort, asthma, and many health problems have occurred in these areas. **(Fig No:12)**



Source: Central Pollution Control Board

Figure No. 13 Status of daily (24 hrs) average Ozone concentration during monsoon & winter (2019) in Ashok Vihar, Delhi

84% and 13% (which is calculated) of days in July are in good and satisfactory condition respectively. A large amount of Ozone concentration has been found on working days viz Monday, Tuesday, Wednesday, Thursday and Friday.**(Fig No: 13a, 13c)**

In December, the concentration of Ozone is in good (0-51) condition. 97% (which is calculated) of days are in good condition in December.At the weekend (i.e. Saturday and Sunday) ozone concentration is moderately less than on working days.**(Fig No: 13b, 13c)**

3.7 Season-wise air quality:

AQI is usually based on pollutant criteria where the deliberation of an individual pollutant is transformed into a sole index using the appropriate method (28). The AQI shows how much air is cleaned or polluted. The contaminants change their ability to contaminate by reacting with natural substances like fog, mist, etc. So the air quality is also varying in every season. In monsoon, AQI has belonged between good to satisfactory condition. Najafgarhand its surrounding areas, IHBAS Dilshad Garden, a little part of East Delhi districts such as Chandni Chowk and East Arjun Nagar, Lodhi Road, Delhi-IITM, Patparganj, and NSIT Dwarka belong in good condition in this season. Because the emission of pollutants is less and there have not much industry asin other areas. But, North-West Delhi district, West Delhi district, Central Delhi district, New Delhi district, and some major parts of South-West Delhi district, North-East Delhi district, East Delhi district, and South Delhi district have belonged to satisfactory conditions. On the other hand, in the winter season, AQI belongs in good to moderately pollutant conditions. Because, in winter amount of fog is very high which is combined with smoke and other atmospheric pollutants and raise smog and border side of Delhi such as North-East Delhi, East Delhi, and South-East Delhi is more polluted than other places of Delhi because of smoke forms for crop burning in the agricultural land areas of the neighbouring states (Haryana, Rajasthan, and Punjab) (Fig No:14).

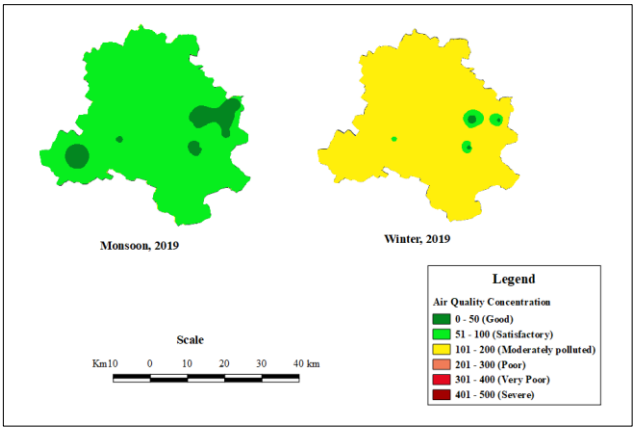


Figure No. 14 Air Quality of Monsoon and Winter in Delhi, 2019

3.8 Vulnerability Zonation:

Based on the concentration rate of all pollutants some places are more vulnerable and some places are safe. In the monsoon, season conditions are better than in winter. Although Najafgarh, IHBAS Dilshad Garden, Vivek Vihar, Ashok Vihar, Chandni Chowk, East Arjun Nagar, Anand Vihar, Mejor Dhyan Chand National Stadium, Lodhi Road, Nehru Nagar, and Pusa stations are most polluted area than others. But, in the winter season, conditions are very dangerous. Bawana, Jahangirpuri,

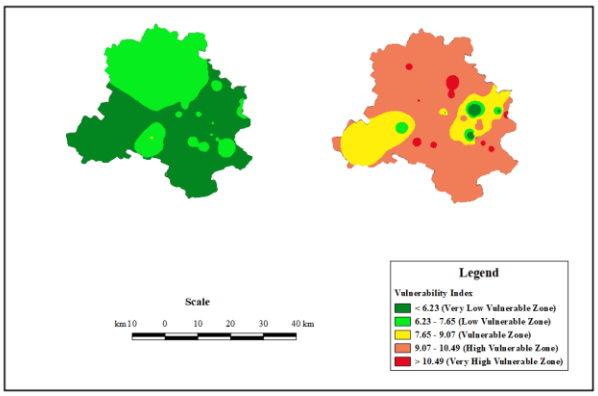


Figure No. 15 Vulnerable Zonation of Monsoon and Winter in Delhi, 2019

Wazirpur, Dwarka Sector-8, IGI Airport, Jawaharlal Nehru Stadium, and their surrounding areas belong toa very highly vulnerable zone. The pollution rate is very high in these areas. Narela, Alipur,

Bawana, DTU, Jahangirpuri, Rohini, Mundka, Wazirpur, IGI Airport, Okhla Phase-2, Dwarka Sector -8Nehru Nagar stations, and their surrounding areas belong to highly vulnerable Zone. IHBAS Dilshad Garden, Vivek Vihar, East Arjun Nagar, ITO, Mandir Marg, Chandni Chowk, Najafgarh **Monsoon** ka sta **winter** heir surrounding areas belong tothe vulnerable Zone and the rest of the part comparatively belongs to the less vulnerable zone (Fig No: 15).

4. Conclusion:

The main aim of this study is to understand seasonal air pollution variation in Delhi. Air pollution is a very vital issue in recent times. In India, Delhi has been considered the most polluted city in the country. Delhi is a megacity as well as it is the capital of India. Delhi is internationally recognized for its extreme pollution level. Among the selected pollutants PM_{10} and $PM_{2.5}$ have

witnessed maximum reduction followed by NO_2, CO and NH_3(28). In this city, the air pollution level is very high due to the presence of major industries, and highly active transport network systems. Land use and land cover pattern determine air pollution level where the built-up area is less pollution level are less and where build-up area and transport network are high pollution level also high, a positive relation is found there. The pollution rate varies in various seasons in Delhi. Pollution level is comparatively high in the winter season because weather phenomena (fog, mist, etc.) play a great role behind it including smoke from stubble burning in the neighbouring state but in July pollution level or pollutant concentration is comparatively low than in December. In July contamination of pollution is high in the day section on the other hand the level of pollution is higher inthe night section in December. Delhi has been considered the most vulnerable area in the winter season. Pollution level is very high in the winter season and has a major impact on human life as well as our environment. Many people suffer many diseases like asthma, Bronchitis, respiratory diseases even death has occurred.

Chief Minister Aravind Kejriwal announced a 10-point "winter action plan"that focuses on dust control to reduce air pollution.Moreover, some plans have been taken to control this pollution those are-submit plans for the inter-state transport sector for short-term, midterm and long-term action points to improve rail-based freight traffic to reduce dependence on trucks,prepare an action plan to check fuel adulteration and random monitoring of fuel quality data,alternate power systems should be promoted in cell towers and use of diesel generator sets discouraged,the Supreme Court order dated 12.08.2016 has imposed an environmental pollution charge of 1% on registration on diesel vehicles with 2000 cc and above.And BS6 bikes have started to be used.

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