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A Comparative assessment of Air Quality using AQI for Delhi-NCR

Swati Bora , Harsh Verma, Yogesh Nath Goswami, Prince Kumar, Prashant Shukla

Galgotia College of Engineering and Technology, Gautam Buddh Nagar, Uttar Pradesh.

Civil Engineering Department, GCET

ABSTRACT:

Air pollution is a complex combination of gases, debris, aerosols, water vapor that is already present due to human development and various natural/anthropogenic activities. Its close association with human development and its complex structure consisting of endless levels of debris and gaseous matrix makes it extremely difficult to manage. For accurate air quality testing, a variety of AQI measurement techniques have been tested as a tool to assess the effect of air pollution. This study reviews air quality testing in the city of Delhi using air quality indicators (AQI). Air quality indicator (AQI) is proposed for the City of Delhi, India, to create a simplified public record and statistical data interpretation. A 24-hour focus on four major pollution issues, viz. Case PM10, PM2.5, Sulfur Dioxide (SO2), and Nitrogen Dioxide (NO2) six months for the year 2020-2021 (August to January) at four different locations in Delhi, Anand Vihar, Ashok Vihar, Rohini, DTU. AQIs are calculated using the IND-AQI and ORNAQI procedures. It was assessed that the AQI for SO2 and NO2 was at a polluted level, while the AQI for PM10 and PM2.5 were at a severely polluted level. Overall combining it was concluded that Delhi air was severely polluted with prime pollutant as PM10. It was therefore determined that ORNAQI became a higher AQI test process compared to IND-AQI.

KEYWORDS: Air Pollution, Air Quality Index, Particulate Matter (PM2.5), SO2, NO2, Oak Ridge National Air Quality Index (ORAQI), IND-AQI (CPCB-AQI), Central Pollution Control Board (CPCB).

INTRODUCTION:

Fresh air is essential for human health and well-being. The presence of hazardous substances in the form of chemical substances and gases in the air leads to deterioration of air quality. Urban air pollution is rapidly declining due to the use of petrol and petroleum products to generate energy, transport, industrial needs, and other activities. Research conducted in Indian cities has confirmed that the concentration of excessive air pollution is extremely dangerous to human health, the continuing depletion of the city's atmosphere due to urban activities, and the lack of concentrated measures will exacerbate the problem in the future.

Pollutants that respond to air quality emissions are PM10, PM2.5, SO2, and NO2. Excessive exposure to these pollutants can cause cardiovascular disease. Delhi is considered one of the most polluted cities in the world and proves to be a good study choice. Reports from the Central Pollution Control Board (CPCB) on air quality have shown the presence of various pollutants over a period of a year, a report published by the world health organization showing an increase in deaths due to air pollution in Delhi.

In this paper, various measures are taken to measure the Air Quality Index to assess the impact of air pollution. The Air Quality Index (AQI) is such an indicator tool widely used around the world and in India for the last 2-3 decades.

AIR QUALITY INDEX:

Now a day, it is important for the public to look at the daily awareness of air pollution levels. AQI is a tool used to report a wide range of air quality and trends. In India, we use the standard CPCB standard for calculating air quality indicators or pollution index. This guide provides an image of the environment such as air quality numbers. And it helps the general public to understand how fresh or polluted air they breathe every day. Overall, this indicator provides a reasonable assessment of air pollution that the average person cannot understand. It also helps to develop air pollution control policies or control equipment and reduce the level of pollution. AQI represents the aggregate results of all pollutants to reflect the overall air quality situation in the best possible way. AQI for certain contaminants is found mainly in the polluting body rating such as PM10, PM2.5, NO2, and SO2, etc.

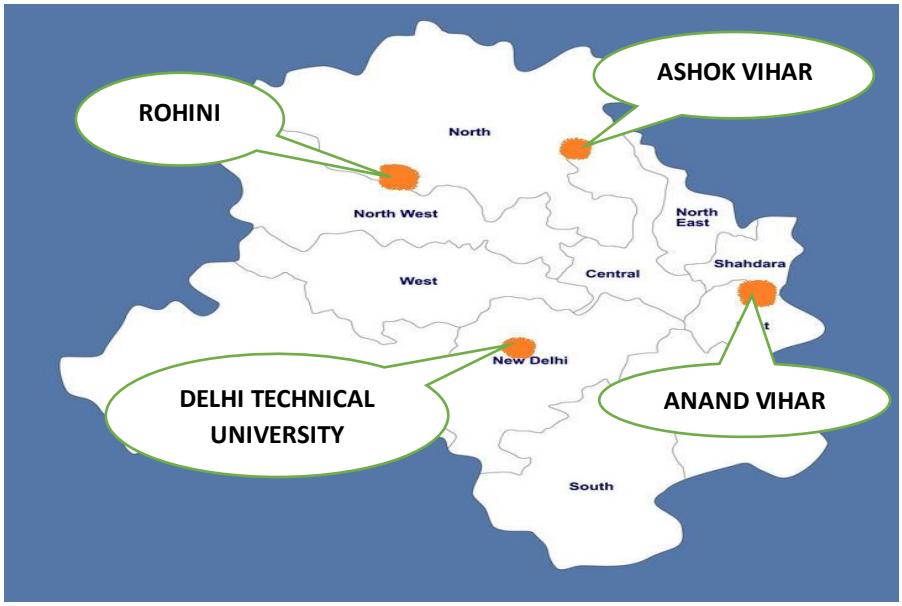
MATERIAL AND METHODS:

STUDY AREA

Delhi, the capital of India accumulating NCR and New Delhi region. It has borders attached to the province of Haryana on three sides and Uttar Pradesh to the east. Delhi has a dry climate with a dry winter and is limited to a hot dry climate. The warm season runs from March 21 to June 15 with a maximum daily temperature of more than 39 ° C (102 ° F). The hottest day of the year is May 22, with a maximum of 40 ° C (104 ° F) and a low of 28 ° C (82 ° F). The cold season runs from 26 November to 9 February with a daily maximum temperature below 20 ° C (68 ° F). The coldest day of the year is January 4, with a minimum of 2 ° C (36 ° F) and a maximum of 14 ° C (57 ° F).

Air Quality Data

Data were obtained from CPCB site monitors with a 24 * 7 pollution control center. The level of pollution in various parts of Delhi was monitored under the National Air Quality Monitoring Program (NAAQMP) where the daily concentration data of NO_2, SO_2, and PM_2. $_5$S collected from the CPCB at various monitoring stations in Delhi (Figure 1 shows the location of the monitoring stations).



(Fig.1) New Delhi map with 4 monitoring stations

AQI Development

Sub-index prices for a variety of pollutants were calculated based on the maximum operation system of CPCB AQI and ORNAQI and were compared from July to January 2020-2021.

COMPARATIVE CLASSIFICATION

CPCB AQI	*ORNAQI*
AQI= (C/Cs) *100	**AQI= [39.02*∑ C/Cs] ^0.967**
AQI Parameters	***AQI Parameters***
GOOD -(AQI<100)	CLEAN – (0>AQI<25)
	LIGHT– (26>AQI<50)
HARMFUL-(AQI>100)	MODERATE– (51>AQI<75)
	HEAVY – (76>AQI<100)
	SEVERE – (AQI>100)

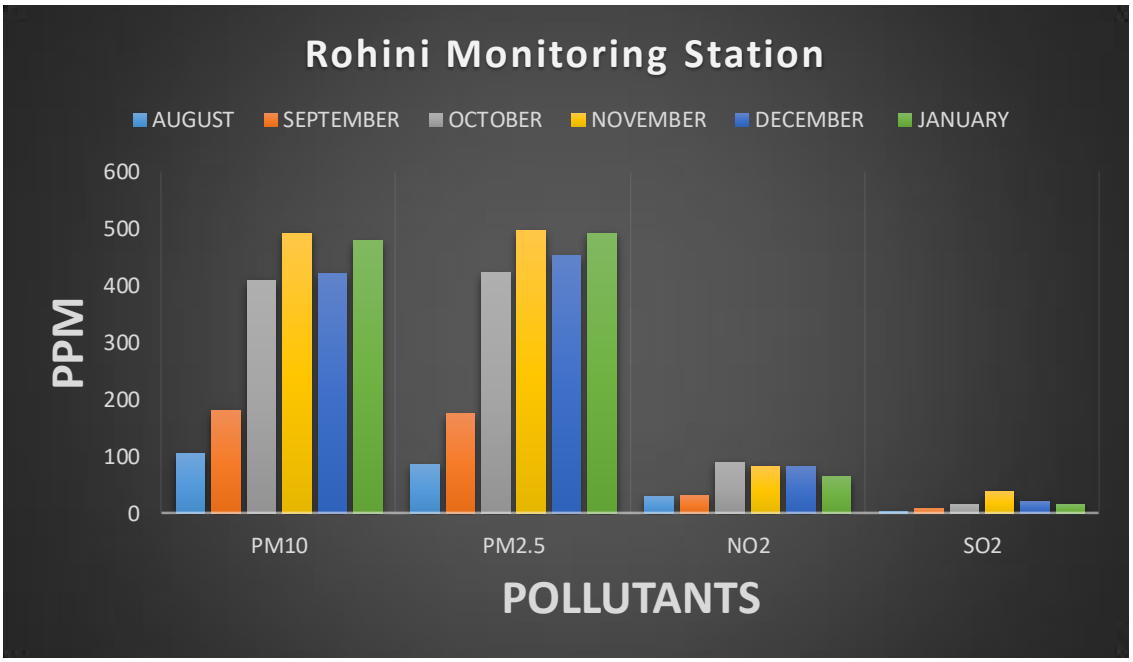
RESULTS AND DISCUSSIONS:

The air quality trends compared for all the monitoring stations for the year 2020-2021
In the analysis, it was observed that AQI values vary among various stations.

Rohini Monitoring Station(August2020-January2021)

	MAXIMUM	MINIMUM
PM10	**492**(NOVEMBER)	**42**(AUGUST)
PM2.5	**496**(NOVEMBER)	**23**(AUGUST)
NO2	**89**(OCTOBER)	**13**(JANUARY)
SO2	**38**(NOVEMBER)	**1**(AUGUST)
CPCB AQI	**400.79**(NOVEMBER)	**75.46**(AUGUST)
ORNAQI	**130.6**(NOVEMBER)	**26.15**(AUGUST)
(SOURCE: - National AIR Quality Index, CPCB)		

- The study shows that pollutant Values for PM10, PM2.5 were under severely polluted categories while the pollutant values for NO2 were under the heavily polluted category and for SO2 it was under the moderately polluted category.
- According to CPCB AQI, it was observed that the region was under harmful air quality for September, October, November, December, and January while it was under Good air quality for August.
- According to ORNAQI, it was observed that the region had a more varied air quality, it was under severe air quality for November, December, and January while for October it was under heavy air quality but for September it was under light air quality and for the August month the air quality was considered clean.

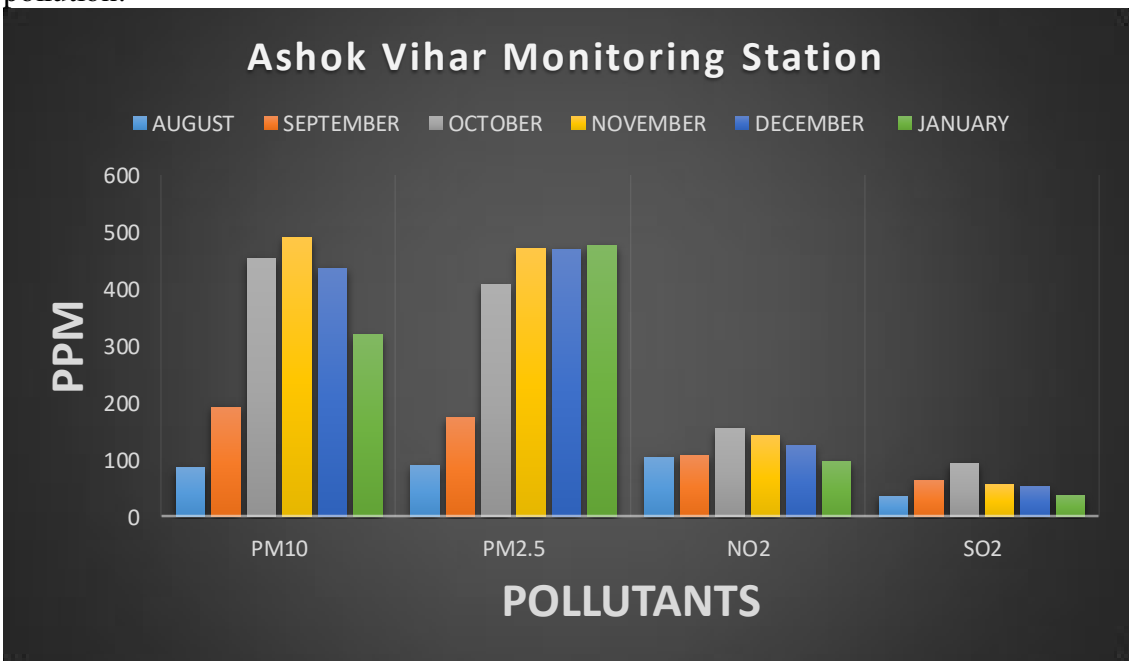


Value Graph for Rohini Monitoring Station

A. Ashok Vihar Monitoring Station(August2020-January2021)

	MAXIMUM	MINIMUM
PM10	**490**(NOVEMBER)	**26**(AUGUST)
PM2.5	**476**(JANUARY)	**20**(SEPTEMBER)
NO2	**154**(OCTOBER)	**5**(OCTOBER)
SO2	**94**(OCTOBER)	**5**(AUGUST)
CPCB AQI	**399.02**(NOVEMBER)	**90.06**(AUGUST)
ORNAQI	**131.6**(NOVEMBER)	**30.57**(AUGUST)
(SOURCE: - National Air Quality Index, CPCB)		

- The study shows that pollutant Values for PM10, PM2.5 were under severely polluted categories while the pollutant values for NO2 and SO2 were under the heavily polluted category.
- According to CPCB AQI, it was observed that the region was under harmful air quality for September, October, November, December, and January while it was on the border of Good air quality for August.
- According to ORNAQI, it was observed that the region was under severe air quality for November, December, and January while for October it was under heavy air quality but for September it was under moderate air quality and for the August month the air quality was considered under light air pollution.



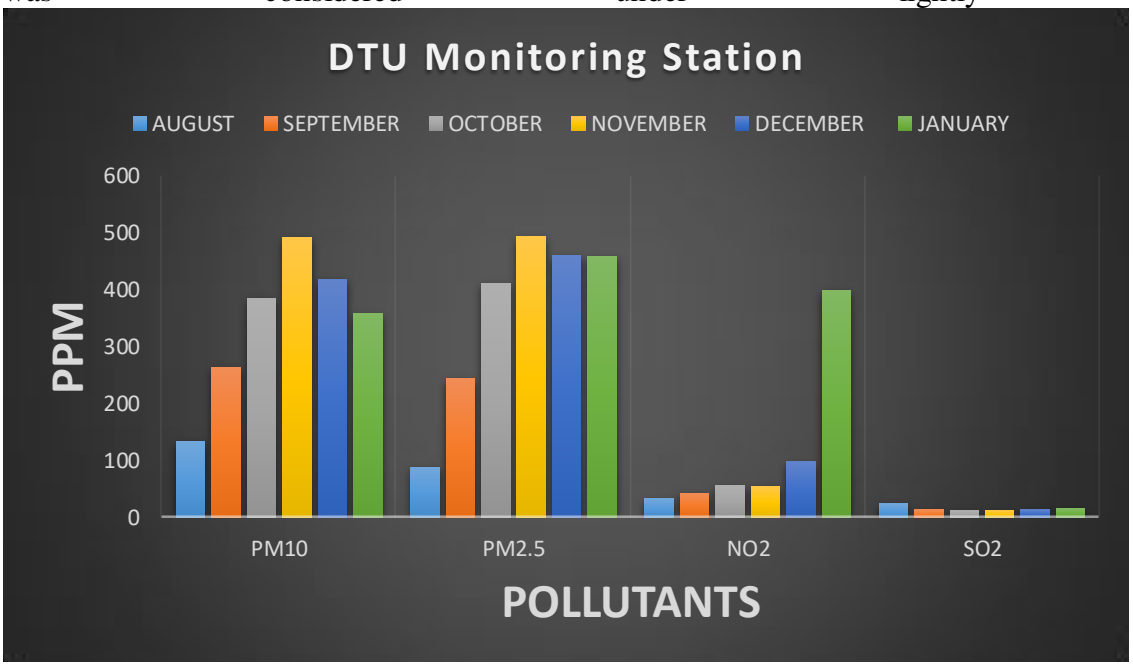
Value Graph for Ashok Vihar Monitoring Station

B. DTU Monitoring Station(August2020-January2021)

	MAXIMUM	MINIMUM
PM10	**491**(NOVEMBER)	**32**(AUGUST)
PM2.5	**493**(NOVEMBER)	**23**(SEPTEMBER)
NO2	**398**(JANUARY)	**4**(AUGUST)

SO2	**24**(AUGUST)	**4**(DECEMBER)
CPCB AQI	**443.54**(JANUARY)	**82.56**(AUGUST)
ORNAQI	**144.70**(JANUARY)	**29.10**(AUGUST)
(SOURCE: - National Air Quality Index, CPCB)		

- The study shows that pollutant Values for PM10, PM2.5, and NO2 were under severely polluted categories while the pollutant values for SO2 was under the satisfactorily polluted category.
- According to CPCB AQI, it was observed that the region was under harmful air quality for September, October, November, December, and January while it was under Good air quality for August.
- According to ORNAQI, it was observed that the region had a more varied air quality, it was under severe air quality for November, December, and January while for October it was under heavy air quality but for September it was under moderate air quality and for the August month the air quality was considered under lightly polluted.

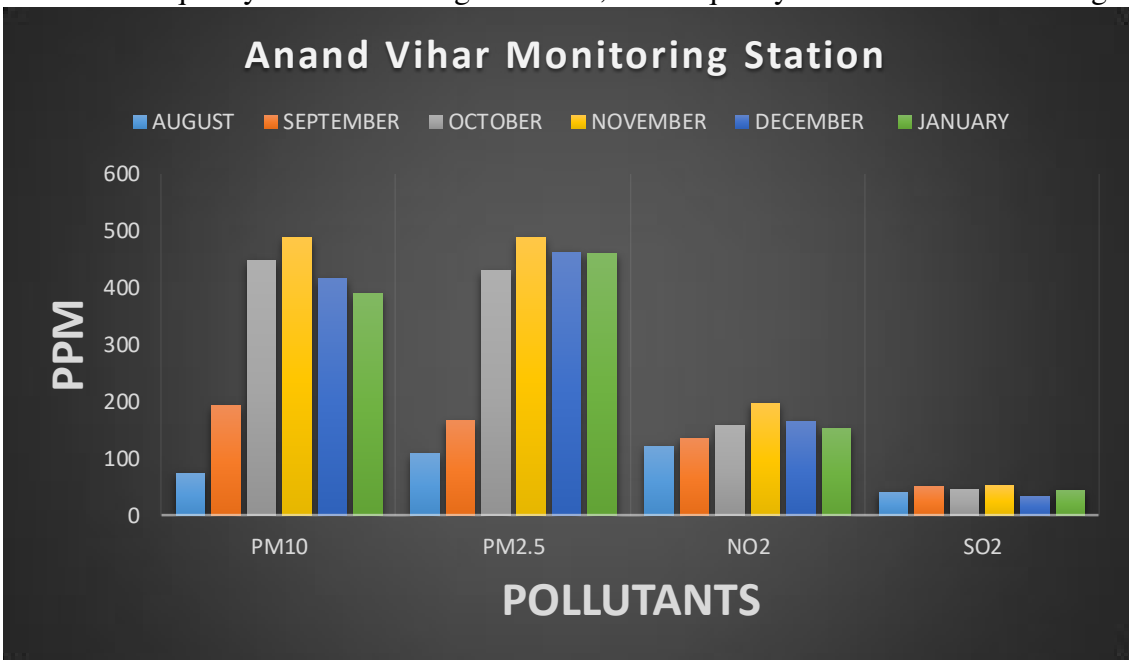


Value Graph for DTU Monitoring Station

C. Anand Vihar Monitoring Station(August2020-January2021)

	MAXIMUM	MINIMUM
PM10	**487**(NOVEMBER)	**22**(AUGUST)
PM2.5	**487**(NOVEMBER)	**17**(AUGUST)
NO2	**197**(NOVEMBER)	**17**(SEPTEMBER)
SO2	**52**(NOVEMBER)	**5**(AUGUST)
CPCB AQI	**449.67**(NOVEMBER)	**99.87**(AUGUST)
ORNAQI	**147.01**(NOVEMBER)	**34.66**(AUGUST)
(SOURCE:- National Air Quality Index, CPCB)		

- The study shows that pollutant Values for PM10, PM2.5 were under severely polluted categories while the pollutant values for NO2 were under the heavily polluted category and for SO2 it was under the moderately polluted category.
- According to CPCB AQI, it was observed that the region was under harmful air quality for September, October, November, December, and January and it was at the border of Good air quality for August.
- According to ORNAQI, it was observed that the region had a lot more varied air quality, it was under severe air quality for October, November, December, and January while for September it was under moderate air quality and for the August month, the air quality was considered to be lightly polluted.



Value Graph for Anand Vihar Monitoring Station

The overall air quality of all the stations was found to be at a critical level in October and November and in December and January were found to be unhealthy and August and September were found to be satisfactory. Delhi Air Quality should be regarded as unhealthy and strong measures should be taken to improve air quality.

To better understand the regional air quality variation from satisfactory to hazard from August to January we have two perspectives on the fall and rise of regional AQI.

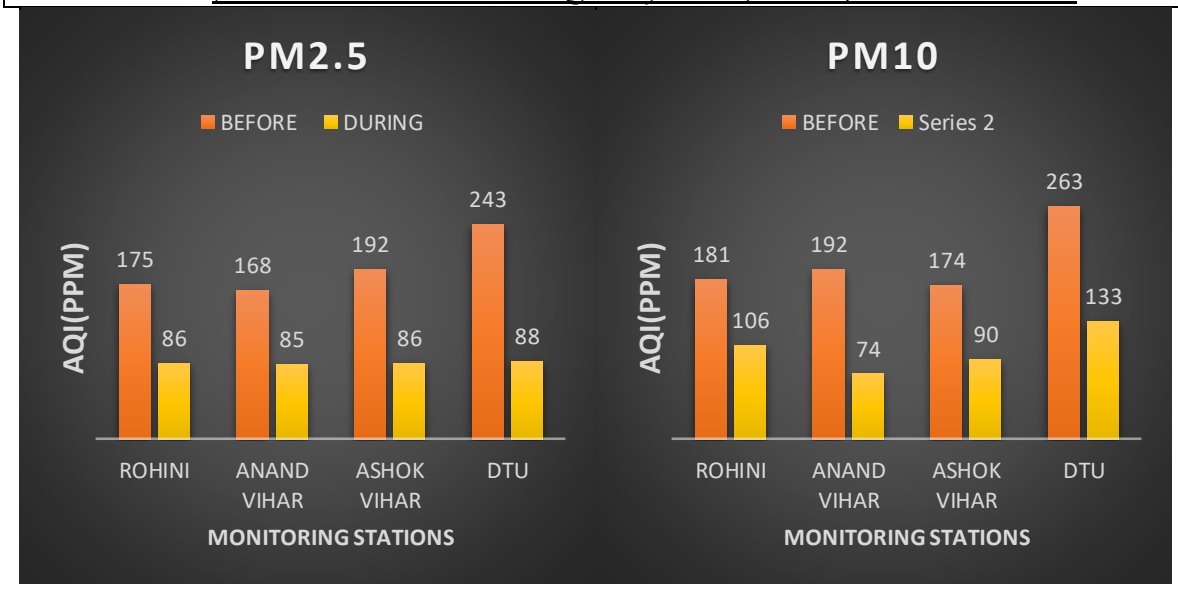
LOCKDOWN EFFECT OVER AQI

The Indian government has announced a full ban from March 25, 2020, on all foreign and local operations in the country due to its containment of COVID-19. The lockdown has affected the air quality of the National Capital Delhi. In this case, data for air pollution (PM10, PM2.5, NO2, SO2) from 4 study area sites were analysed compared to last year's data. The results showed that the PM10 and PM2.5 levels dropped to (55-65%). NOx and NO showed a significant reduction (50-78%). Similarly, consistent and significant

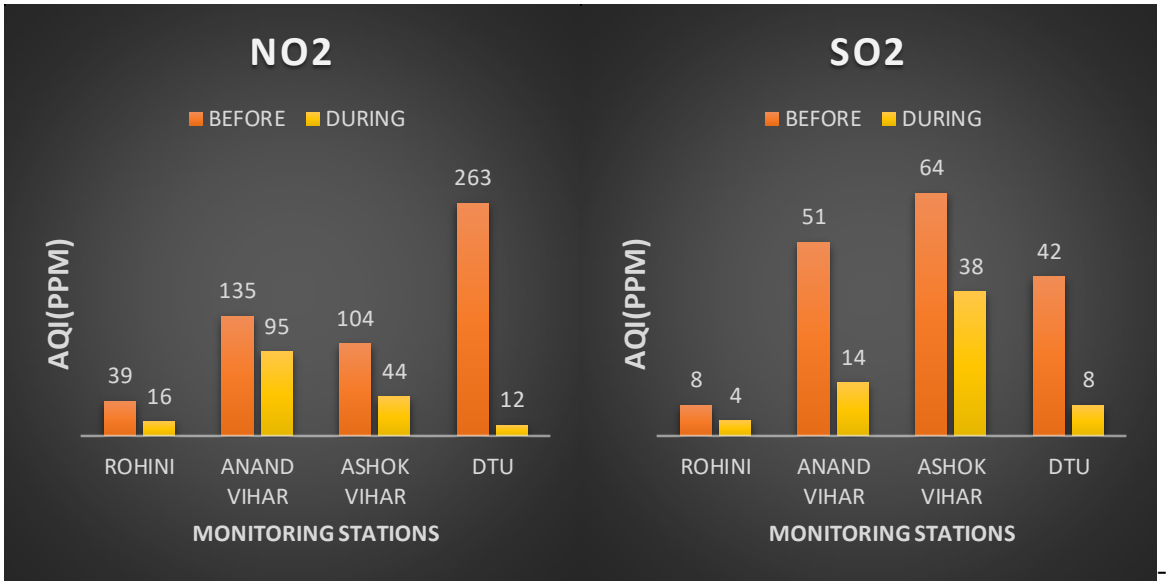
reductions in other air pollutants such as SO2 (60%) have been observed. The Lockdown Air Quality Index (AQI) is showing improvement as its value dropped significantly (50-60%).
During this lockdown, it has been noted that air pollution levels fall within or below the approved air quality standards set by the Central PCCB of India (CPCB).

	PERIOD	*PM2.5*	*PM10*	*NO2*	*SO2*	*CPCB AQI*	*ORNAQI*
ROHINI	BEFORE	175	181	39	8	206	67
	DURING	86	106	16	4	75	29
	VARIATION	-89	-75	-23	-4	-131	-38
	VARIATION %	**50.85**	**41.4**	**58.97**	**50**	**63.59**	**56.71**
ANAND VIHAR	BEFORE	168	192	135	51	254	86
	DURING	85	74	95	14	99	34
	VARIATION	-83	-118	-40	-37	-155	-52
	VARIATION %	**49.40**	**61.45**	**29.62**	**72.5**	**61.02**	**60.46**
ASHOK VIHAR	BEFORE	192	174	104	64	226	77
	DURING	86	90	44	38	91	32
	VARIATION	-106	-84	-60	-26	-135	-45
	VARIATION %	**55.20**	**48.27**	**57.69**	**40.625**	**59.76**	**58.44**
DTU	BEFORE	243	263	42	24	272	89
	DURING	88	133	12	8	84	31
	VARIATION	-155	-130	-30	-16	-188	-58
	VARIATION %	**63.78**	**55.08**	**71.42**	**66.66**	**69.117**	**65.16**

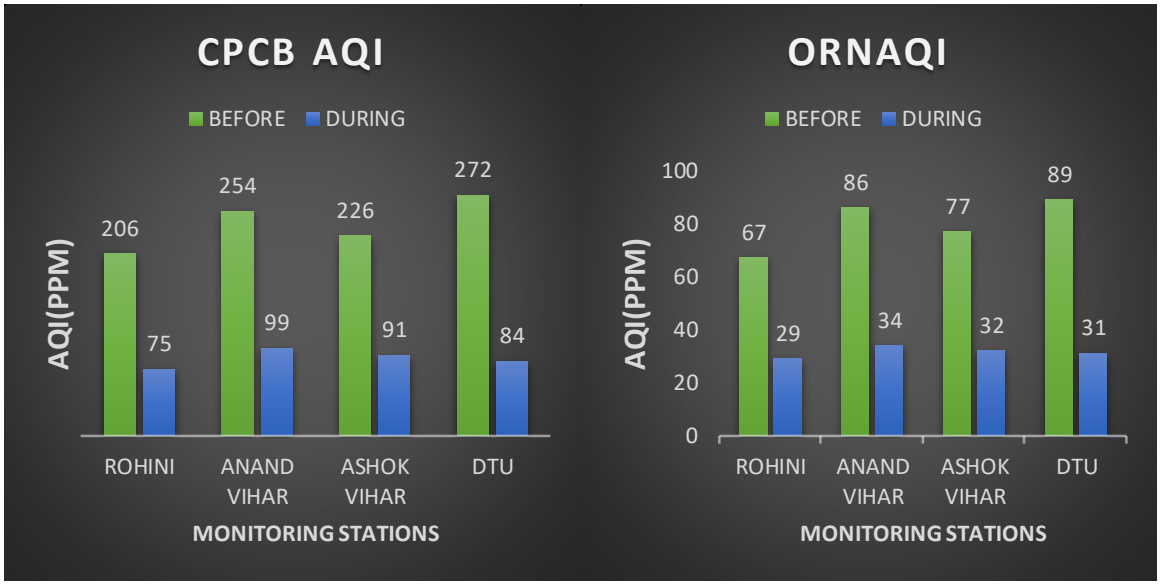
(SOURCE:- National Air Quality Index, CPCB) and Calculation



Variation in PM2.5 and PM10 due to lockdown



Variation of SO2 and NO2 due to lockdown



Variation of AQIs in Delhi due to lockdown

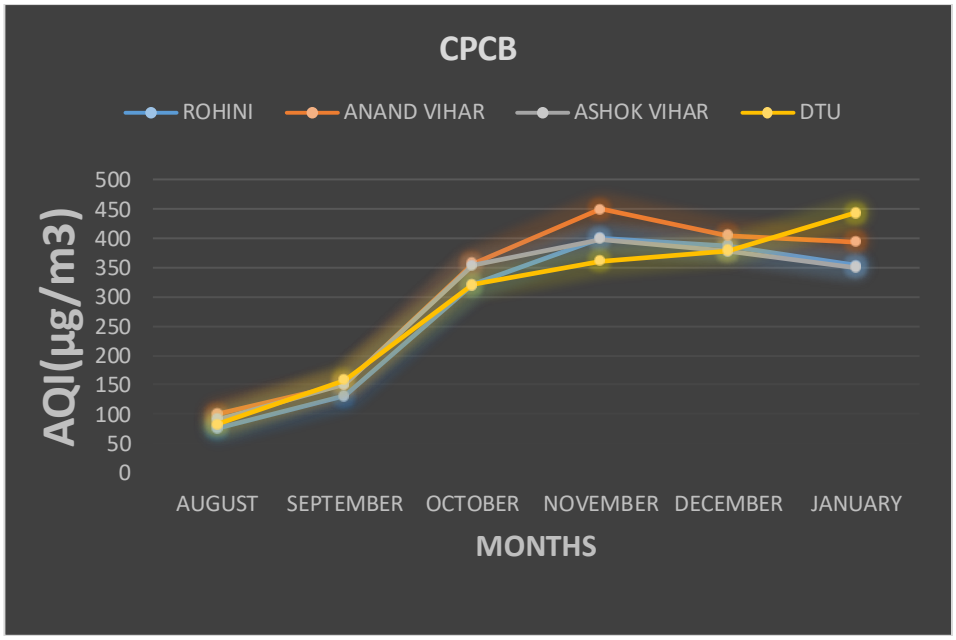
- This decrease in the pollution index was due to complete lockdown due to which there was no movement of transport, also the industries and other manufacturing plants were not running, which resulted in very low or approximately no emission of pollutants like NO2, SO2, PM2.5.
- There was also no construction work being carried out or construction plants working due to which there was a significant decrease in the PM10 and PM2.5 readings.
- Since July, August and September generally witness the monsoon season due to which results in the easy and quick settlement of the pollutants with the humidity in the atmosphere. This could also be the prominent reason for the very low AQI and pollution Index compared to previous data.

DIWALI EFFECT OVER AQI

Air pollution is worse in the winter months (October to January) as the particles remain suspended in the air for a long time due to low temperatures, wind speeds, and very high humidity. The winter months coincide with the most popular festival in India, namely, Diwali. In the paper, we used hourly data collected from October to January to quantify the impact of Diwali on air quality, particularly PM2.5, PM 10, NO2, SO2 particulate concentration, in Delhi with two different AQI settings. We found that Diwali leads to small, but mathematically significant growth in air pollution.

According to CPCB AQI Index: -

	Rohini	***Anand Vihar***	***Ashok Vihar***	***DTU***	***Average***
September	73.65%	50.34%	66.86%	91.58%	70.61%
October	145.18%	138.062%	135.133%	103.186%	130.39%
November	24.64%	25.79%	12.34%	12.46%	18.81%
December	-3.92%	-9.90%	-5.27%	-4.88%	-5.99%
January	-8.81%	-2.51%	-7.35%	17.001%	-8.918%
(Source:- National Air Quality Index, CPCB) and Calculations					

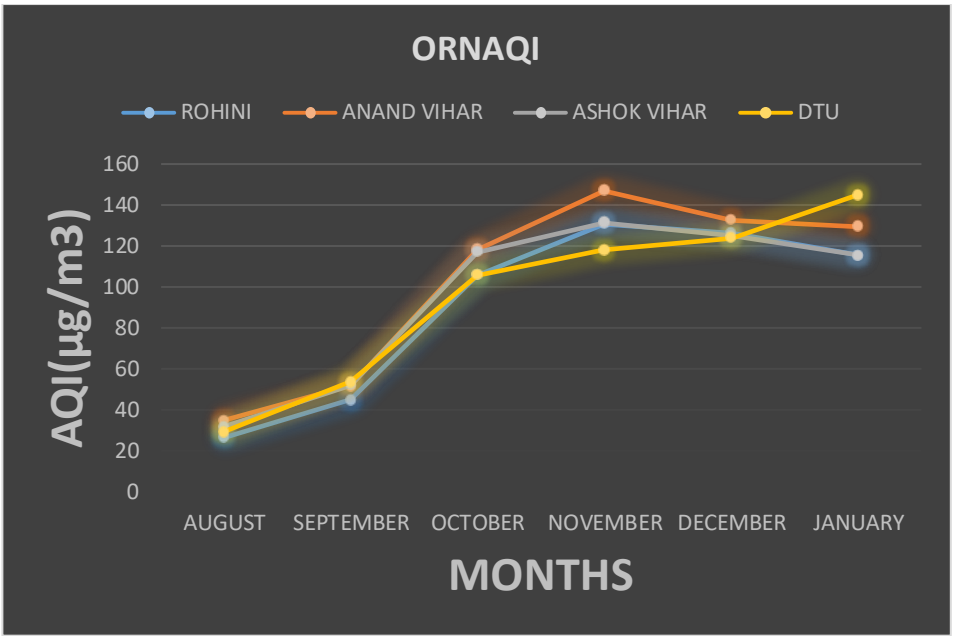


Exponential rise in CPCB AQI index due to Diwali and Winters

- We have assessed that the AQI levels for the places were low for August and there was a minimal spike of 70.61% for September but for October there has been a huge spike in the AQI index.
- The AQI index rose by about 130.39% from the previous month due to the ongoing festival of Diwali and the spike continued to reach its peak by adding another increase in AQI for about 18.81% from the previous month.
- This increase in November can also be seen as due to winter intake longer time for pollutants to settle down due to fog, low atmospheric pressure, and high humidity.
- After November there has been seen a continuous descent in the graph for December and January. The AQI index decreased by about 14.908% from its peak value till January and kept on decreasing further.

According to ORNAQI Index: -

	Rohini	***Anand Vihar***	***Ashok Vihar***	***DTU***	***Average***
September	70.12%	49.05%	63.82%	83.58%	66.64%
October	137.35%	128.644%	126.01%	97.52%	122.381%
November	23.636%	24.456%	12.34%	11.76%	18.048%
December	-3.20%	-9.7%	-5.10%	-4.87%	-5.72%
January	-8.72%	-2.33%	-7.422%	16.96%	-8.858%
(Source:- National Air Quality Index, CPCB) and Calculations					



Exponential rise in ORNAQI index due to Diwali and Winters

- We have assessed that the AQI levels for the places were low for August and there was a minimal spike of 66.64% for September but for October there has been a huge spike in the AQI index.
- The AQI index rose by about 122.381% from the previous month due to the ongoing festival of Diwali and the spike continued to reach its peak by adding another increase in AQI for about 18.048% from the previous month.
- This increase in November can also be seen as due to winter intake longer time for pollutants to settle down due to fog, low atmospheric pressure, and high humidity.
- After November there has been seen a continuous descent in the graph for December and January. The AQI index decreased by about 14.305% from its peak value till January and kept on decreasing further.

CONCLUSION:

1. This brief review of air quality indices shows wide interest and concern for the poor air quality problems. The major differences among the indices were found in the aggregation function, the number of index classes (and their associated colours) and related risk levels and descriptive terms. The CPCB AQI had only two indexes for the classification of risk level due to which it was unable to assess the pollution levels as even a slight change in the values of the AQI resulted in extreme risk levels. Whereas on the other side in the ORNAQI it has 5 different levels of indexes due to which it was easy to differentiate the levels of threat for various pollutants
2. It was observed that the pollutants are sometimes consistently different from place to place, not only in concentration to be monitored but also in setting the threshold values. Likewise, in the CPCB AQI system, there was an individual formulation of pollutants over the AQIs due to which its overall AQI computation had errors and mismatches as different pollutants had a different reading daily so it was unable to track down which pollutant was responsible for the overall rise in the AQI. Whereas the ORNAQI uses the cumulative function for pollutants so it is easy to track down the pollutants responsible for the high rise of AQI.

3. The ORNAQI potentially contribute to public understanding by providing information that is easily accessible and allows them the opportunity to modify their behaviour appropriately in response to changes in air quality.
4. The review of CPCB AQI methods reveals that the method does not have the flexibility to accommodate a new pollutant. This is because the method is designed for a specific number of pollutants. Also, the CPCB AQI method has a very small index which does not let your elaboration on the pollutants to very specific results.
5. The indexing method of CPCB AQI does not consider the synergistic effects of the pollutants, that is, pollutants are not aggregated in the index calculation. Furthermore, the indexing methods are not based on health criteria. Thus, further work is required on the nature of the scale (1-100, 100-500) and the multi-pollutant problem to make it uniform.
6. The review of the ORNAQI method reveals that the method has a wide indexing system and also includes the aggregation effects of the pollutants in the index due to which it is easy to formulate the risk levels.
7. The aggregation function in the ORNAQI is suitable for only a few pollutants that are in more quantity, for smaller or sub resulting pollutants the ORNAQI system does not have the suitability to compute and formulate it into the analysis. Thus, furthermore work is required on the aggregation function to make it uniform for smaller pollutants.

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