Quest Journals
Journal of Research in Environmental and Earth Science
Volume 5~ Issue 2 (2019) pp: 21-28
ISSN(Online) : 2348-2532
www.questjournals.org

Research Paper

Comparing levels of air pollutants in New Delhi, India one year after emergency level conditions and policy changes

Sai Shruti Sood

ABSTRACT: *In this paper, the difference in air pollution levels in India's capital city of Delhi (NCR) one year after an air pollution emergency followed by new policies implemented is discussed. The parameters taken for this study are PM2.5, PM10 and NO2. 50 days of daily average data of each of the three pollutants from 3 different AQI (Air Quality Index) and continuous monitoring stations from around the city for two consecutive years for the same dates is presented. This data is then compared and used for concluding the effectivity of the control measures and policies.*
KEYWORDS: *New Delhi, Air Pollution, Government, CPCB*

Received 30 Sept.., 2019; Accepted 15 Oct. , 2019 © The author(s) 2019.
Published with open access at www.questjournals.org

I. INTRODUCTION

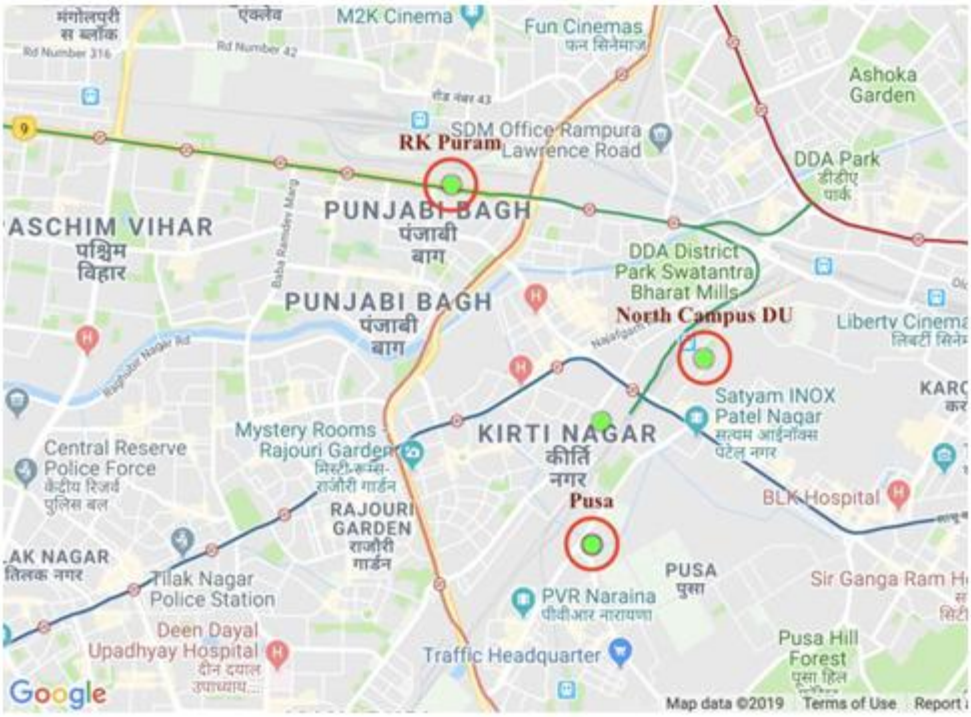
The city of New Delhi, India, along with its neighbouring cities of Noida and Gurugram, is repeatedly seen on the list of the world's most polluted cities, being ranked number 11 on the basis of the data collected in 2018 [1]. Every year towards the months of October, November and December, the level of particulate matter in the city severely rises, and in November 2017, toxic smog was visible throughout the city, and most monitoring stations indicated a max AQI of 500 on November 7 and 8. This could attributed majorly to vehicular traffic, after effects of Diwali and crop burning in neighbouring states [2]. This would call for a 'Severe + or Emergency' response as per the GRAP (Graded Response Action Plan) which includes but is not limited to road rationing schemes (Odd-Even rule), stopping construction activities, even long term measures later such as the shutting down of the Badarpur coal plant, etc [3]. The National Air Quality Index (AQI) was launched in New Delhi on September 17, 2014 under the Swachh Bharat Abhiyan, and consists of six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. While the AQI takes into consideration eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb) [4]. In this study only the first 3 are taken as most stations actually only monitor these as they are the most hazardous and problematic. Based on the measured ambient concentrations, corresponding standards and likely health impact, a sub-index is calculated for each of these pollutants. The worst sub-index reflects overall AQI. The data in this paper is presented as sub-AQI scores as well as ambient concentrations as the AQI maxes out at 500, whereas the ambient concentrations detected can be more precise. However, the AQI data is also just as important due to the ease of understanding it and relating levels of air pollution to levels of health risk.

PM (Particulate matter) is a widespread air pollutant, consisting of a mixture of solid and liquid particles suspended in the air. Commonly used indicators describing PM that are relevant to health refer to the mass concentration of particles with a diameter of less than 10 µm (PM 10) and of particles with a diameter of less than 2.5 µm (PM2.5). PM2.5, often called fine PM, also comprises ultra fine particles having a diameter of less than 0.1 µm. Particles can either be directly emitted into the air (primary PM) or be formed in the atmosphere from gaseous precursors such as SO2, NOX, NH3 and non-methane volatile organic compounds (secondary particles). Primary PM and the precursor gases can have both man-made (anthropogenic) and natural (non-anthropogenic) sources. Anthropogenic sources include combustion engines (both diesel and petrol), solid-fuel (coal, lignite, heavy oil and biomass) combustion for energy production in households and industry, other industrial activities (construction, mining, manufacture of cement, ceramic and bricks, and smelting), and erosion of the pavement by road traffic and abrasion of brakes and tyres. Agriculture is the main source of NH 4+. Secondary particles are formed in the air through chemical reactions of gaseous pollutants. They are products of atmospheric transformation of nitrogen oxides (mainly emitted by traffic and some industrial processes) and sulfur dioxide resulting from the combustion of sulfur containing fuels. Secondary particles are mostly found in fine PM. PM10 and PM2.5 include particles that are small enough to penetrate the thoracic region of the respiratory system. The health effects of PM are well documented. They are due to exposure over both the short term (hours, days) and long term (months, years) and include respiratory and cardiovascular morbidity, such as aggravation of asthma, respiratory symptoms and an increase in hospital admissions, as well as mortality from cardiovascular and respiratory diseases and from lung cancer. Susceptible groups with pre-existing lung or heart disease, as well as elderly people and children, are particularly vulnerable. For example, exposure to PM affects lung development in children, including reversible deficits in lung function as well as chronically reduced lung growth rate and a deficit in long-term lung function [5]. The main effect of breathing in raised levels of NO2 is the increased likelihood of respiratory problems. NO 2 inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis.

Increased levels of NO2 can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. Children with asthma and older people with heart disease are most at risk [6].

II. AQI AND DATA COLLECTION

As previously mentioned, data for this study was collected from 3 fixed continuous AQI and continuous monitoring systems operating under NAMP (National Air Quality Monitoring Programme) namely Pusa, R K Puram and North Campus, DU. The above mentioned stations are circled in red in Map 1.



Map 1

(https://app.cpcbccr.com/AQI_India/)

The data for both the sub-AQIs as well as the ambient concentrations was collected for the period of 50 days in 2017, as well as in 2018. The dates for 2017 occur right after Diwali (Oct 19 in 2017), a fireworks festival which is a big contributor to the sudden and strong onset of severe levels of air pollution for the winter months, which is already a huge factor in retaining suspended PM in the air. These dates (Oct 21 - Dec 9) also include the actual smog incident (Nov 7 - 8), as well as the time periods before and after GRAP (Graded Response Action Plan) control measures such as odd-even road space rationing scheme (Nov 13 - 17). The same dates for 2018 also include the day before and after Diwali itself (Nov 7). The stations were selected on the basis of their placement in areas with constant vehicular traffic and residential activity as well as the distance between them for more coverage, as well as due to most other stations not having enough data for the selected pollutants for both years.

A possible margin of error is that on a few random days, a station would simply not have collected any data and show 0 ambient concentration for one or all our pollutants and thus no calculated AQI. As a way to make up for this only those specific data points that weren't recorded, have been taken as the mean of the data of the days before and after. Having 3 different stations also helps here as the total city average would still be more accurate than one midpoint. The sub-AQI scores for each pollutant have a different concentration threshold for the 6 categories as shown in table 1. These sub-AQI scores actually determine the severity of the responsive action required according to the GRAP.

Table 1
(https://cpcb.nic.in/displaypdf.php?id=bmF0aW9uYWwtYWlyLXF1YWxpdHktaW5kZXgvQWJvdXRfQVFJLnBkZg==)
Data in form of sub-AQI calculated for us from the NAMP helps us directly relate the health risks at a given category of the AQI as shown in table 2.

Table 2
(http://www.indiaenvironmentportal.org.in/files/file/Air%20Quality%20Index.pdf)

III. CHANGE IN AMBIENT CONCENTRATIONS

AQI for ambient concentrations

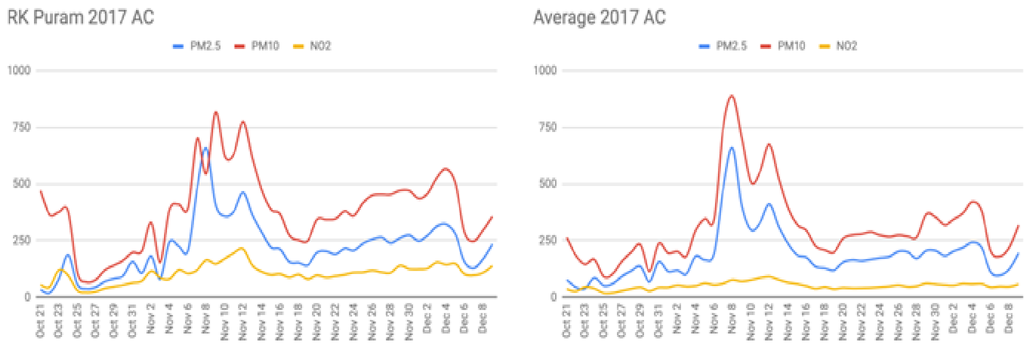
AQI Category (Range)	PM_{10} (24hr)	$PM_{2.5}$ (24hr)	NO_2 (24hr)	O_3 (8hr)	CO (8hr)	SO_2 (24hr)	NH_3 (24hr)	Pb (24hr)
Good (0–50)	0–50	0–30	0–40	0–50	0–1.0	0–40	0–200	0–0.5
Satisfactory (51–100)	51–100	31–60	41–80	51–100	1.1–2.0	41–80	201–400	0.5–1.0
Moderately polluted (101–200)	101–250	61–90	81–180	101–168	2.1–10	81–380	401–800	1.1–2.0
Poor (201-300)	251–350	91–120	181–280	169–208	10–17	381–800	801–1200	2.1–3.0
Very poor (301–400)	351–430	121–250	281–400	209–748	17–34	801–1600	1200–1800	3.1–3.5
Severe (401–500)	>430	>250	>400	>748	>34	>1600	>1800	>3.5

* CO in mg/m3 and other pollutants in μg/m3 ;

In this section, the change in the ambient concentrations of NO2, PM2.5 and PM10 a year after the emergency is observed. After finding the change in the ambient concentrations, conclusions can be drawn on the improvement or deterioration rate of the air quality in Delhi. Figures 1-4 represent the daily data of the pollutants taken from the 3 fixed stations, as well as one final average graph. All data is in the units of µg/m3 (AC data from 2017). *AC : ambient concentrations

AQI	Associated Health Impacts
Good (0–50)	Minimal impact
Satisfactory (51–100)	May cause minor breathing discomfort to sensitive people.
Moderately polluted (101–200)	May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults.
Poor (201–300)	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease.
Very poor (301–400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
Severe (401–500)	May cause respiratory impact even on healthy people, and serious health impacts on people with lung/ heart disease. The health impacts may be experienced even during light physical activity.

Health risks at given AQI

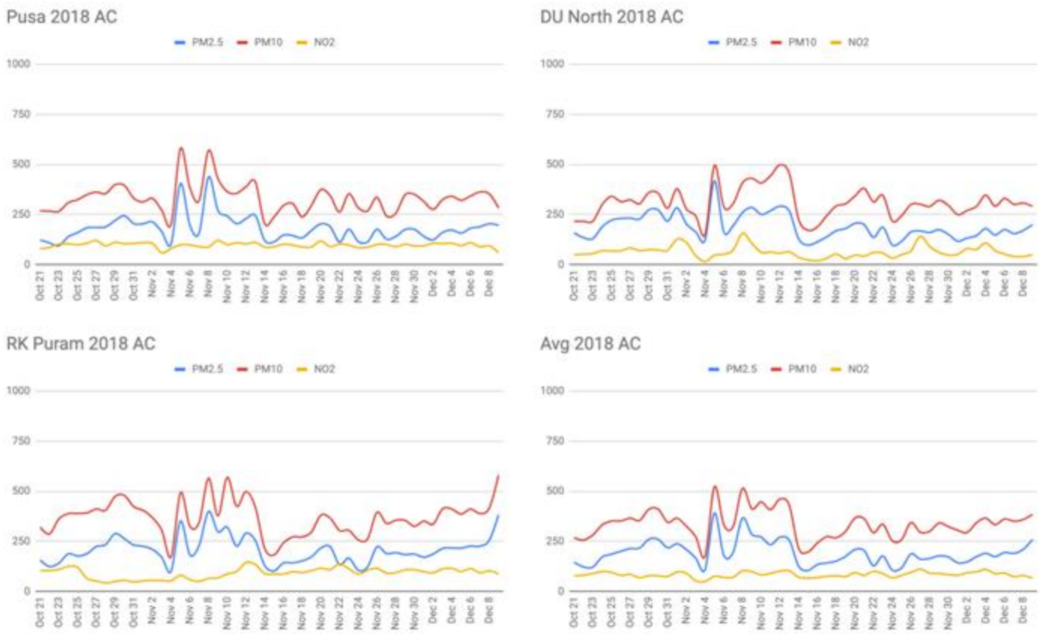


Figures 3-4

A few clear observations can be made from this data. Firstly, the pollutants' concentration for Nov 7-9 can be quantified, with an average peak ambient concentration on Nov 8 of ~**659µg/m3**, **887µg/m3** and **77µg/m3** for PM2.5, PM10 and NO2 respectively. Just to better visualise the severity of those amounts of pollutants, they are ~**x11** and ~ **x9** times the national air quality standards for a 24 hours time weighted average and ~**x16** and ~**x15** times for an annual time weighed average for PM2.5 and PM 10 respectively [7]. The associated health risks at this level are discussed in the change in AQI section of this paper. The highest recorded ambient
concentrations of PM2.5 and PM10 was logged on Nov 8 at the North campus DU station, at ~**715µg/m3** and ~**1188µg/m3** respectively.

Secondly, after the clearly visible peak of PM on Nov 8, we can start to see a decline in ambient concentrations. This can majorly be attributed to two factors, the GRAP measures and a change in wind as wind flow from NW only continued till 12th November. From 13th, wind flow shifted towards NW under influence of western disturbance approaching Delhi. There was also a possible shift in mixing height. The most intensive GRAP measure would have been the previously mentioned odd-even road space rationing scheme which lasted from Nov 13 to Nov 17. While in this situation it clearly seems to have helped, an analysis of the previous two test runs of this control measure suggests that it was actually not that effective. Thus, in this situation it was mostly the meteorological changes that helped control the pollution [8].

The above data can now be compared to data for the same dates for 2018. Figures 5-8 represent the daily data of the pollutants taken from the 3 fixed stations, as well as one final average graph. All data is in the units of µg/m3 (AC data from 2018).

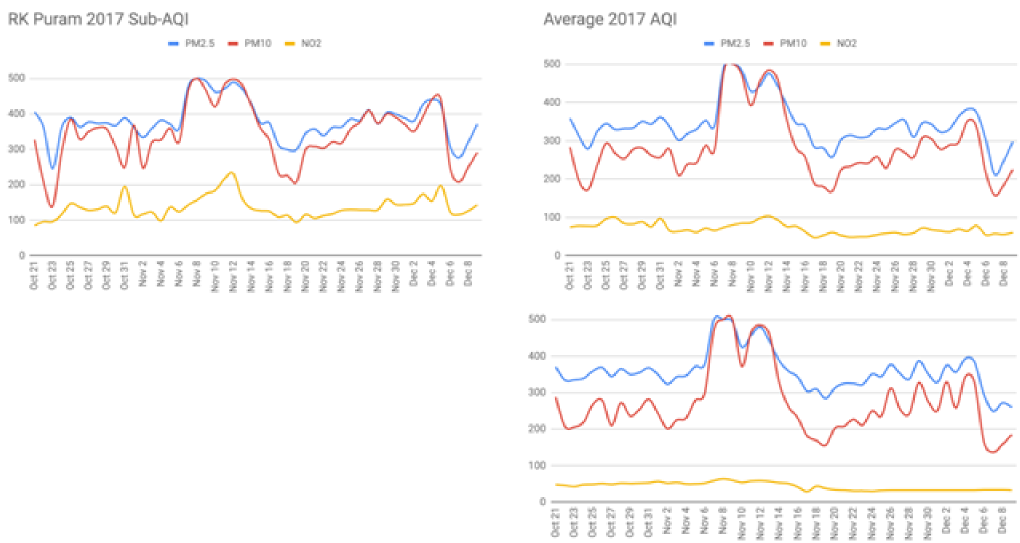


Figures 5-8

It is easily observed that this time there was not a short two-three day period of exceedingly severe AC like Nov 7-9 2017, but instead consistently high AC. Diwali this year happened on Nov 7, and that spike is clearly observed on the date of Nov 8 across all stations. This is clear evidence that despite the Delhi supreme court's pseudo-ban on firecrakers, this rule was poorly enforced and/or followed. For a more in depth data comparison, changes have been calculated and logged in table 3. All data is in the units of µg/m3. All entries are a specified station's average for the selected 50 days for a specified year. % Change is also calculated for each station for each pollutant.

Table 3

With this directly calculated comparison, it is observed that in fact all pollutants on average experienced an average increase. However, one odd result seen here is how all PM increases only happened around the Pusa station, that too by quite noticeable levels. An argument could be made about how in 2017 the fixed monitoring station at Pusa does not seem to function properly, as it detects barely any NO2 and by figure 1 we see seems to experience far more fluctuations in PM levels sometimes all the way to below 10µg/m3. These readings could be inaccurate due to the fact that the other stations report much different levels of AC on the same dates. Further, NAMP seems to have deployed another continuous fixed monitoring system at the same location around Jul 5 in 2018, as the NAMP online system shows there to be a IMD (India Meteorological Department) as well as a DPCC (Delhi Pollution Control Committee) station at Pusa. This is yet another area



Figures 9-10

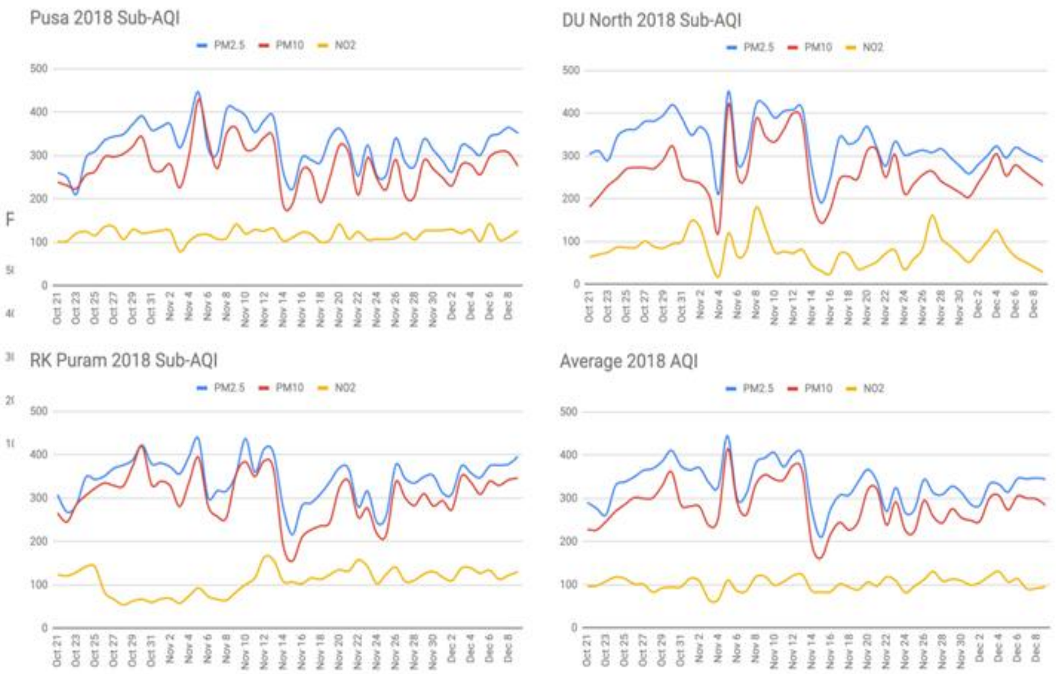
	PM2.5			PM10			NO2		
Station	2017	2018	% Change	2017	2018	% Change	2017	2018	% Change
Pusa	139.377	180.2426	29.32%	236.5861	329.3302	39.20%	15.4184	97.8994	534.95%
DU North	200.5189	189.8214	-5.33%	318.8356	309.5514	-2.91%	31.2672	64.185	105.28%
RK Puram	217.6033	207.5374	-4.63%	384.6648	368.4976	-4.20%	105.6819	91.408	-13.51%
Average	**185.83**	**192.53**	**3.61%**	**313.362**	**335.793**	**7.16%**	**50.789**	**84.497**	**66.37%**

where AQI score graphs and data could come handy as they would allow for more room for error due to general categorisation.

IV. CHANGE IN SUB-AQI SCORES

In this section data can be compared more qualitatively for the 50 days from both years due to it being in the form of sub-AQI scores. As previously explained, comparing data in sub-AQI scores can be beneficial as it helps us much more easily relate health risks to pollution levels, has a max cap to prevent data skewing, etc.

Figures 9-12 contain all the sub-AQI data for the three stations as well as a total average graph. All data is in the units of sub-AQI score, refer to table 1 to understand the different category thresholds.



Figures 11-12

Already it is seen that despite the pollution spike on November 8 being much worse than the one on Nov 12, in the sub-AQI data and graph it shows both the spikes to be almost exactly equally dangerous. From this data we see that even the average AQI (highest sub-aqi) is almost consistently **'severe'** or **'very poor'**. It is seen to be so for **44/50** days of the data collected (36 very poor, 8 severe).
To see the comparison and change in AQI, the data for the same dates from 2018 from the same stations is plotted in figures 13-16 (3 individual stations data and one total average data).

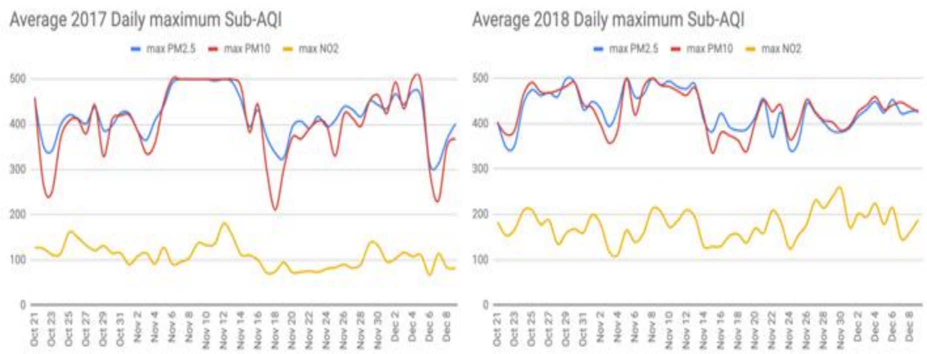
Figures 13-16

It can be observed that in 2018 no station showed a peak daily average of a 500 AQI score for any pollutant, but most definitely NO2 sub-AQI scores have seen a rise. Further we know that in 2018 the Diwali fireworks lighting, although not fully legal, occurred on Nov 7 which shows a slight rise again after an initial spike around Nov 5 due to stubble burning as well as an influence of biomass burning pollutants in Delhi NCR. Calm winds and stable atmosphere was also reported to be very likely and thus lead to the PM not dispersing [9]. Now the change in sub-AQIs from last year can be observed and compared, as presented in table 4. All data is presented in terms of a sub-AQI score, which can be used to infer severity category as well as health risks from tables 1 and 2 respectively.

Table 4

It can be observed here that NO2 levels certainly saw a rise whereas PM levels saw a decrease. This would indicate that while certain measures around PM, which is solid, have worked. However, it also clearly shows that in fact emissions from vehicles in no way have decreased. Health risks from nitrogen oxides may potentially result from NO2 itself or its reaction products including O3 and secondary particles. Epidemiological studies of NO2 exposures from outdoor air are limited in being able to separate these effects. Additionally, NO2 concentrations closely follow vehicle emissions in many situations so NO2 levels are generally a reasonable marker of exposure to traffic related emissions [10].

The NAQI (National Air Quality Index) system also logs the max sub-AQI a pollutant reaches everyday and so those numbers could also be compared for a better understanding of pollutant trend changes in a year. This data is presented in figures 17-18 for both years (labeled) for the those year's average daily maximum AQI graphs. All data is presented in terms of a daily maximum sub-AQI score (highest score recorded), which can be used to infer severity category as well as health risks from tables 1 and 2 respectively.



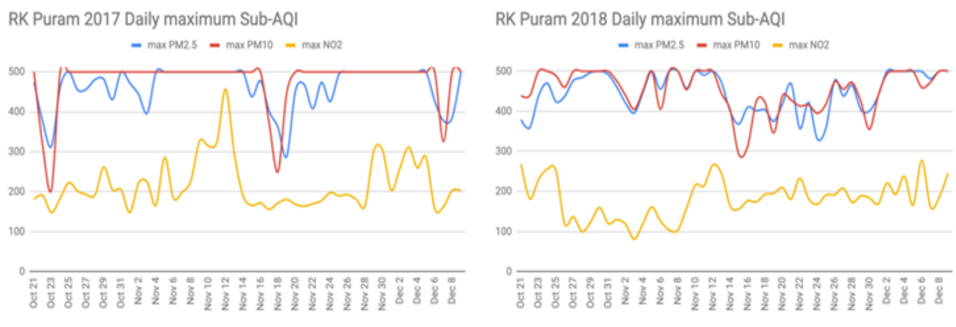
Figures 17-18

From these graphs it can be seen that peak PM in the air has gone down yet peak NO2 has gone up. This can be used to prove once again that vehicular traffic has increased but perhaps measures such as shutting down the Badarpur coal power plant as well as short term countermeasures such as turning on sprinkling systems have helped decrease PM pollution. While both NO2 and PM can occur naturally and even though vehicular engines also produce PM, we could also infer that construction activity has slowed down in certain areas as that is one factor that only contributes to PM. To support this, the data from the RK Puram station for

2017 and 2018 can be compared, from tables 3 and 4. That station has seen the largest % change out of all the stations in this study, and all of it has been a negative trend. This is especially seen visually in the difference between the graphs of max sub-AQI data from the RK Puram station from 2017 to 2018, represented in figures 19-20. All data is presented in terms of a daily maximum sub-AQI score (highest score recorded).

	PM2.5			PM10			NO2		
Station	2017	2018	% Change	2017	2018	% Change	2017	2018	% Change
Pusa	294.26	324.48	10.27%	233.100	277.56	19.07%	32.08	118.16	268.33%
DU North	359.58	330.38	-8.12%	273.48	263.12	-3.79%	43.62	78.86	80.79%
RK Puram	381.44	344.4	-9.71%	343.5	303.74	-11.57%	136.12	109.14	-19.82%
Average	**345.093**	**325.267**	**-5.75%**	**283.360**	**254.907**	**-10.04%**	**70.607**	**102.053**	**44.54%**

Research Paper



Figures 19-20

Clearly it is seen that peak PM sub AQI levels, as well as PM AC (from table 3) have gone down around this station in particular, but almost all increased around the Pusa station.

V. CONCLUSION

Despite the CPCB allotting 379.5Lakh rupees to air quality management and air quality R&D in their 2018 annual action plan [11], and the supreme court passing new laws, 2700 data points suggest an overall more consistent degradation of air quality, despite a AC data skew in favour of a decrease of pollution scenario. This also speaks about the mindset of people as how 2017 is always seen as the worst year for air pollution despite each year actually getting consistently worse. From closely examining different pollutant changes differently, another particular conclusion made was the unnecessary increase in vehicular activity, which is a trend that is sure to grow every year. Practices of stubble burning will also not be slowing down due to an increase in population, despite bringing about massive economic loss and adverse health effects, especially to children [12].

REFERENCES

[1]. All AC Data : https://app.cpcbccr.com/ccr/#/caaqm-dashboard-all/caaqm-landing
[2]. All AQI Data : https://app.cpcbccr.com/AQI_India/
[3]. https://www.theguardian.com/cities/2019/mar/05/india-home-to-22-of-worlds-30-most-polluted-cities-greenpeace-says
[4]. https://www.theguardian.com/world/2017/nov/07/delhi-india-declares-pollution-emergency-as-smog-chokes-city
[5]. https://cpcb.nic.in/uploads/final_graded_table.pdf
[6]. https://cpcb.nic.in/displaypdf.php?id=bmF0aW9uYWwtYWlyLXF1YWxpdHktaW5kZXgvQWJvdXRfQVFJLnBkZg==
[7]. http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf
[8]. https://www.environment.gov.au/protection/publications/factsheet-nitrogen-dioxide-no2
[9]. https://cpcb.nic.in/uploads/National_Ambient_Air_Quality_Standards.pdf
[10]. https://cpcb.nic.in/air/grap/18thMOM-TaskForce-GRAP13.11.2017.pdf
[11]. https://cpcb.nic.in/air/grap/32ndMOM-TaskForce-GRAP05112018.pdf
[12]. https://www.greenfacts.org/en/nitrogen-dioxide-no2/level-3/01-presentation.htm#0p0
[13]. https://cpcb.nic.in/annual-action-plans/
[14]. https://www.livemint.com/news/india/air-pollution-from-crop-stubble-burning-costing-india-billion-annually-study-1551682436123.html

XXX" Comparing levels of air pollutants in New Delhi, India one year after emergency level conditions and policy changes" Quest Journals Journal of Research in Environmental and Earth Science, vol. 05, no. 02, 2019, pp. 21-28