CHARACTERISING THE POLLUTION CONCENTRATION IN HIGHLY URBANIZED AREA: AN APPLICATION OF REMOTE SENSING

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ABSTRACT:

According to estimates from the World Health Organization (WHO), air pollution contributes to about seven million deaths worldwide annually. Currently, more than 90% of people breathe air that exceeds the WHO's recommended threshold of pollutants. This high degree of air pollution results in serious public health problems, such as pneumonia, acute asthma, chronic respiratory conditions, and shortness of breath. The execution of solutions to lower pollution exposure is therefore required, a study into the causes of air pollution. The "National Clean Air Programme (NCAP)", a five-year action plan, has been launched by the Ministry of Environment, Forest and Climate Change (MOEFCC, 2019), Government of India. The program's primary objective is to combat significant air pollution problems over the Indian subcontinent. As a result of economic growth, air pollution concentrations have consistently climbed to dangerous levels. To investigate influence of anthropogenic parameters on urban air, statistical analysis has been carried out for 8 Indian cities for pre- and post-COVID period using Sentinel-5P earth observatory data. These factors include population density, land use and total registered vehicles. The results of the investigation demonstrated that during the lockdown, air pollution levels in cities decreased. It is also discovered that pollutant levels have escalated once more since the lockdown limitations were lifted. It is clear from the findings that parameters affect pollution exposure. This demonstrates categorically that the pandemic has a beneficial effect on pollution exposure. A policy framework can be advised for policymakers based on the study done.

1. INTRODUCTION

1.1 The COVID-19 lockdown and pollution exposure

The World Health Organization declared COVID-19 a global public health emergency (WHO) on January 30, 2020. A national lockdown was imposed over India from March 25 through May 31, 2020. Through restrict the propagation of coronavirus, several relaxations were implemented from phase I to phase IV. During the lockdown, all Indian citizens were urged to remain indoors. All modes of transportation, including local and international aircraft as well as highways, were shut down. As a result, there was a decrease in outdoor activities, personal travel, social, such as theatres, sports, and restaurants; academic and business closures across the construction and commercial sectors (Kumar et al., 2020). Almost all industry were shut down, with the exception of critical services such as food and medicine. As a result of the epidemic, greenhouse gas emissions from transportation and industry have been halted. As a result, there is a reduction in anthropogenic contaminants. The COVID-19 outbreak is referred to as a 'anthropogenic emissions switch-off' experiment by the authors (Kumar et al., 2020). The authors go on to say that turning off an anthropogenic emission establishes a pollution benchmark, which many cities may strive for under 'normal' circumstances. This switch-off can give important and special educational opportunities, such as future rules for improving urban air quality and prospective control mechanisms. According to study by (Guo et al., 2017; Mukherhee & Agrawal, 2018; Sharma et al., 2020; Shukla et al., 2020), India has faced numerous air pollution issues in recent decades. This is due to the rapid expansion of industries and the quick growth of the population. Air pollution concentrations have reached dangerous levels as a result of economic expansion, consistently exceeding ambient air quality requirements. According to new research, residing within 50 metres of a major road increases your risk of lung cancer by 10%. It has also been discovered that poor air quality has an effect on the heart, increasing the risk of coronary heart disease and heart attacks (Rieke, C., 2020). According to (Mahato et al., 2020; Sharma et al., 2020), there have been few studies on air quality changes in India as a result of the COVID-19 epidemic. However, same studies discovered a significant drop in key air pollutants (e.g., PM_{10}, $PM_{2.5}$, SO_2, CO, NO_2, O_3, and NH_3), owing to fewer on-road cars and the halt of non-essential sectors. Authors have found that global carbon dioxide emissions decreased by 17%, with half of the reduction coming from the transportation sector due to a reduction in fumes from sclerotic traffic and the rest coming from the industry and power sectors (Le Quéré et al., 2020; Safarian et al., 2020).

1.2 Anthropogenic activities and pollutants

In climate change and tropospheric chemistry, nitrogen oxides (NO, NO_2) play a key role (Pathakoti et al., 2021). Transportation (32 %), thermal power plants (28 %), industrial operations (21 %), and burning of biomass (19 %) account for the majority of global NOx (NO, NO_2) emissions in India, although soils and lightning are natural sources of NOx (Biswal et al., 2021). Thermal power plants, urban centres, and industrial zones are NO_2 hotspots. Carbon monoxide (CO), in addition to NO_2, is a significant gas in the troposphere and the primary source of the secondary pollutant ozone in NOx-rich conditions. Despite the fact that carbon dioxide is not a direct greenhouse gas, it has the potential to cause global warming due to its impacts on the lifetime of many greenhouse gases. Anthropogenic emissions provide a considerable amount of CO to the atmosphere. NOx pollution is estimated to have caused about 0.1 million fatalities worldwide (Anenberg et al., 2017), 4 million asthma cases each year (Achakulwisut et al., 2019), and respiratory infections and cardiovascular mortality are on the rise (Chen et al., 2012). The COVID-19 lockdown has compelled most countries to impose severe shutdown measures, which have decreased economic and transit operations. In many industrialized countries, this led to considerable drops in air pollutants such NO_2, CO_2, PM, CO,

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SO_2, and aerosols (Kanniah et al., 2020; Lal et al., 2020; Le et al., 2020; Ranjan et al., 2020; Sharma et al., 2020).

1.3 Objectives of the study and study area

The study is carried out to understand the level of pollution exposure. The objectives of the study are (1) To understand the pollution characteristics of Indian cities 2) To analyze factors influencing and responsible for rise in the pollutants exposure. To understand the pollution characteristic pre, during and post lockdown conditions were compared. The parameters like population density, residential landuse, green space, industrial landuse, and total registered transport vehicles are used to identify the factors influencing the pollutant rise. The present study is conducted for eight Indian cities (Figure 1). The different eight Indian cities—Greater Mumbai, Delhi, Kolkata, Surat, Pune, Lucknow, Bengaluru, and Hyderabad have been chosen to analyze the pollution exposure. The cites are considered based on various parameters like pollution exposure level, population density, road density, Industries etc. This study will help decision makers to redesign area and to promote landuse not trapping the pollution.

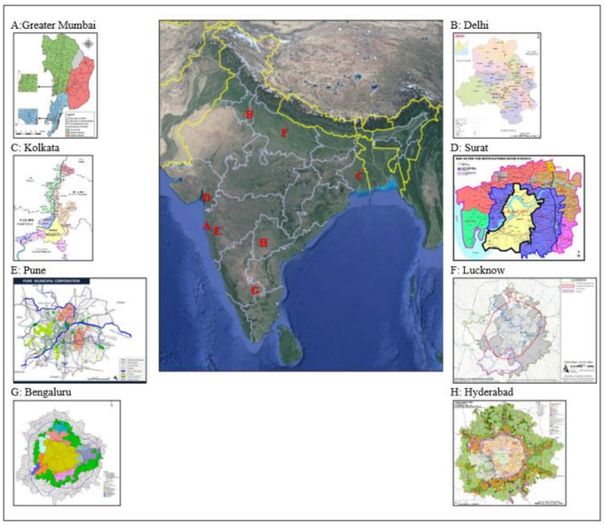

Figure 1. Study area

2. METHODOLOGY AND DATA COLLECTION

2.1 Methodology

The methodology is shown in figure 2. First, the problems regarding pollution exposure over Indian cities are identified. Based on issues, different parameters, various technologies used literature is reviewed. Considering all these factors in mind, objectives are formed. For this study, selection of Indian cities done based on megacities and million plus cities. Then, data collection from satellite is done for three pollutants nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and carbon dioxide (CO). Collected data is analyzed with respect to time and parameters considered. For analysis, graphs and scatter plots are made. Comparison is done with the help of graphical representations formed. Results are discussed and formation of planning policies are done.

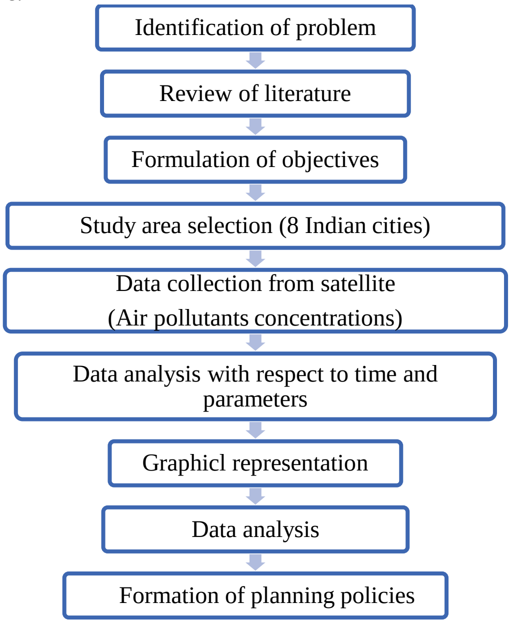

Figure 2. Methodology flow chart

2.2 Data collection

The TROPOMI Sentinel-5P satellite dataset is used as the main source of information for pollution concentration measurements. Online resources and the official websites of the relevant cities are used to gather secondary data. This comprises the "Road Transport Year Book", "Comprehensive Mobility Plans (CMP)" and "City Development Plans (CDP)" (Refer table 1).

City	Area (in km²)	Population (in million)	Population density (in persons per km²)	Land use (in %)				Total registered transport vehicles
				Transportation and communication	Residential	Green space	Industrial	
Greater Mumbai	458.28	12.44	27145	12.80	24.90	3.70	5.40	3052901
Delhi	1483.00	16.79	11320	12.00	53.00	16.00	4.00	11391551
Kolkata	1875.00	16.70	7978	5.40	31.20	0.90	5.90	1917878
Surat	715.00	4.80	6720	4.94	14.33	0.33	5.44	3378193
Pune	243.84	3.11	12777	13.05	42.55	8.37	4.05	2717322
Lucknow	244.82	2.88	11764	32.04	41.99	4.08	3.84	2340901
Bengaluru	1206.97	8.94	7410	7.28	17.63	1.71	3.78	8054030
Hyderabad	7204.00	9.41	1306	1.63	6.83	18.35*	2.60	2714510

(*Includes special area, conservation, forest and water bodies)

Table 1. City wise anthropogenic factors responsible for pollution exposure

3. DATA ANALYSIS

The data analysis has been carried out by comparing pollutant concentrations in form of column number densities for Indian cities. This comparison is based on graphs generated for all pollutants and monthly data collected for three years 2019, 2020 and 2021. Year 2020 is considered as benchmark because of COVID-19 pandemic, air quality has improved due to shutdown of all anthropogenic activities. As per data analysis from India's Central Pollution Board, there was significant difference in air quality in the country. Also, Indian residents saw the towering peaks of Himalayas from Punjab for the first time in 30 years, due to massive drop in pollution caused by the country's coronavirus lockdown in April (www.abc.net.au/news). So, for comparison of pollutant concentration, data of April month is considered.

3.1 Analysis of pollutants in core area

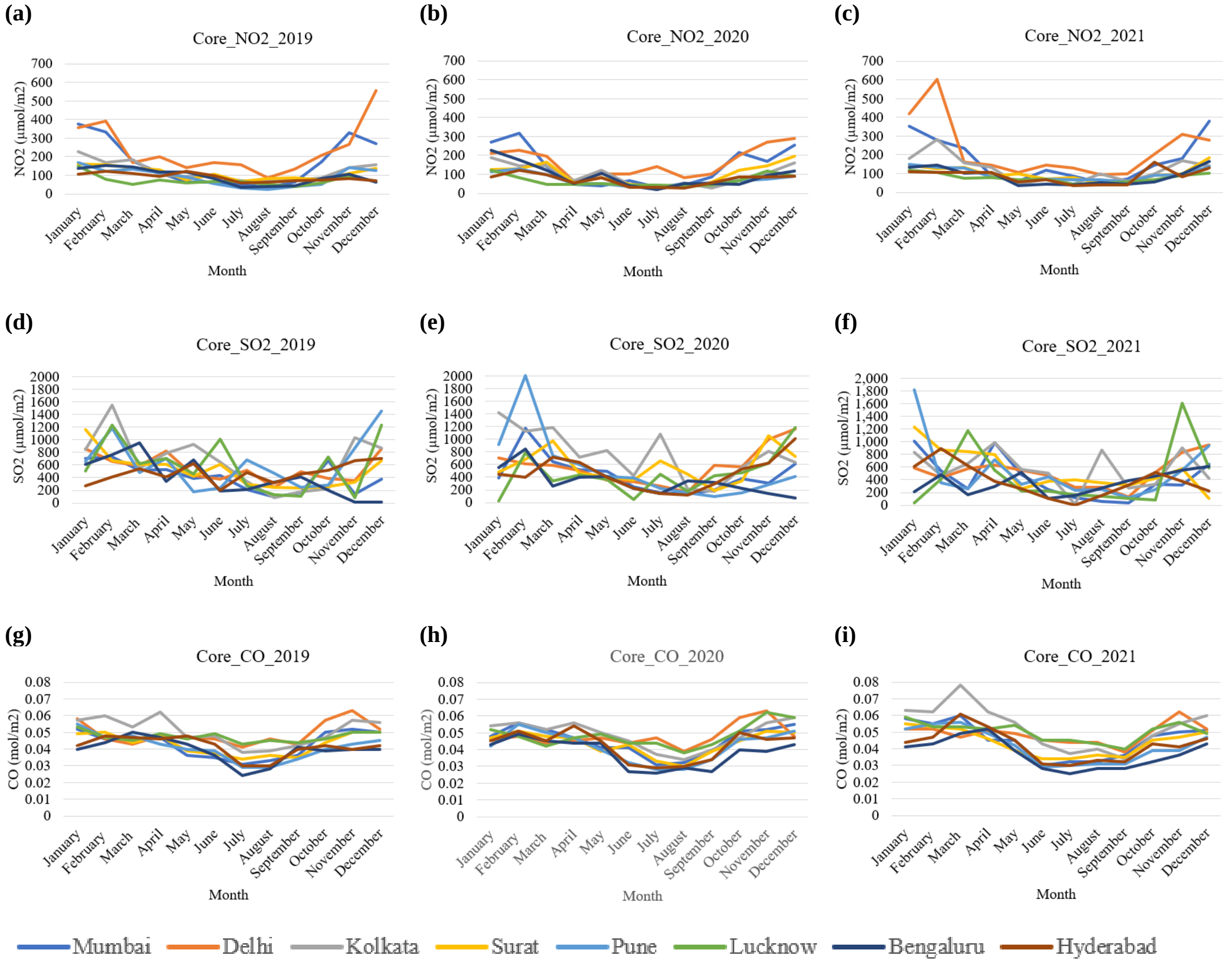

Figure 3. Pollutants concentration in core area of city

In the figure 3, it is observed that monthly variation of nitrogen dioxide in core areas of cities for years 2019, 2020 and 2021 (graphs (a), (b) and (c), respectively). It is also observed that, there is reduction in NO_2 concentrations for year 2020 due to lockdown. Also, it is noticed that concentrations are at higher range in winter season than in summer season. This is due to the phenomenon of temperature inversion. From the figure 3, (a), (b) and (c), it is found that if whole year is considered then it is observed that Delhi is having more NO_2 concentration and Lucknow shows less NO_2 pollution than other cities. For Mumbai, NO_2 mean measurement was 114.556 µmol/m^2 in April 2019 and 47.916 µmol/m^2 in April 2020. This shows reduction of NO_2 pollutant concentration of 58.17%. There is increase in concentration to 91.967 µmol/m^2 in April 2021, which shows increment of 91.93%. The measurement in Delhi at higher range, reduction of 68.63% is observed during lockdown. For April 2021, higher increase is noticed of 132.71% than April 2020. Kolkata city shows decline of 36.26% if compare April month in 2019 and 2020. Kolkata also shows higher increment of 100.15% in April 2021. Surat city's NO_2 pollution is reduced by 56.76% in April 2020. In 2021, NO_2 concentration increment is of 58.16%. For Pune city, NO_2 reduction of 53.82% in the year 2020 and increase of 61.12% in the year 2021. Lucknow city shows less measurements for NO_2 pollutant with reduction of 34.62% in lockdown period and observed increment of 59.79% in year 2021. Decline of 56.28% is observed in April 2020 for Bengaluru city and higher increase of 101.90% in post-lockdown time. Hyderabad city shows reduction of 41.8% for year 2020 and shows increase of 93.81% for 2021.

From the figure 3, (d), (e) and (f), it is found that if whole year is considered then it is observed that Kolkata is having more SO_2 concentration and Bengaluru shows less SO_2 pollution than other cities. Mumbai city shows decline of 31.05% if compare April month in 2019 and 2020 having SO_2 measurements 527.408 µmol/m^2 and 511.034 µmol/m^2, respectively. There is increment of 92.27% in April 2021 with concentration of 982.539 µmol/m^2. For Delhi city, there is reduction of 38.25% in the year 2020 and increase of 14.8% in the year 2021. There is minor reduction is noticed for Kolkata city in April 2020 which is only 9.19% reduction. Again, it has increased by 36.99% after lockdown. Surat city shows reduction by 24.71% of SO_2 measurement in year 2020 and increment of 71.48% in April 2021. For Pune, reduction of SO_2 pollutant concentration of 15.92% is noticed during lockdown and increment of 20.04% after lockdown. Lucknow city, measurement is reduced by 38.24 % in April 2020 and in April 2021, SO_2 concentration increased by 26.97%. The measurement in Bengaluru shows increase of 17% and decrease of 28% than April 2020. For Hyderabad city, there is increment of 51.97% and decrease of 40.7% observed during and after pandemic, respectively.

From the above (g), (h), (i) graphs, if whole year is considered, it is observed that Kolkata is having more CO concentration and Bengaluru shows less CO pollution than other cities. For Mumbai city, there is no change in CO concentration for both April months of the year 2019 and 2020 with measurement 0.047 mol/m^2. Further, CO measurement reduced to 0.045 mol/m^2 which is decline of 22.22% in April 2021. Delhi city shows decline of only 6.25% if compare April month in 2019 and 2020. There is increment of 13.33% in April 2021. Kolkata city shows reduction of 9.23% in April 2020 and increment of 10.71% in April 2021. There is increment of only 2.08% of CO pollutant for Surat city and decline of 2013% is noticed for April 2021. In Pune city, CO increased by 9.3% in April 2020 and again is increased by 4.25% in April 2021. For Lucknow, reduction of CO pollutant concentration of 4.25% and increment of 10.64% during and after lockdown, respectively. In April 2020, 6.38% reduction noted for Bengaluru city and again increase of 18.18% in 2021. For Hyderabad, in April 2020, increment of 17.39% is observed. For April 2021, there is no variation seen as compare to April 2020.

3.2 Analysis of pollutants in outskirts area

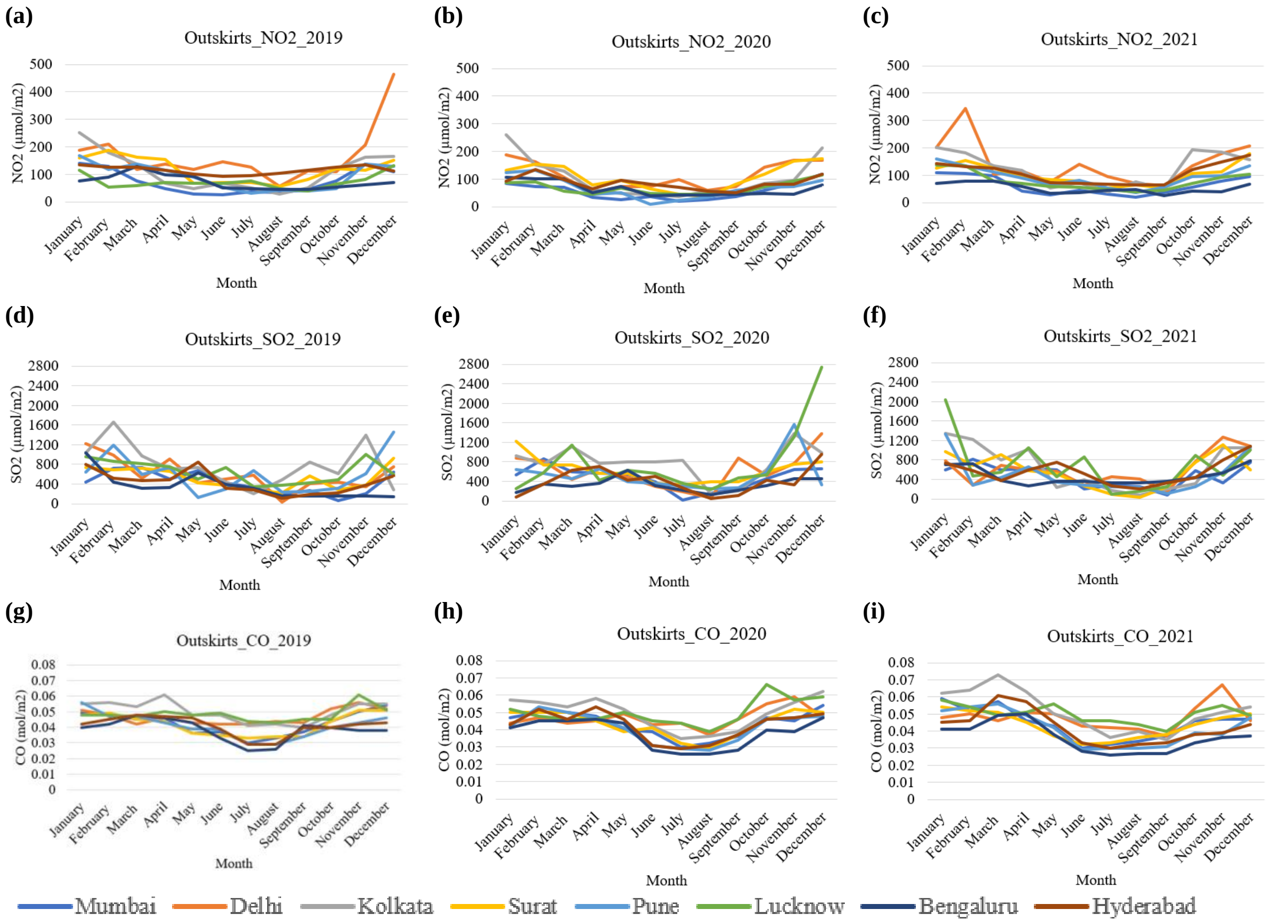

Figure 4. Pollutants concentration in outskirts area of city

In the figure 4, monthly variation is observed of nitrogen dioxide in outskirts areas of cities for years 2019, 2020 and 2021 (graphs (a), (b) and (c), respectively). From the above (a), (b), (c) graphs, if whole year is considered, it is observed that Delhi is having more NO_2 concentration for all three years and Bengaluru shows less NO_2 pollution than other cities for year 2019 and 2021. For year 2020, Mumbai shows less pollution. The NO_2 concentration were 46.936 µmol/m^2 and reduced to 34.057 µmol/m^2 in April month of year 2019 and 2020, respectively for Mumbai city. It is reduction of 27.44%. For April 2021, NO_2 measurement was increased to 41.931 µmol/m^2 which shows increase of 23.12%. Delhi city shows less measurements for NO_2 pollutant and reduction of 62.35% is noted for year 2020. In April 2021, higher increment of 121.41% is noticed. For Kolkata city, only 7.8% reduction is observed for April 2020 and again higher increase of 89.36% happened after unlock. For Surat, reduction of NO_2 pollutant concentration of 48.74% during pandemic and increment of 15.49% after pandemic. Pune city having measurement reduced by 61.01% in April 2020 and in April 2021, higher increase of 101.04% observed. In Lucknow reduction of 36.15% for 2020 and for April 2021 increase of 53.94% than April 2020 is noted. For Bengaluru city, NO_2 measurement having reduction of 47.76% in the year 2020 and increase of 15.71% in the year 2021. Hyderabad city shows decline of 45.03% if compare April month in 2019 and 2020 and shows increment of 64.84% in April 2021.

From the figure 4, (d), (e), (f) graphs, it is observed that Kolkata is having more SO_2 concentration for year 2019 and 2020 than other cities. Bengaluru shows less SO_2 pollution for all three years. In 2021, Lucknow city shows higher SO_2 measurements than other cities. For Mumbai, SO_2 mean measurement was 494.95 µmol/m^2 in April 2019 and 570.957 µmol/m^2 in April 2020. This shows increase of SO_2 pollutant concentration of 15.36%. There is again increase in concentration to 627.881 µmol/m^2 in April 2021, which shows increment of 9.97%. There is reduction of 27.83% for Delhi city in 2020 and again slight decrease of 8.38% in year 2021. Kolkata city shows increase of 9.57% in April 2020 and in April 2021 increment of 32.26% is noticed. Surat city shows decline of 13.92% if compare April month in 2019 and 2020 and increment of 2.98% in April 2021. For Pune city, decline of 10.26% is observed for SO_2 concentration in year 2020 and again shows decrease of 0.8307% in year 2021. For Lucknow city, SO_2 measurement reduction of 44.4% in the year 2020 and highly increase of 147.99% in the year 2021 is observed. The SO_2 measurement in Bengaluru, 8.01% increased for April 2020 and for April 2021 reduction of 24.74% than April 2020 is noted. Hyderabad city shows increase in measurement by 44.93 % in April 2020. In April 2021, SO_2 concentration shows reduction of 15.59%.

4. EFFECT OF ANTHROPOGENIC ACTIVITIES ON POLLUTION CONCENTRATIONS

To have the further analysis on how anthropogenic activity and urbanization affecting in pollution rising, various parameters are considered for analysis. The parameters like population density, residential landuse, green space, industrial landuse, and total registered transport vehicles which are influencing to the city pollution is correlated with pollutants. It is to check which factors influencing the most. To understand the impact of population, 8 Indian cities are divided in two groups based on significant population criteria. Group A cities includes Greater Mumbai, Delhi, Kolkata, Bengaluru and Hyderabad having population above 5 million. Group B cities includes Surat, Pune and Lucknow with population below 5 million, but above 1 million. The analysis is presented as two scatter plots as (a) for group A cities and (b) for group B cities.

4.1 Influence of different parameters on nitrogen dioxide pollutant concentration

4.1.1 Influence of residential landuse

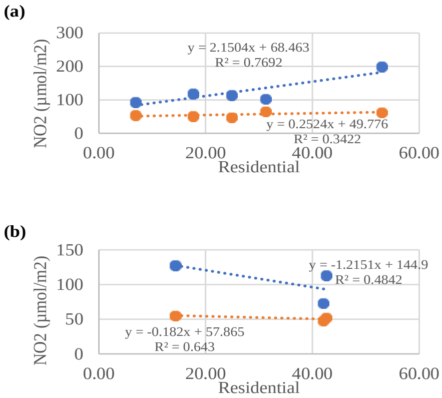

Figure 6. Influence of residential landuse on NO_2

From the above (g), (h), (i) graphs, it is observed that Kolkata is having more CO concentration and Bengaluru shows less CO pollution than other cities. For Mumbai, CO mean measurement was 0.046 mol/m^2 in April 2019 and 0.048 mol/m^2 in April 2020. This shows increment of CO pollutant concentration of 4.35%. There is again reduction in concentration to 0.046 mol/m^2 in April 2021, which shows decrease of 4.17%. CO concentration for Delhi city shows decline of only 2.17% in year 2020 and for April 2021, shows increase of 13.33%. For Kolkata city, reduction of 4.92% is observed in April 2020. Further, it is observed increment of 8.62% in April 2021 for CO measurement. Surat city shows increase of 2.27% during lockdown and no change in pollutant concentration with respect to April 2020. Pune city shows increment of 9.3% if compare April month in 2019 and 2020. There is again increment of 4.25% in April 2021. Lucknow city, concentration is reduced by 8% in April 2020 and in April 2021, increase of 10.87% is noticed. The measurement in Bengaluru city, CO measurement was same for both years 2019 and 2020. For April 2021, there increment of 8.7%. In April 2020, 12.77% increase is noted for Hyderabad city and again increase of 7.55% is observed after pandemic period.

4.1.2 Influence of population density

It can be observed in the above figure 5, population density has positive relation with nitrogen dioxide pollutant concentration for group A cities in the year 2019 (plot (a)). But it shows negative relation for year 2020. This may be because of lockdown, as all the anthropogenic activities were halted. For group B cities, it shows negative corelation with NO_2 for both the years.

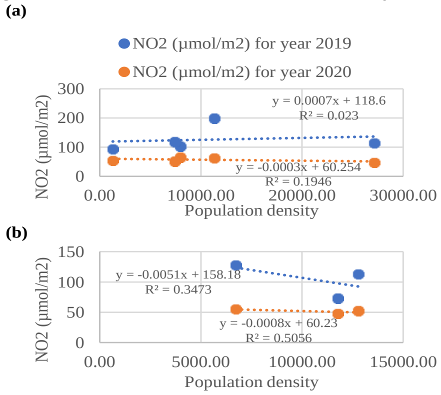

Figure 5. Influence of population density on NO_2

From the plots (figure 6) it can be observed, there is significant impact of residential area on NO_2 concentrations for group A cities both years. There is presence of vehicular emission in residential area with higher anthropogenic activities. For lockdown time, this relation is positive, but with slightly less slope. Opposite nature is seen in case of group B cities. There may be more plantation in residential areas, so nullifying the effect of pollutants.

4.1.3 Influence of green space

The percentage green spaces show the negative relation with NO_2 concentrations and this is very good result (figure 7). As green space increases, NO_2 pollution decreases. For group A, plots show less variation. But for group B cities, reduction is at higher level.

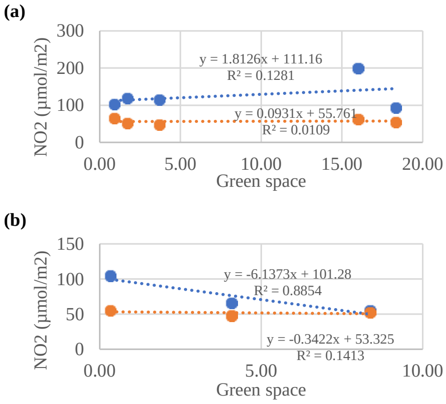

Figure 7. Influence of green space on NO_2

4.1.4 Influence of industrial landuse

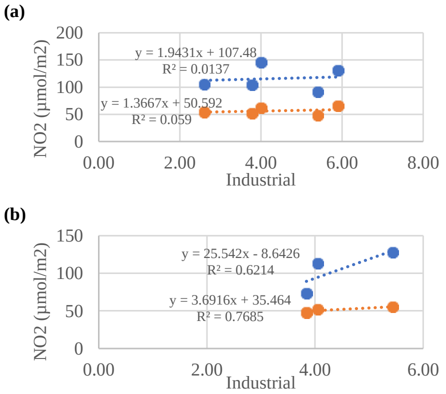

Figure 8. Influence of industrial landuse on NO_2

All the plots above shown in figure 8, shows positive relation with industrial landuse. This shows industries are impacting very much for pollution exposure. Cities are developing and so industrial sector is increasing. This ultimately results in higher pollution levels.

4.1.5 Influence of total registered transport vehicles

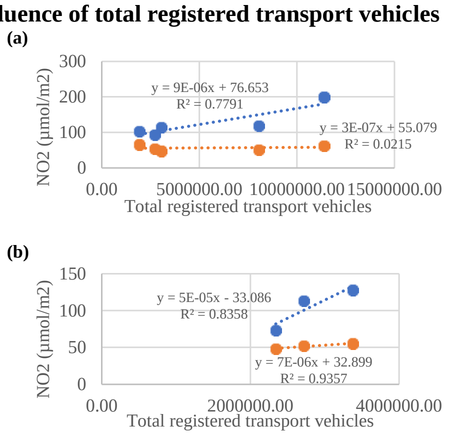

Figure 9. Influence of total registered transport vehicles on NO_2

As registered vehicles increases, more vehicular use tends to increase in pollution concentration of nitrogen dioxide. All the plots shown in the above figure 9, shows the positive relation with total registered transport vehicles. Three of the plots having good R^2 value more than 0.5. This implies, there is more influence to vehicular emission on NO_2 pollutant concentration.

4.2 Influence of different parameters on sulfur dioxide pollutant concentration

4.2.1 Influence of population density

Figure 10 shows relation between population density and sulfur dioxide pollutant concentration. It can be observed that, as population density increases, pollution increases for both groups of cities. There is negative effect in the year 2020 for group A cities, this is due to stoppage of anthropogenic activities.

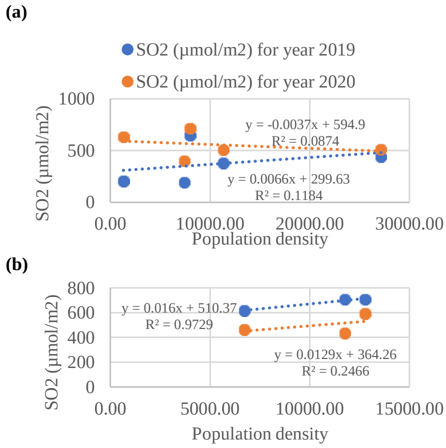

Figure 10. Influence of population density on SO_2

4.2.2 Influence of residential landuse

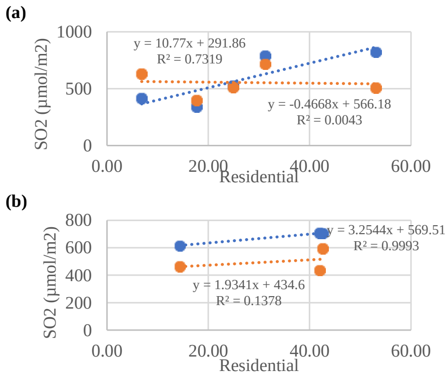

Figure 11. Influence of residential landuse on SO_2

As residential area increases the SO_2 concentration levels are increasing. People are living, vehicles are there, so anthropogenic activities are high. Also, it can be inferenced out that, this is rising at higher level for year 2019. Stable plot in 2020 shows anthropogenic activities are reduced and hence level of pollution has reduced.

4.2.3 Influence of green space

Figure 12 shows negative relation of SO_2 green space in year 2019, with increase in green spaces pollutant concentration reduces. Green spaces are responsible to reduce pollution exposure. But, in the year 2020, both groups of cities show opposite results.

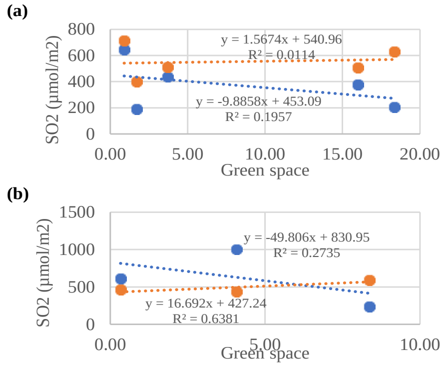

Figure 12. Influence of green space on SO_2

4.2.4 Influence of industrial landuse

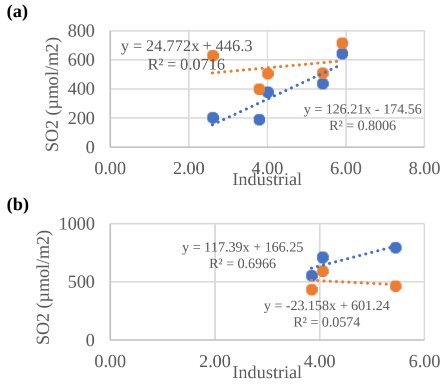

Figure 13. Influence of industrial landuse on SO_2

Both groups of cities show positive relation with industrial landuse and SO_2 pollution. 69 % of sulfur dioxide pollution is due to industries and this fact becomes true as plots are observed. The increment in pollution is at higher level before lockdown period than in year 2020.

4.2.5 Influence of total registered transport vehicles

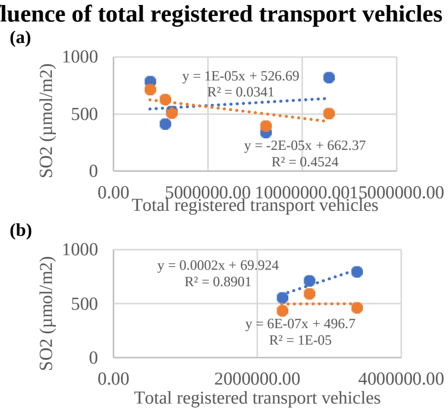

Figure 14. Influence of total registered transport vehicles on SO_2

Figure 14 shows relation with total registered transport vehicles and SO_2 pollution. Before lockdown period, plots show positive relation for both groups of cities. Pollution increases with increase in vehicles. But, during lockdown, plot depicts negative correlation as vehicular emission was drastically reduced. Plot shows stable relation for group B cities.

4.3 Influence of different parameters on carbon monoxide pollutant concentration

4.3.1 Influence of population density

It can be observed that in figure 15, carbon monoxide concentration is stable for group A cities for year 2019 with related to population density. But it shows decrement in year 2020. For group B cities, there is positive relation in year 2019. There is no change in pollution for group B cities in year 2020.

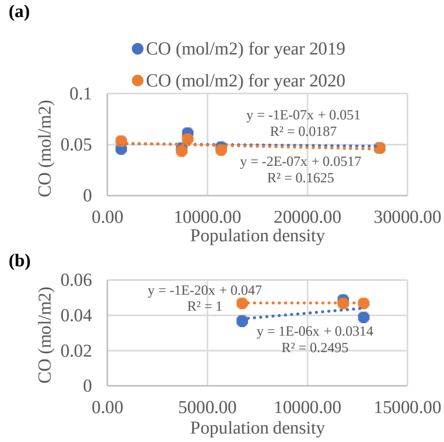

Figure 15. Influence of population density on CO

4.3.2 Influence of residential landuse

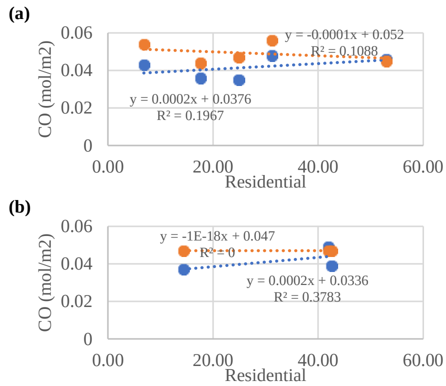

Figure 16. Influence of residential landuse on CO

Public vehicles drive in residential areas. The percentage residential area shows the positive relation with increase in CO level for both group of cities in year 2019. There is decline in plot in pandemic time, indicating reduction of anthropogenic activities reduces pollution exposure. There is no change for other cities in 2020.

4.3.3 Influence of green space

In figure 17, green spaces show negative relation with pollutants, which is a good sign. It can be observed for year 2019 for both groups of cities. In lockdown time, there is positive relation and stable plot for other cities.

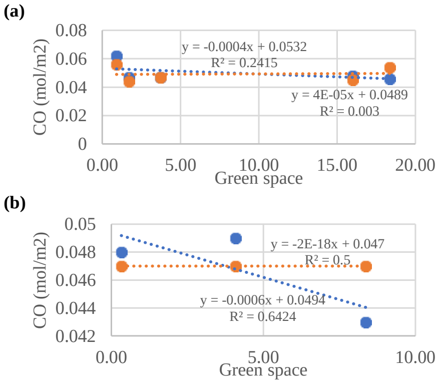

Figure 17. Influence of green space on CO

4.3.4 Influence of industrial landuse

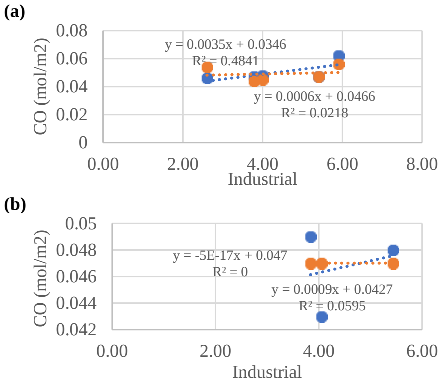

Figure 18. Influence of industrial landuse on CO

All the plots above shown in the figure 18, indicates positive relation with respect to industrial landuse. In the year 2019, there is higher increment in pollution concentration than in year 2020. There is slightly stable plot for lockdown for group A cities, which depicts reduction in anthropogenic activities. No change in plot for other group of cities.

4.3.5 Influence of total registered transport vehicles

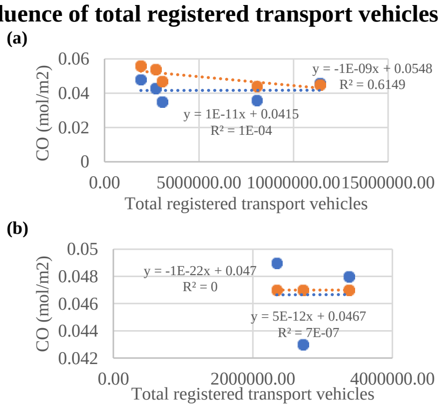

Figure 19. Influence of total registered transport vehicles on CO

Figure 19 shows stable plots for corelation between CO pollutant and total registered transport vehicles. Almost straight-line plots are noticed for both groups of cities in year 2019. In year 2020, group A cities shows decrease in slope indicating negative relation. In 2020, stop in travelling activity, so reduction in pollution. No change is seen for other city group in year 2020.

4. CONCLUSIONS

Pollution exposure is harmful to humans. An optimal level of pollution can be observed when anthropogenic activities halt. COVID-19 outbreak was the ideal period to benchmark pollutant concentrations where anthropogenic emissions switch off. So, the pandemic period imposed minimal pollution exposure. Concerning this, different years before and after lockdown has studied and it is found that, in the absence of anthropogenic activities, the level of pollution is minimal. NO_2 pollution was reduced between 40 to 70% during a lockdown. SO_2 pollution decrement was between 10 to 50%, while CO concentrations showed very less variation up to 20%. Further, the study is enhanced to understand which parameter is playing a major role in particular pollution exposure. Eight different cities are classified into two groups considering the relation of different parameters to study pollution exposure. From the results, it can be defined that parameters like population density, vehicles, landuse as residential and industrial have a significant influence on pollution exposure. Green spaces are a boon to lessen pollution. This analysis is done with the TROPOMI Sentinel-5P, which is very helpful for the collection of records at a larger scale and with a different time scale. With the help of this study, further analysis can be created for a combined effect of all the pollutants by preparing regression models or artificial neural network models. Based on that, decision-makers will get to know exactly which anthropogenic activity is responsible for which type of pollution. Accordingly suggestive, constructive results can be considered at a city level, and regional level to remove pollution hotspots.

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