A Comparative Study of Pollution Levels in Major Cities of India During Covid-19 in India

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Abstract

This paper aims to study the major pollutants of the four metro cities of India before and after covid 19 first wave. The cities considered for the study are Bangalore, Delhi, Mumbai, and Kolkata. The major pollutants considered for the study are PM2.5, PM10, NO, NO2, NOx, SO2, CO, and Ozone. The basic aim of the study is to find the effect of lockdown and covid restrictions on the level of pollutants across the four major cities of India. We used both parametric and non-parametric tests for the analysis using SPSS. From the study, it is clear that there is a significant decrease in all the major pollutants across India's major cities.[6]

JEL Classification: Q53, Q56

Keywords: Covid-19, pollutants, PM2.5, PM10, NO, NO2, NOx, SO2, CO, Ozone

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INTRODUCTION

According to the latest statistics from the World Health Organization, air pollution in cities is increasing at an alarming rate, particularly in growing economies like India, where pollutants harm human health and hasten glacier melt. In a statement, A*numita Roy Chowdhury*, executive director of the Centre for Science and Environment, stated, "This implies air pollution is now a national catastrophe that requires stringent and strong nationwide action across all cities of India". According to the Delhi-based think-tank, cities outside of India's major cities are growing increasingly polluted is concerning. (Sarkar, 2016). Air pollution is one of the major concerns to humans in this modern world, especially in a developing country like India. Due to air pollution, around four million deaths have occurred globally (Cohen et al., 2017).

One of the major pollutants, larger PM10 particles (mainly dust, sand, and soot), are prevalent in Indian cities. These particles reflect heat, making cities warmer and contributing to climate change at lower elevations. In terms of PM10 levels, India has eight cities in the top 30 globally. In India, around 1.2 million people died due to particle matter (PM) pollution in 2017 (Balakrishnan et al., 2019). A report published by the OECD mentions that the major sources of Air pollution constitute particle matter (PM) of different sizes (Nuclear Technology Development, 2018). India ranked third among the world's most polluted cities, with a PM2.5 value of 51.9 µg/m³, based on the 2020 World Air Quality Report (*World Air Quality Report Region & City PM2.5 Ranking*, 2020)**.** According to WHO, PM 2.5 levels below ten µg/m³ minimize the health risk. The results of the study are based on PM 2.5 analysis for 106 countries. A comparison of PM2.5 levels has been made across the globe, which shows that air pollution can be a major threat to humans.

During the phased unlocking in January 2021 in India, there was an increase in the PM2.5 concentration. The data collected for Delhi showed an increase of 185 percent compared to the level in the lockdown phase (Shukla et al., 2022). The major cause of the increased level was pollution and increased vehicle emissions.

In India, the first COVID-19 case was found on January 30, 2020. The Indian Government imposed a lockdown after a sudden increase in the cases, from March 25 to May 31, 2020. This was done to stop the spread of the virus among human beings. There was a drastic reduction in pollution and emission within four days, as observed by the central pollution control board (CPCB) (Sharma et al., 2020; Singh et al., 2020). As per (Paital & Das, 2021), India had won the war when the first wave of COVID, but the country suffered from a peak during the second wave due to factors like lack of planning, failure to set strategies for the future, and curb Covid -19 (Bhuyan, 2021).

Many researchers have looked into the relationship between Covid-19 and air pollution. Due to the continual lockdowns limiting traffic and industrial activities. Studies have also examined the relationship between air pollution and Covid-19 infections and deaths (van der Valk & in 't Veen, 2021). Air pollution wreaks havoc on the respiratory system, causing serious lung damage and cancer. Coronavirus affects the respiratory system, and air pollution can worsen the effects of the virus and increase mortality. Furthermore, air pollution is thought to hasten the transmission of the Coronavirus through the pollutants, resulting in a high infection rate.

To aid in COVID-19, the WHO and many other organizations have released guidelines and notifications for air pollution reduction. Experimental findings (Róka et al., 2021) back this up. Seventy-eight percent of mortality was highly connected to places with high NO2 levels during the outbreak of COVID-19 in nations like Italy, Germany, Spain, and France (Ogen, 2020). COVID-19-related mortality was particularly prevalent in Northern Italy, where pollution levels were particularly high compared to other regions (Conticini et al., 2020). These examples

show air pollution is the major cause of COVID-19 transmission (Martelletti & Martelletti, 2020). In this paper, we are studying the change in the pollution level due to lockdowns and steps taken by the Government of India. Is there a significant change in the pollution level due to actions taken by the Government of India due to Covid-19 and the fact that pollutants affect the spread and severity of infection of Covid-19?

METHODS

The pollution data was collected from the Central Pollution Control Board dashboard (CPCB) (*Central Control Room for Air Quality Management*, 2021). The data collected was from the four major cities of India, which were highly affected because of covid-19. They are Bengaluru, Chennai, Delhi, and Kolkata. The major pollutants considered for the study are PM2.5, PM10, NO, NO2, NOx, SO2, CO, and Ozone. The study duration was from April 26, 2019, to April 26, 2021. We divided the data into two parts from April 26, 2019, to April 25, 2020, as pre covid and April 26, 2020, to April 25, 2021, as during covid 19.

Since the data is time-series data, we are interested in the paired change in the pollutants for the same duration. For analyzing the effect of the pollutants mentioned above on cities, we have performed a parametric paired t-test and a Non-parametric Wilcoxon Signed Rank Test.

Paired t-test

Before applying the t-test, we have to check the assumption of paired t-test. One major assumption is the Normality of the measurement and equality of variance of both the groups, i.e., before covid and after covid. Both the assumptions are not satisfied; though the t-test is considered a robust test, we apply the paired t-test to the data if the sample size is large. A non-parametric Wilcoxon signed-rank test is also applied for the same data. The analysis here is done city-wise for all eight major cities.

The Null hypothesis for the t-test is

Ho: There is no significant difference between the Pollutant level before covid and after covid

The Null hypothesis for Wilcoxon Signed rank test is

Ho: The median of the Pollutant level before covid and after covid are equal

Bangalore is one of the major metro cities of India with a population of 1,31,93,035, and during covid 39,40,795 ("Karnataka Reports 366 New Covid-19 Cases, 17 Deaths," 2022) people were infected with a total death count of 39,936. Delhi, the capital of India, contains a population of 3,20,65,760. During the covid period of 18,27,489 ("Delhi Reports 3674 Fresh Covid Cases 30 Deaths," 2022), people were infected, with a total death count of 25,927. The current population of Kolkata is 1,51,33,888, and in total, there are 20,15,107 covid cases ("West Bengal Records 89 New Coronavirus Cases, Existing Covid Restrictions to Continue till March 15," 2022) with a total death count of 21,176. Mumbai being the first city in India to operate trains, has a total population of 2,09,61,000 and contains a total covid case of 10,45,630 ("Mumbai Reports 1160 New Covid-19 Cases, 10 Deaths," 2022) with a total death count of 16,612. It is seen that the highest covid cases and deaths are found across Bangalore city

RESULTS

Paired t-test and Wilcoxon Signed-Rank test results for each of the four cities are presented in Tables 1 to 4. The tables show t values, degree of freedom, and p values for the paired t-test and the Wilcoxon Signed-Rank test, positive and negative ranks, along with z and p values. The results for Bangalore are presented in Table 1, Delhi in Table 2, Kolkatta in Table 3, and Mumbai in Table 4.

Table 1: Paired t-test and Wilcoxon Signed Rank test for Bangalore City

Pairs	Pollutants	Mean	N	SD	Std. Error Mean	t	df	Sig. (2-tailed)	Ranks	N	Mean Rank	Sum of Ranks	Z	P
PM2.5_2020 - PM2.5_2019	PM2.5_2019	29.437	346	13.918	.748	.694	345	.488	Negative	187	171.27	32028	-1.081	.280
	PM2.5_2020	28.810	346	15.284	.821				Positive	159	176.12	28003		
PM10_2020 - PM10_2019	PM10_2019	78.780	346	30.274	1.627	4.809	345	.000	Negative	228	176.07	40143	-5.440	.000
	PM10_2020	68.229	346	27.298	1.467				Positive	118	168.54	19887		
NO_2020 - NO_2019	NO_2019	17.491	292	20.651	1.208	11.192	291	.000	Negative	239	161.56	38612	-11.927	.000
	NO_2020	3.974	292	3.775	.220				Positive	53	78.59	4165		
NO2_2020 - NO2_2019	NO2_2019	32.378	345	18.177	.978	2.883	344	.004	Negative	175	199.21	34862	-2.708	.007
	NO2_2020	27.484	345	17.921	.964				Positive	170	146.01	24822		
NOx_2020 - NOx_2019	NOx_2019	29.318	345	21.706	1.168	7.856	344	.000	Negative	215	196.40	42225	-6.680	.000
	NOx_2020	18.011	345	9.299	.500				Positive	130	134.30	17459		
SO2_2020 - SO2_2019	SO2_2019	3.434	275	2.840	.171	-1.320	274	.188	Negative	82	163.50	13407	-4.218	.000
	SO2_2020	3.731	275	1.556	.093				Positive	193	127.17	24543		
CO_2020 - CO_2019	CO_2019	1.087	345	.410	.022	15.183	344	.000	Negative	278	188.64	52442	-12.337	.000
	CO_2020	.661	345	.263	.014				Positive	66	104.52	6898		
Ozone_2020 - Ozone_2019	Ozone_2019	36.123	346	15.376	.826	3.379	345	.001	Negative	149	195.40	29114	-.484	.628
	Ozone_2020	32.713	346	7.465	.401				Positive	197	156.94	30917		

Source: Data collected by the researcher from CPCB

From table 1, it is clear that there had been a change in the pollution levels before covid and after covid for all the pollutants levels. If we see the value of paired t-test, there seems to be no significant change for the pollutants PM 2.5 and SO2, but there had been a significant change to lockdown for other pollutants. Similarly, Frome the Wilcoxon signed-rankest z and p values, PM 2.5 and Ozone, there is no significant change due to lockdown, but there is a significant change for all other pollutants.

Table 2: Paired t-test and Wilcoxon Signed Rank test for Delhi City

Pairs	Pollutants	Mean	N	SD	Std. Error Mean	t	df	Sig. (2-tailed)	Ranks	N	Mean Rank	Sum of Ranks	Z	P
PM2.5_2020 - PM2.5_2019	PM2.5_2019	97.682	350	83.232	4.449	-3.740	349	0.000	Negative	143	157.76	22560	-4.304	0.000
	PM2.5_2020	112.842	350	92.261	4.931				Positive	207	187.75	38865		
PM10_2020 - PM10_2019	PM10_2019	184.166	351	121.395	6.479	-4.655	350	0.000	Negative	130	160.81	20905	-5.248	0.000
	PM10_2020	217.639	351	138.657	7.401				Positive	221	184.94	40871		
NO_2020 - NO_2019	NO_2019	10.236	351	14.048	0.749	-3.858	350	0.000	Negative	120	179.63	21555	-4.906	0.000
	NO_2020	14.472	351	19.920	1.063				Positive	231	174.11	40220		
NO2_2020 - NO2_2019	NO2_2019	46.179	351	18.541	0.989	18.248	350	0.000	Negative	293	192.42	56380	-13.550	0.000
	NO2_2020	27.998	351	18.253	0.974				Positive	57	88.50	5044		
NOx_2020 - NOx_2019	NOx_2019	32.895	351	19.333	1.032	5.069	350	0.000	Negative	236	184.73	43596	-6.680	0.000
	NOx_2020	26.597	351	24.290	1.296				Positive	115	158.08	18179		
SO2_2020 - SO2_2019	SO2_2019	16.993	348	9.841	0.527	3.357	347	0.001	Negative	204	174.06	35509	-2.845	0.004
	SO2_2020	14.977	348	7.036	0.377				Positive	143	173.91	24869		
CO_2020 - CO_2019	CO_2019	0.967	349	0.493	0.026	-2.674	348	0.008	Negative	152	170.09	25853	-2.152	0.031
	CO_2020	1.068	349	0.583	0.031				Positive	193	175.29	33831		
Ozone_2020 - Ozone_2019	Ozone_2019	31.176	315	15.689	0.884	-1.989	314	0.048	Negative	152	145.55	22123	-1.707	0.088
	Ozone_2020	34.024	315	22.782	1.283				Positive	163	169.61	27647		

Source: Data collected by the researcher from CPCB

From table 2, it is clear that there had been a change in the pollution levels before covid and after covid for all the pollutants levels. If we see the p-value for paired t-test, there seems to be a significant change in all the pollutants due to the lockdown. Similarly, from the Wilcoxon signed-rank test z and p values, only for Ozone, there is no significant change due to lockdown, but there is a significant change for all other pollutants.

Table 3: Paired t-test and Wilcoxon Signed Rank test for Kolkata City

Pairs	Pollutants	Mean	N	SD	Std. Error Mean	t	df	Sig. (2-tailed)	Ranks	N	Mean Rank	Sum of Ranks	Z	P
PM2.5_2020 - PM2.5_2019	PM2.5_2019	52.243	247	34.08227	2.168	-4.355	246	0.000	Negative	105	105.87	11116	-3.734	0.000
	PM2.5_2020	61.078	247	44.778	2.849				Positive	142	137.40	19511		
PM10_2020 - PM10_2019	PM10_2019	101.929	255	65.341	4.091	-7.543	254	0.000	Negative	76	103.71	7882	-7.157	0.000
	PM10_2020	127.972	255	79.317	4.967				Positive	179	138.31	24758		
NO_2020 - NO_2019	NO_2019	36.663	211	30.616	2.107	4.259	210	0.000	Negative	144	109.33	15744	-5.137	0.000
	NO_2020	28.299	211	29.949	2.061				Positive	67	98.84	6622		
NO2_2020 - NO2_2019	NO2_2019	42.340	211	23.752	1.635	-2.562	210	0.011	Negative	114	83.98	9573	-1.813	0.070
	NO2_2020	46.599	211	35.660	2.454				Positive	97	131.88	12792		
NOx_2020 - NOx_2019	NOx_2019	77.218	211	50.633	3.485	0.875	210	0.382	Negative	141	94.84	13373	-2.466	0.014
	NOx_2020	74.529	211	63.269	4.355				Positive	70	128.47	8993		
SO2_2020 - SO2_2019	SO2_2019	9.794	256	6.087	.380	-8.362	255	0.000	Negative Ranks	71	99.13	7038	-7.935	0.000
	SO2_2020	12.710	256	7.702	.481				Positive	185	139.77	25858		
CO_2020 - CO_2019	CO_2019	.690	262	.445	.027	-10.083	261	0.000	Negative	48	116.14	5574	-9.385	0.000
	CO_2020	1.001	262	.609	.037				Positive	212	133.75	28355		
Ozone_2020 - Ozone_2019	Ozone_2019	32.524	261	13.363	.827	-4.501	260	0.000	Negative	101	116.53	11769	-4.363	0.000
	Ozone_2020	36.604	261	14.780	.914				Positive	160	140.13	22421		

Source: Data collected by the researcher from CPCB

From table no. There had been a change in the pollution levels before covid and after covid for all pollutants levels. If we see the p-value for paired t-test, there seems to be a significant change in all the pollutants due to the lockdown, except for NOx. Similarly, from the Wilcoxon signed-rank test, z and p values, only for NO2, there is no significant change due to lockdown, but there is a significant change for all other pollutants.

Table 4: Paired t-test and Wilcoxon Signed Rank test for Mumbai City

Pairs	Pollutants	Mean	N	SD	Std. Error Mean	t	df	Sig. (2-tailed)	Ranks	N	Mean Rank	Sum of Ranks	Z	P
PM2.5_2020 - PM2.5_2019	PM2.5_2019	27.478	281	56.726	3.384	.654	280	.514	Negative	152	127.24	19340	-.345	.730
	PM2.5_2020	25.117	281	19.475	1.161				Positive	129	157.22	20281		
PM10_2020 - PM10_2019	PM10_2019	68.763	185	35.554	2.613	1.677	184	.095	Negative	116	84.93	9851	-1.713	.087
	PM10_2020	62.823	185	35.847	2.635				Positive	69	106.57	7353		
NO_2020 - NO_2019	NO_2019	24.124	281	15.515	.925	16.532	280	.000	Negative	246	150.13	36932	-12.558	.000
	NO_2020	6.339	281	5.100	.304				Positive	35	76.83	2689		
NO2_2020 - NO2_2019	NO2_2019	26.684	296	23.882	1.388	16.472	295	.000	Negative	273	156.37	42689	-14.053	.000
	NO2_2020	2.889	296	4.171	.242				Positive	23	55.09	1267		
NOx_2020 - NOx_2019	NOx_2019	49.045	294	29.793	1.737	20.612	293	.000	Negative	252	165.51	41708	-13.726	.000
	NOx_2020	8.898	294	8.516	.496				Positive	42	39.45	1657		
SO2_2020 - SO2_2019	SO2_2019	15.574	299	9.166	.530	-4.847	298	.000	Negative	87	170.79	14858	-4.982	.000
	SO2_2020	20.332	299	16.677	.964				Positive	211	140.72	29692		
CO_2020 - CO_2019	CO_2019	2.280	318	.799	.044	18.984	317	.000	Negative	267	173.43	46307	-12.923	.000
	CO_2020	1.491	318	.502	.028				Positive	50	81.92	4096		
Ozone_2020 - Ozone_2019	Ozone_2019	19.050	295	14.918	.868	3.624	294	.000	Negative	178	163.48	29099	-5.211	.000
	Ozone_2020	14.765	295	11.408	.664				Positive	115	121.50	13972		

Source: Data collected by the researcher from CPCB

From table no. 4, it is clear that there had been a change in the pollution levels before covid and after covid for all the pollutants levels. If we see the p-value for paired t-test, there seems all the pollutants there had been a significant change in due to lockdown, except for PM2.5 and PM 10. Similarly, from the Wilcoxon signed-rank test z and p values, for PM2.5 and PM 10, there is no significant change due to lockdown, but there is a significant change for all other pollutants.

CONCLUSION AND RECOMMENDATIONS

Using Wilcoxon Signed Rank and paired t-tests for the key four-tier– 1 cities of Bengaluru, Delhi, Kolkata, and Mumbai, we determined whether there was an effect or change in pollution levels before and after Covid. From the analysis, we find that Bengaluru has all pollutants present. It has the effect of major pollutants being PM10 which can be reduced by taking required pollutant measures. Delhi has all the pollutants present except for Ozone. Even though the present covid cases count is less, the city needs to take the required measures to reduce the covid cases. Kolkata has high pollutant measures except for NOx and NO2, where required measures need to be taken care of to reduce them. Mumbai should reduce its pollution and generate its energy sustainably, leading to control of corona cases and leading a healthy life. The above-generated report shows the rise of pollutants in major cities in India, and resulting measures can be taken to control various pollutants.

Recommendations

A selection of the recommendations that can be given even though there are fewer changes in pollutants are shown below.

- Bengaluru must install Air pollutant control equipment and maintain its surroundings, reducing PM 2.5, PM10, NO, NO2, NOx, SO2, CO, and ozone emissions in the air.
- There is a high requirement to install a pollutant control board and control the emission of pollutants in the air.
- Kolkata needs to install electric-oriented vehicles leading to a reduction in SO2 emissions in the air.
- As Mumbai has fewer air pollutants, sustainable energy generation strategies to maintain its eco-friendly nature.

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