AIR POLLUTION AND CORONAVIRUS LOCKDOWN

DELHI

17%

amount of days in 2020 with PM 2.5 levels below 100

MUMBAI

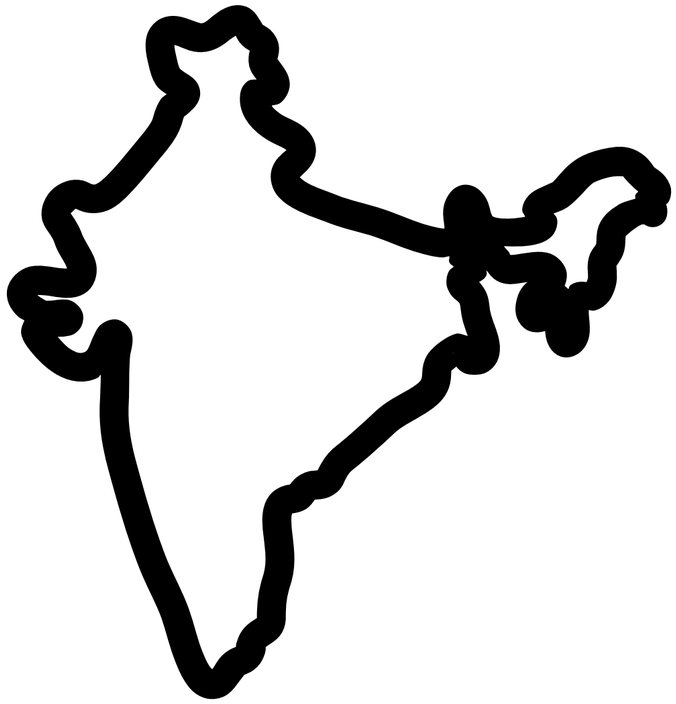
50%

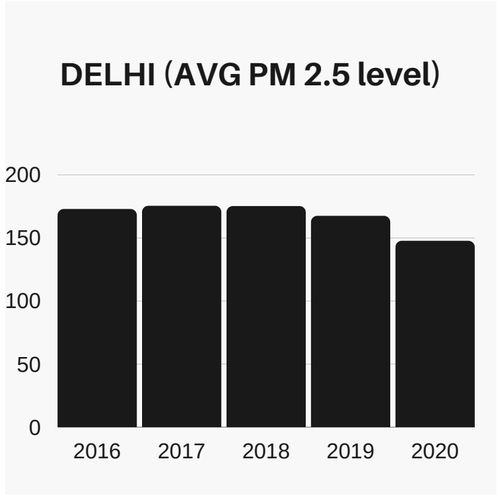
amount of days in 2020 with PM 2.5 levels below 100

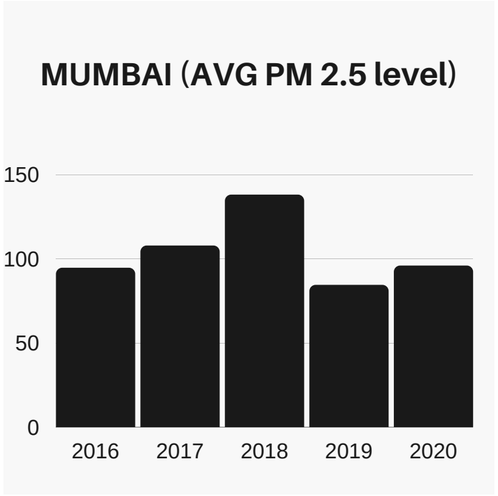
BENGALURU

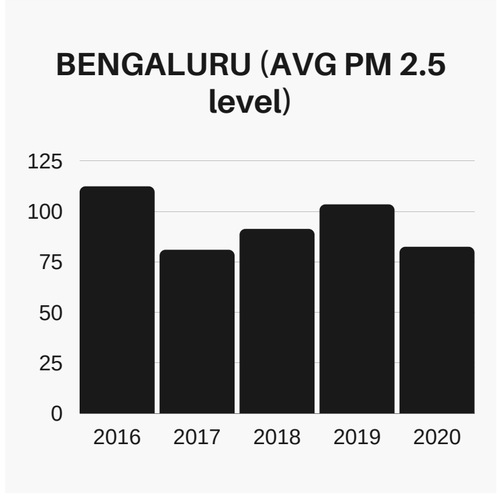
88%

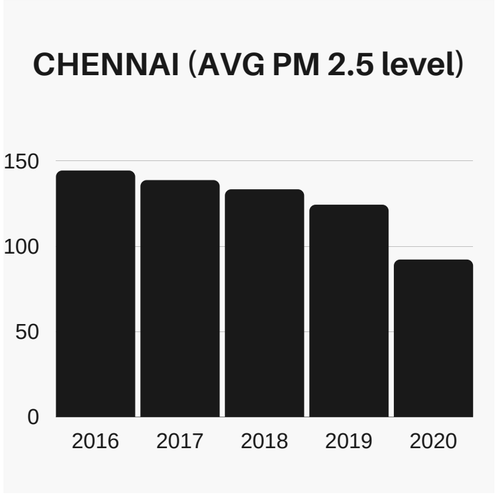
amount of days in 2020 with PM 2.5 levels below 100







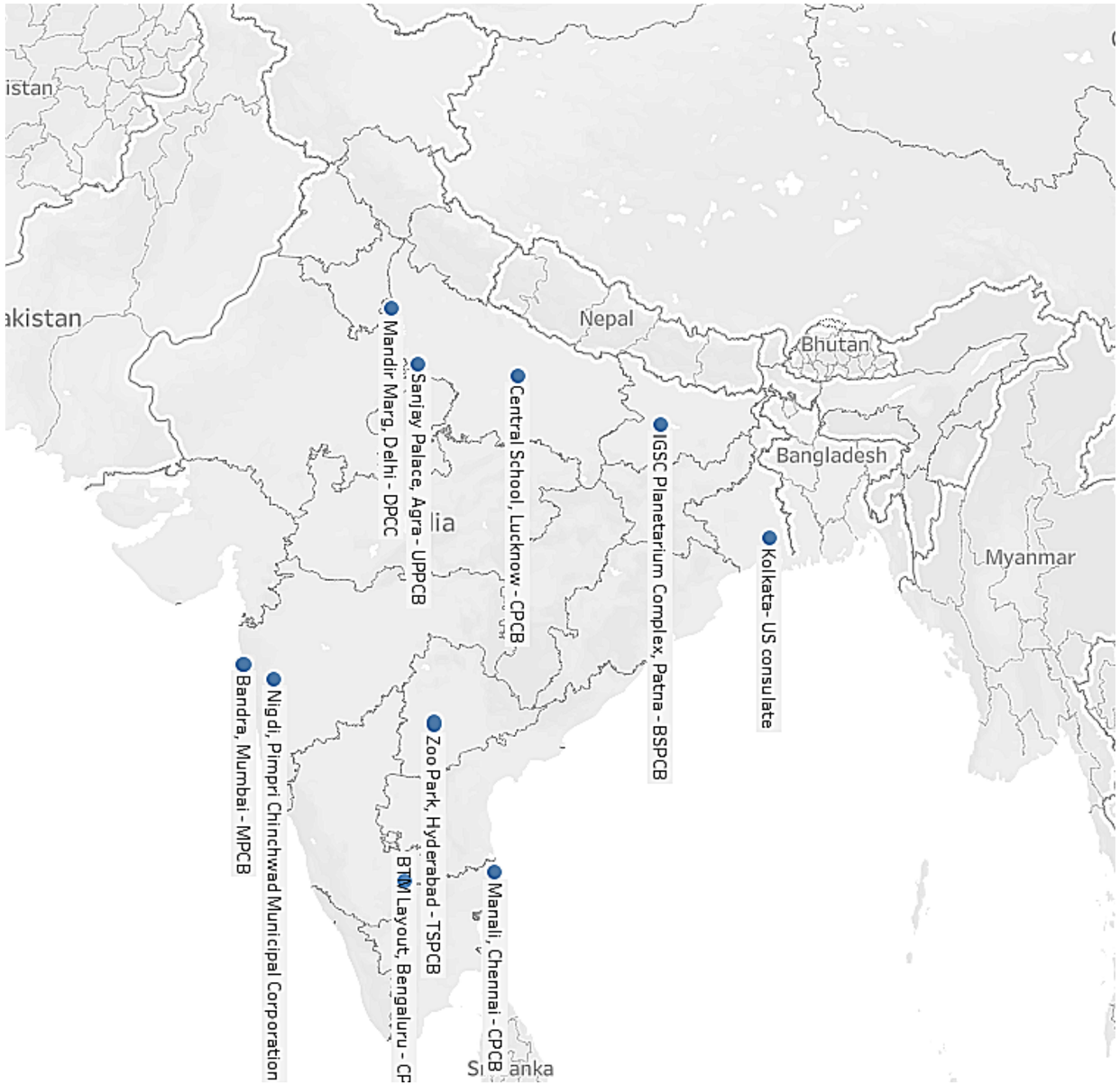




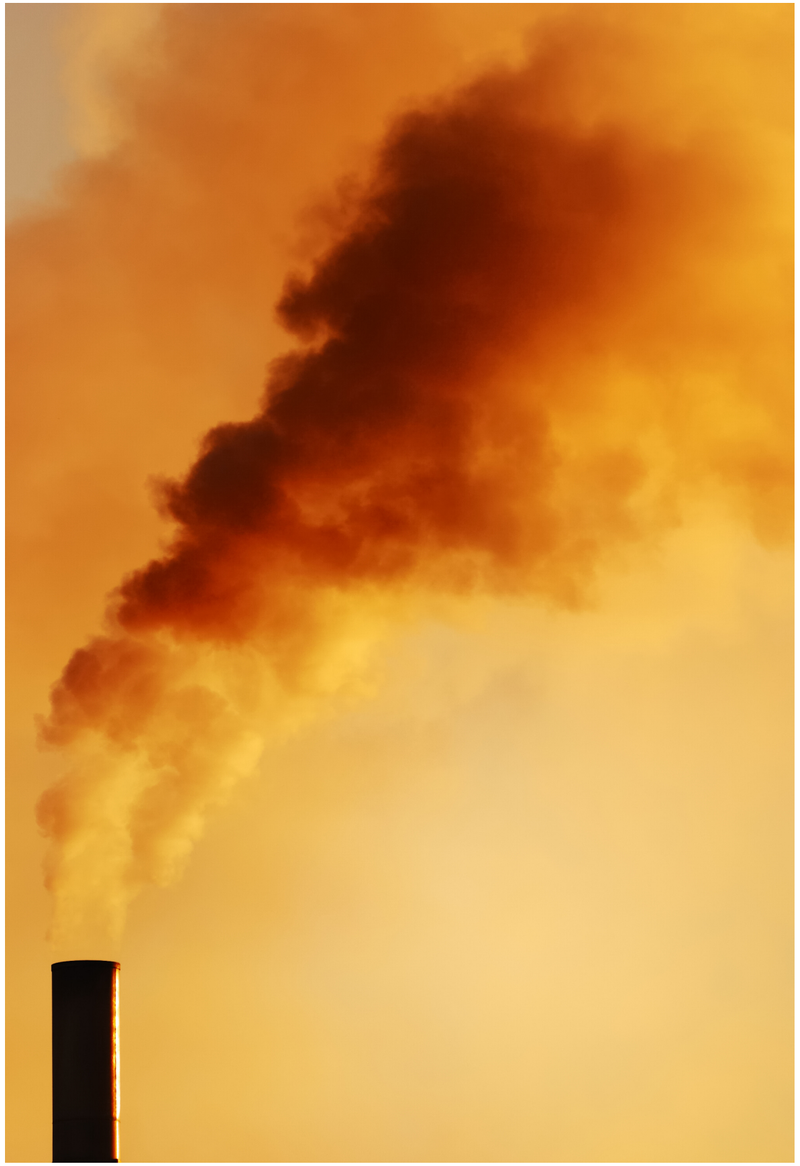
- **2020 data used is till 22nd May only**

Analysis by:- Sanayya
(sanayya1998@gmail.com)

MONITORING STATIONS USED FOR THE ANALYSIS

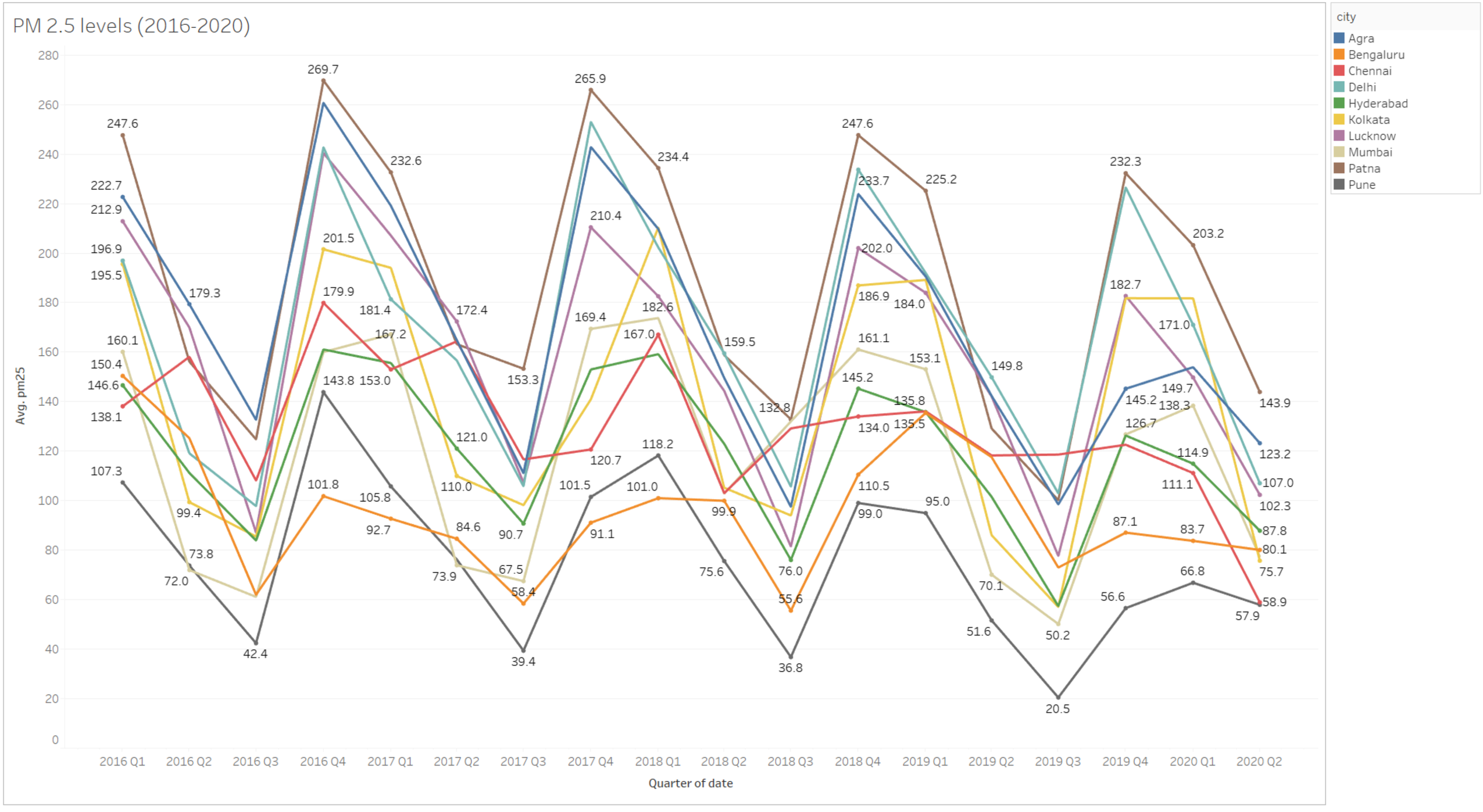


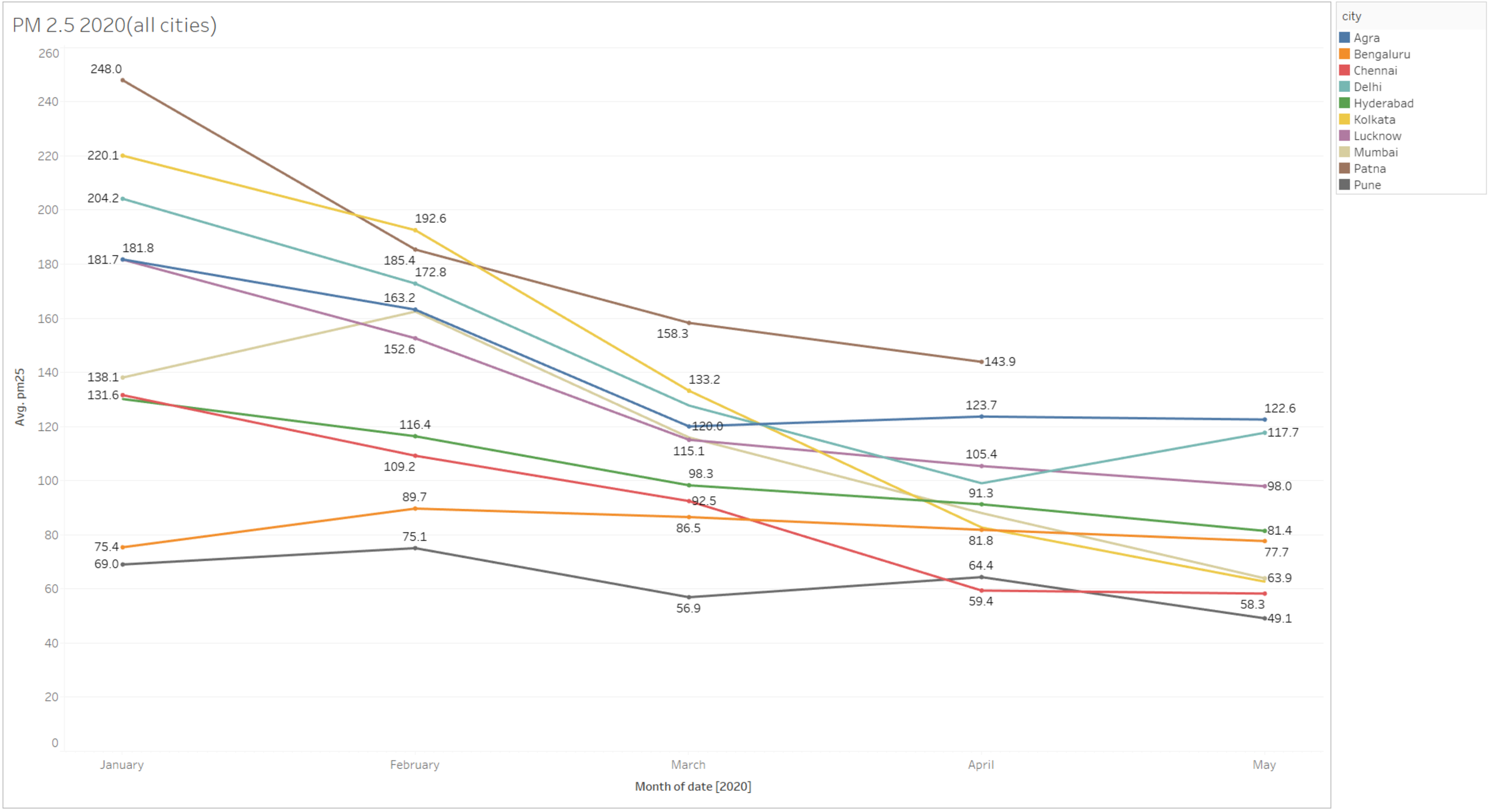
Pollution data can vary vastly even in a city from one place to another. As it is not a scientifically sound approach to just take average of the pollutants of all the monitoring stations of a particular place / state , we have focused on individual stations for a better analysis and reliability of the assessment.



Industrial and Vehicular Air Pollutants

- PM 2.5
- PM 10
- Ozone (O3)
- NO2
- SO2
- CO


PM 2.5 levels (2016-2020)
city
Agra
Bengaluru
Chennai
Delhi
Hyderabad
Kolkata
Lucknow
Mumbai
Patna
Pune
Avg. pm25
Quarter of date
2016 Q1
2016 Q2
2016 Q3
2016 Q4
2017 Q1
2017 Q2
2017 Q3
2017 Q4
2018 Q1
2018 Q2
2018 Q3
2018 Q4
2019 Q1
2019 Q2
2019 Q3
2019 Q4
2020 Q1
2020 Q2
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280


PM 2.5 2020(all cities)
Avg. pm25
Month of date [2020]
January
February
March
April
May
0
20
40
60
80
100
120
140
160
180
200
220
240
260
city
Agra
Bengaluru
Chennai
Delhi
Hyderabad
Kolkata
Lucknow
Mumbai
Patna
Pune
248.0
220.1
204.2
181.8
181.7
138.1
131.6
75.4
69.0
192.6
185.4
172.8
163.2
152.6
116.4
109.2
89.7
75.1
158.3
133.2
120.0
115.1
98.3
92.5
86.5
56.9
143.9
123.7
105.4
91.3
81.8
64.4
59.4
122.6
117.7
98.0
81.4
77.7
63.9
58.3
49.1

Impact of lockdown on individual air pollutant species in various Indian cities

We will be analysing the main six species of air pollution- *PM 2.5, PM 10, O3, NO2, SO2, CO*. Nationwide lockdown in India due to Coronavirus started on 25th March 2020, therefore, our analysis will compare the levels of the above mentioned species for the months March, April and May in 2020 vis-à-vis their corresponding levels in 2016, 2017, 2018 and 2019.

PM 2.5

Particle pollution mainly comes from motor vehicles, wood burning heaters and industry.Owing to reduced vehicular activity and closure of industry and the transport sector, **Delhi** saw **31 % less and 25 % less** PM 2.5 emissions in **April and May 2020** compared to **April and May 2019**. Similarly, **Bengaluru** saw a decline of **42 %** in PM 2.5 emissions for the same period.

	2016			2017			2018			2019			2020		
city	March	April	May	March	April	May	March	April	May	March	April	May	March	April	May
Agra	168.4	205.0	184.5	179.5	162.8	158.6	164.4	153.4	157.9	151.3	147.1	143.3	120.0	123.7	122.6
Bengaluru	143.4	139.5	128.7	102.1	115.6	80.7	99.2	137.0	106.6	129.3	143.5	129.0	86.5	81.8	77.7
Chennai	171.2	171.6	160.8	142.8	169.8	161.3	151.9	107.6	94.8	137.7	85.0	139.4	92.5	59.4	58.3
Delhi	138.6	146.7	126.2	150.8	157.7	168.2	154.3	158.0	164.3	144.0	145.1	158.5	127.8	99.0	117.7
Hyderabad	136.0	121.0	89.7	136.5	147.2	115.3	137.3	107.0		141.5	134.1	144.4	130.1	118.2	134.5
Kolkata	153.7	110.3	98.7	150.2	122.7	112.3	161.3	113.7	96.3	141.0	97.8	94.9	133.2	82.7	62.7
Lucknow	171.8	175.3	171.0	184.2	186.3	173.7	154.1	156.5	138.3	174.4	157.3	142.8	115.1	105.4	98.0
Mumbai	102.7	80.1	79.8	123.4	104.2	81.0	127.1	97.0		88.5	67.8	54.9	73.1	67.8	104.4
Patna	184.1	159.5	160.0	190.4	183.0	144.6	198.6	174.2	154.5	160.6	133.6	134.6	158.3	143.9	
Pune	116.1	93.4	70.3	63.1	104.3	72.6	108.5	89.8	77.7	74.1	58.6	56.1	56.9	64.4	49.1

PM 10

PM10 (particles with a diameter of 10 micrometres or less): comes from motor vehicles and also includes dust from construction sites, landfills and industrial sources. Due to restriction on construction activities, less road dust, restricted non essential vehicular activity and suspension of industrial activities, **Delhi** saw a decline of **54 %** and **53 %** in PM 10 emissions in **April and May 2020** compared to **April and May 2019** whereas **Hyderabad** saw a decline of **22 %** and **27 %** in PM 10 emissions for the same period.

	2016			2017			2018			2019			2020		
	Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2	
city	March	April	May	March	April	May	March	April	May	March	April	May	March	April	May
Delhi	104.2	154.1	133.9	114.0	158.6	152.6	120.5	153.1	133.4	113.4	148.6	175.9	73.5	68.3	81.4
Hyderabad	70.8	70.2	56.7	90.9	103.8	80.0	81.7	67.9		83.1	75.4	91.5	69.9	58.3	66.9
Mumbai	75.5	58.0	52.9	89.2	72.9	50.1	83.5	62.7		81.6	60.2	51.9	54.9	44.8	48.9
Pune	101.7	89.3	66.8	64.8	98.7	72.4	103.7	95.2	84.3	72.3	58.5	52.7	64.5	69.0	51.2

OZONE (O3)

Ground level ozone is the main component of smog and is the product of the interaction between sunlight and emissions from sources such as motor vehicles and industry. Ground level ozone is more readily formed during the summer months and reaches its highest concentrations in the afternoon or early evening. Owing to this, **Delhi** saw a decline of **41 %** in O3 emissions in **April 2020** compared to **April 2019.**

	2016			2017			2018			2019			2020		
city	March	April	May	March	April	May	March	April	May	March	April	May	March	April	May
Agra	6.3	6.6	30.7	36.8	45.0	35.2	10.5	14.1	15.5	5.0	5.0	24.2	3.6	17.9	36.1
Bengaluru	35.5	86.0	20.6	37.0	30.5	22.7	26.7			33.8	20.5	24.5	20.1	19.7	16.8
Delhi	17.2	27.6	27.8	24.8	32.9	32.1	21.8	22.5	25.2	14.5	13.7	14.0	6.2	8.0	28.4
Hyderabad	32.0	27.9	20.9	54.0	60.9	54.8	22.5	21.2		19.3	20.0	33.7	14.6	10.7	8.8
Lucknow	42.1	47.4	41.9	48.3	70.4	21.2	29.7	29.4	21.6	15.6	23.6	8.8	16.0	4.9	14.2
Mumbai	12.2	6.7	7.3	24.4	16.3	22.8	46.3	35.8		33.5	16.3	9.9	18.5	5.0	3.6
Pune	99.8	77.2	63.5	63.5	66.5	53.3	105.0	68.8	48.3	116.2	99.3	74.4	89.4	78.7	69.4

Nitrogen Dioxide (NO2)

Nitrogen dioxide is a highly reactive gas formed by emissions from motor vehicles, industry, unflued gas-heaters and gas stove tops. Owing to vehicular restrictions, **Delhi** saw a decline of **61 %** and **63 %** in NO2 emissions in **April and May 2020** compared to **April and May 2019** whereas **Chennai** saw a decline of **52 %** and **66 %** in NO2 emissions for the same period.

	2016			2017			2018			2019			2020		
city	March	April	May	March	April	May	March	April	May	March	April	May	March	April	May
Agra	18.59	15.18	12.81	21.90	21.73	20.70	39.97	36.60	32.71	13.23	15.17	16.10	21.35	19.10	12.76
Bengaluru	6.35	8.41	10.10	10.29	10.45	8.50	14.48	12.25	15.13	10.71	10.47	13.03	11.74	8.00	9.57
Chennai	5.67	4.93	7.29	10.62	11.03	13.10	8.29	6.80	15.53	18.35	8.77	10.40	5.07	4.20	3.52
Delhi	22.07	28.09	22.16	23.42	29.07	31.83	23.52	27.47	27.28	21.69	23.13	25.71	18.08	9.00	9.40
Hyderabad	1.00	18.89	19.79	14.10	20.43	13.66	26.39	22.53		29.27	22.80	19.14	14.77	21.00	21.50
Lucknow	9.62	22.25	23.88	11.97	10.00	7.04	24.26	20.57	19.97	20.73	2.00	6.26	9.83	4.70	5.42
Mumbai	2.74	4.07	3.10	12.35	8.87	8.06	13.65	12.17		6.13	10.00	5.81	18.62	1.52	3.60
Pune	15.47	12.70	13.87	31.61	22.00	16.71	19.85	19.89	19.30	41.81	31.63	18.97	15.35	10.70	10.41

Sulphur Dioxide (SO2)

It is formed by fossil fuel combustion at power plants and other industrial facilities. It contributes to the formation of particulate matter pollution. From the Highlight table below, **SO2 emissions in Delhi did not change much** compared to previous years mainly because of the fact that **70 %** of SO2 emissions in Delhi originates from power plants located around Delhi (as per TERI Emission Inventory, 2018) which were operational during the lockdown as well as some biomass/refuse burning. In Chennai, there is a decline of **68 %** and **71 %** in SO2 emissions in **April and May 2020** compared to **April and May 2019**.

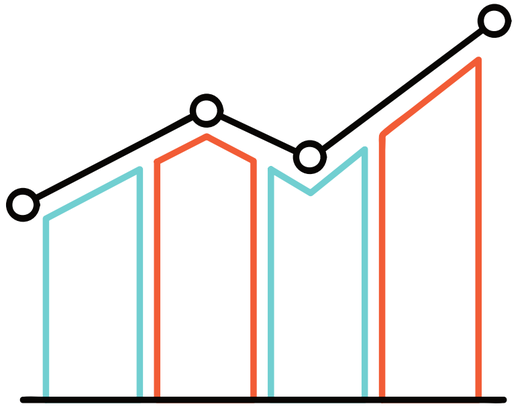
	2016			2017			2018			2019			2020		
	Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2	
city	March	April	May	March	April	May	March	April	May	March	April	May	March	April	May
Agra	9.48	3.36	8.93	7.10	7.07	5.55	8.68	10.30	14.45	6.48	5.73	9.06	13.32	13.07	12.81
Bengaluru	1.11	1.14	1.00	7.16	3.30	2.43	2.17	2.63	2.71	1.80	1.00	1.59	2.50	2.60	2.88
Chennai	3.82	2.07	2.13	7.07	5.43	3.94	7.97	5.37	3.83	8.23	4.57	4.68	5.13	1.43	1.33
Delhi	10.71	16.32	8.19	5.84	8.83	8.60	9.90	10.57	7.00	4.23	4.93	5.00	6.68	10.00	9.50
Hyderabad	3.77	3.97	3.96	11.71	13.57	10.76	3.10	3.32		1.05	1.06	1.20	3.06	1.05	1.05
Lucknow	3.41	4.04	6.06	2.74	3.19	1.65	2.13	1.29	1.10	1.97	1.59	2.19	2.26	3.63	3.35
Mumbai	1.77	3.37	2.80	7.81	6.27	5.00	11.90	12.00		5.33	11.00	8.94	8.83	16.30	27.24

Carbon Monoxide (CO)

Carbon monoxide (CO) is usually generated by motor vehicles and industry but can also be formed during bushfires. Due to the absence of vehicular activity and industrial activities, **Mumbai** saw a decline of **51% and 57%** in CO emissions in **April and May 2020** compared to **April and May 2019** whereas **Bengaluru** saw a decline of **39%** in CO emissions in **April 2020** compared to **April 2019**.

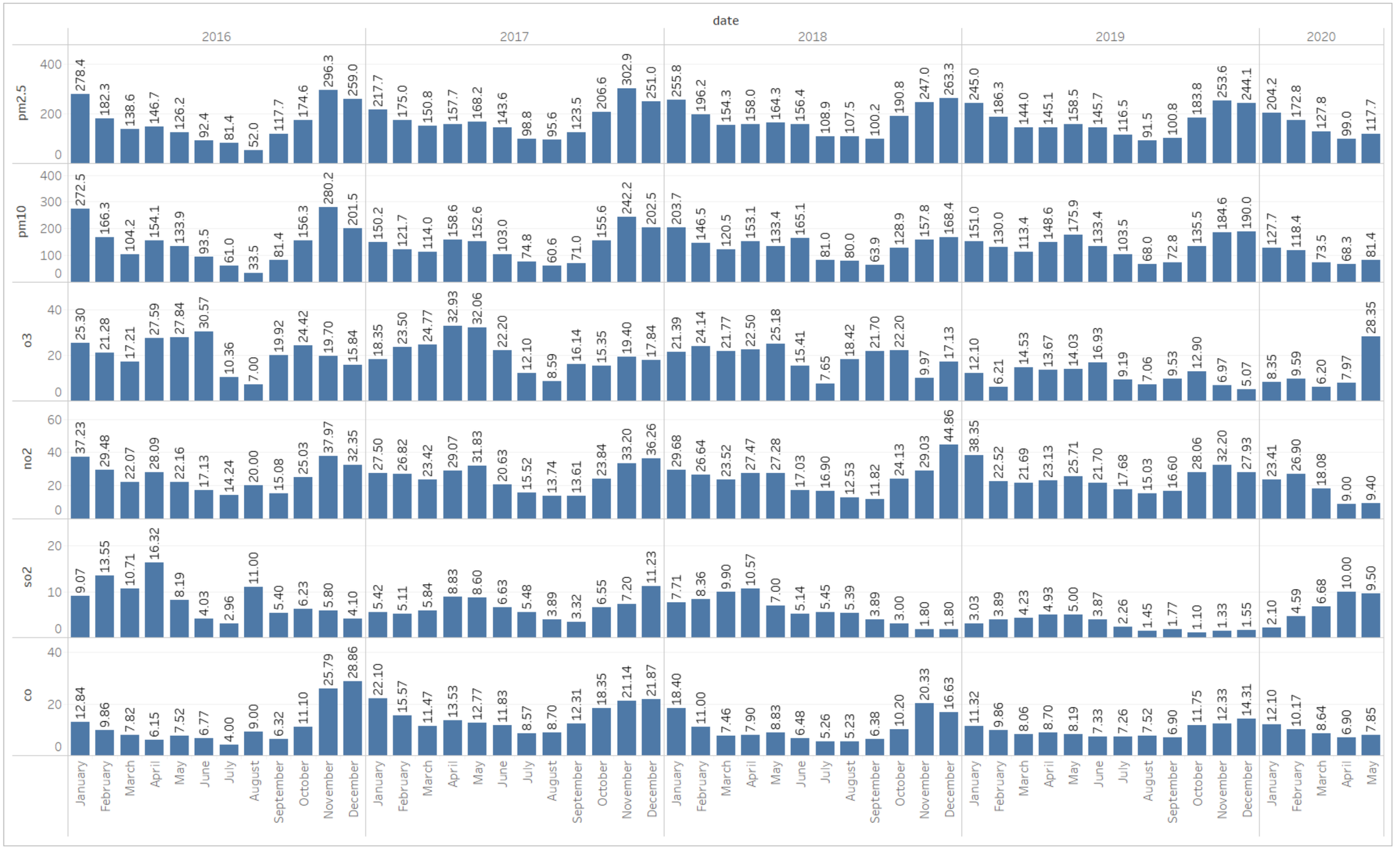
	2016			2017			2018			2019			2020		
	Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2	
city	March	April	May	March	April	May	March	April	May	March	April	May	March	April	May
Bengaluru	9.31	5.30	7.87	3.87	6.10	7.15	7.52	5.44	4.58	9.61	12.10	8.58	8.39	7.30	7.76
Chennai	10.72	6.80	11.83	3.97	5.53	5.67	6.52	8.67	8.03	6.97	9.60	10.24	6.90	5.20	7.81
Delhi	7.82	6.15	7.52	11.47	13.53	12.77	7.46	7.90	8.83	8.06	8.70	8.19	8.64	6.90	7.85
Hyderabad	8.68	7.74	6.35	7.71	9.87	8.14	10.00	12.68		5.83	5.96	5.68	5.97	4.14	4.77
Lucknow	7.48	7.21	6.31	11.10	9.67	8.32	9.55	7.93	6.19	8.27	12.03	13.97	9.06	7.53	7.30
Mumbai	6.06	4.27	5.35	7.39	5.73	4.71	13.90	11.78		15.40	16.03	14.52	12.41	7.83	6.19

City-wise analysis and forecast of three Indian cities

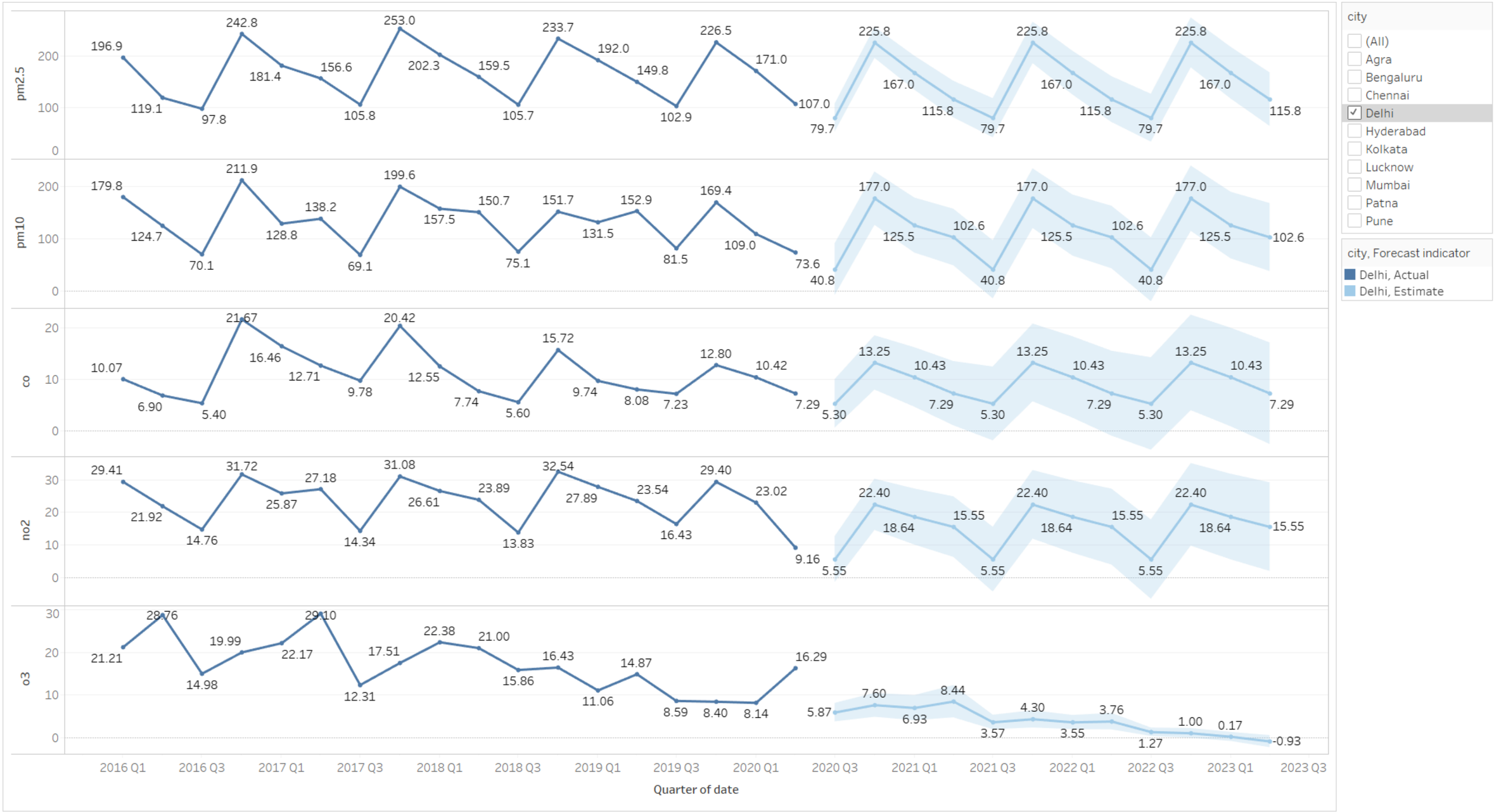


We will be analyzing three cities in India- Delhi, Mumbai and Hyderabad, looking at their air pollution levels from 2016-2020 and then analyzing the change during lockdown and extrapolating it for a period of 3 years i.e., 2020-2023.

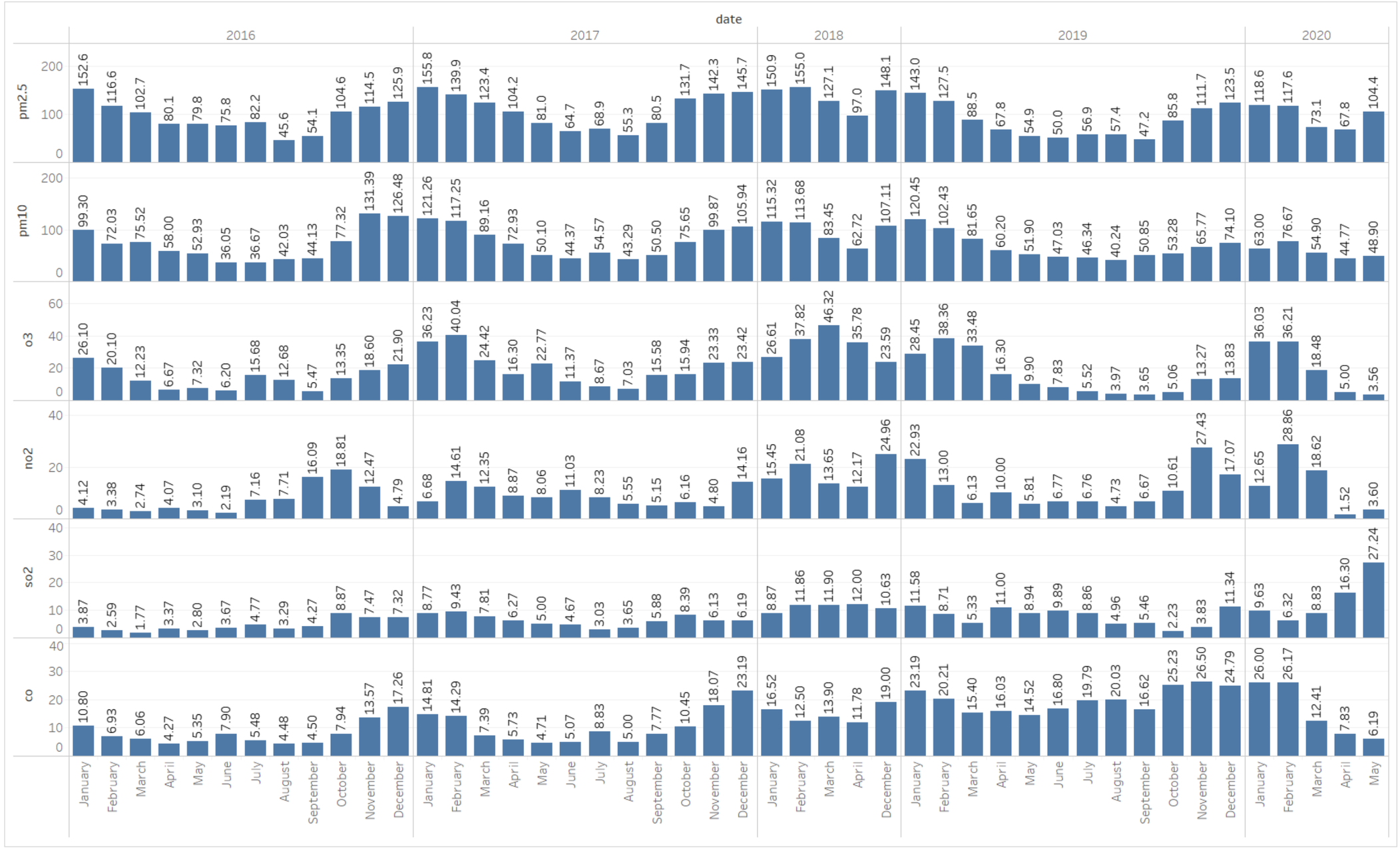
DELHI (2016-2020)



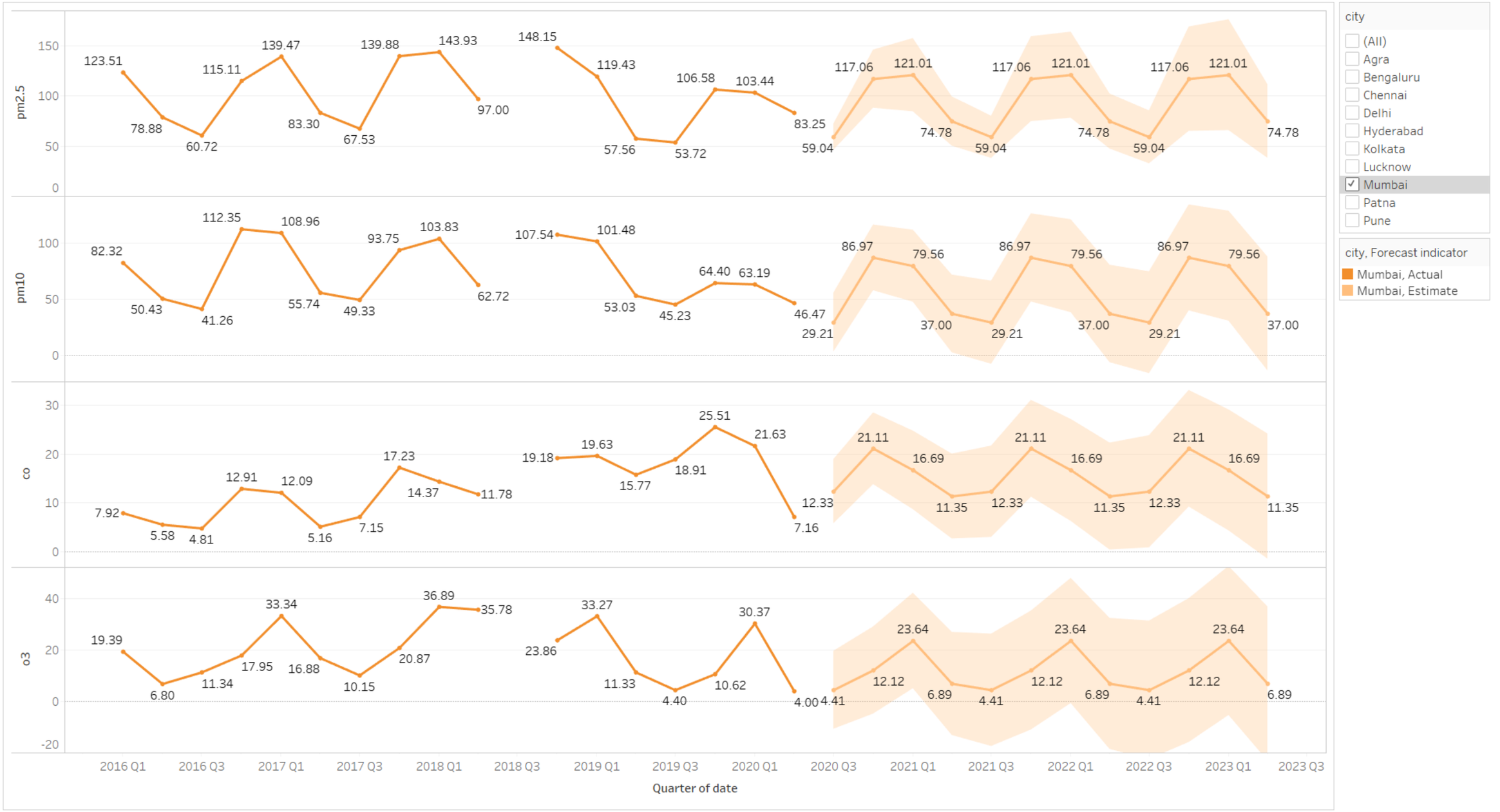
DELHI (2016-2023)



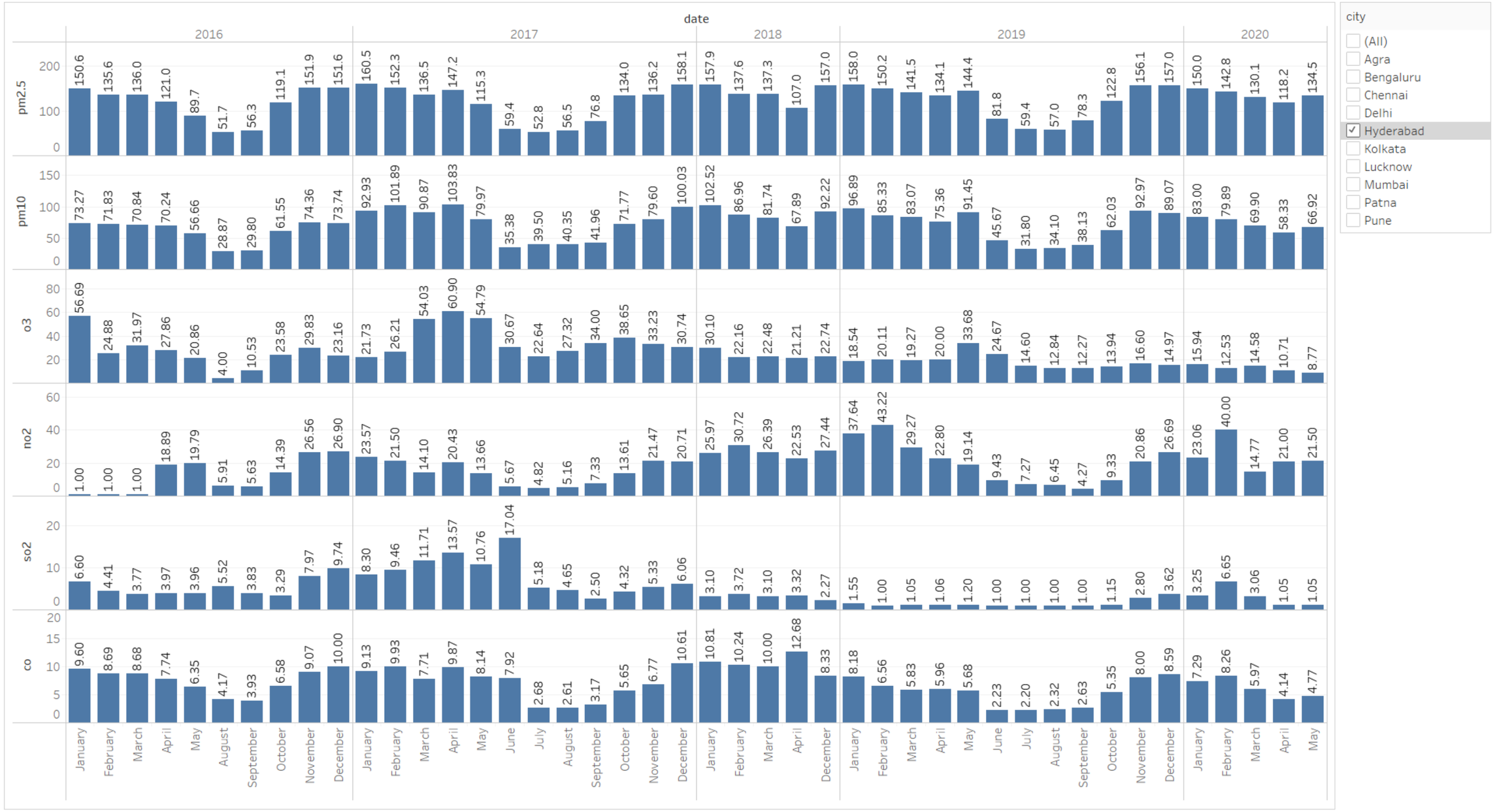
MUMBAI (2016-2020)



MUMBAI (2016-2023)



HYDERABAD (2016-2020)



HYDERABAD (2016-2023)

SUMMARY AND CONCLUSION

India has always had an air pollution problem. The most deadliest pollutant PM 2.5 reaches alarming levels in the nation's capital which holds the title of the most polluted city in the world. Various other cities in India also have very alarming levels of PM 2.5 levels as well as NO2 levels which forms ground level ozone (O3) leading to smog formation.

The data has been sourced from the Word Air Quality Project at https://www.waqi.info which sources data from CPCB, DPCC, SAFAR etc and various other organizations.

As shown in the analysis in **Slide 4** which shows PM 2.5 levels in various cities for the period 2016-2020, we can see that most India metropolises have very high levels. In **Slide 5**, the line graph of PM 2.5 levels in various cities for the period of January 2020 to May 2020 (till 22 March) shows that since the lockdown due to Coronavirus started on 25th March 2020, PM 2.5 levels in most cities that we analyzed fell to record levels that are not seen normally in these months. This fall in PM 2.5 levels can be attributed to the reduced vehicular activity and closure of industries. PM 2.5 levels in Patna did not change significantly which might be due to the continued movement of vehicles.

In **Slides 7-12**, we have analyzed the levels of the main individual species in various Indian cities that make up the air pollution- PM 2.5, PM 10, O3, NO2, SO2, CO for the months of March, April and May in 2020 vis-à-vis their corresponding levels in 2016, 2017, 2018 and 2019 to gauge the impact of lockdown due to coronavirus. PM2.5 and PM10 levels in most cities owing to restricted vehicular as well as industrial activity. Since 81% of Delhi's NOx

comes from the transport sector (as per TERI Emission Inventory, 2018), NO2 levels in Delhi saw a sharp reduction of 61% and 63% for April and May 2020 compared to the corresponding months in 2019. Reduced NO2 levels also contributed to a 43% decline in O3 levels in Delhi. SO2 didn't had any significant reduction due to Corona as 70% of SO2 emissions in Delhi is because of the power plants which were operational during lockdown as well.

In **Slides 13-19,** we have analyzed, three Indian cities- **Delhi, Mumbai and Hyderabad** for the periods **2016-2020** and then used that data and also accounting the current shift during lockdown to extrapolate it for the period **2020-2023** using **exponential forecasting with seasonality** to account for the various trends our data had. **Delhi** saw significant reductions in almost all contaminants except SO2 and CO for the period of lockdown when compared to previous years. SO2 and CO are exceptions because the major source of SO2 emission in Delhi are power plants which were operational during lockdown as well whereas for CO, biomass/refuse burning in some areas in and around Delhi might be the reason. **Mumbai** also saw significant reductions emissions for the period of lockdown owing to absence of vehicular activity as well as restricted industrial operations. **Hyderabad,** too, saw a moderate reductions for the period of lockdown in emission levels compared to previous year because of favourable weather as well as absence of vehicular activity as well and restricted industrial operations.

This analysis has clearly demonstrated that air pollution in major Indian cities is mostly anthropogenic (human-made) and when such activities came to a halt, it has shown everyone a Proof Of Concept (POC) that clean air can be achieved. These three pollutants -- NOx, PM2.5 and PM10 -- are mainly generated from vehicular combustion and road traffic, especially NOx. Lockdown suspended all non-essential vehicular activity suddenly which led to less traffic on the road leading to less generation of road-dust (PM10). We can learn from this. People in cities like Delhi had forgotten what it was to experience clear blue skies and fresh air and now experiencing it firsthand, people have become more concerned about cleaner air and are raising awareness. If Coronavirus has taught us one thing, it is that we need to take strict measures to find the solution to a problem, but before that, we need to accept that there is a problem- in case of Coronavirus, the government took the issue head-on and imposed a strict lockdown to slow the spread. India, has still not had a democratized demand from the masses for clean air. It is also clear from the forecasts in our analysis that this clean air phase is short lived and temporary. Granted, people have cleaner air and this has been a boon for some but the way we achieved is not sustainable nor we would like to achieve this way as it comes at a big cost of economy and societal well-being. As is also evident from our forecasts that gradually emissions will reach pre-lockdown levels. It is true because once the restrictions are lifted- there is also a possibility that several environmental protections will be loosened for the economy to bounne back and mitigate the damage which will lead to a drastic upsurge in emissions and present levels may be harder than ever to achieve. To mitigate the threat of air pollution, the issue needs to tackled head-on just as the coronavirus pandemic is being tackled because air pollution kills more than a million people a year in India. The reduction in emissions should be a wake up call and a reality-check so that we can figure out a new normal and force more debates and stonger policy actions to clean up India's air.