CVL100
AQI Calculation for Bandra, Mumbai over 2018

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Abstract. Air pollution is an alarming issue threatening the health and well-being of all the citizens of the world. One way to quantitatively determine the quality of the air is through the Air Quality Index (AQI). The Central Pollution Control Board(CPCB) in India, prescribes the method for calculating the Air Quality Index of a region using measurements of gaseous pollutants in the air. The concentration of most potent pollutants, like $PM10, PM2.5, SO_2, NO_2, CO, O_3$ are recorded at periodic intervals. However, different pollutants are harmful at different levels of concentration. Therefore, these values are normalised to an universal index, the standards for which are set by the CPCB. This allows for ranking the pollutants based on immediate threat, better resource allocation and therefore, determining a more effective plan of action.

In this paper, hourly pollutant concentration data from the CPCB has been collected for the Bandra station in Mumbai from the period January 1st, 2018 (12AM) to December 31st, 2018 (11:59PM). This has been used to calculate the average AQI over the different months of the year and interpret the variation over different seasons. The above exercise would enable us to determine the time periods when the air quality is most hazardous and take suitable steps to prevent adverse effects to the sensitive sections of the populace.

1 Introduction

The effects of air pollution on human health are profound. Pollutants like TSP, SO_2 and NO_2 cause increased cases of mortality due to increased respiratory and cardiovascular distress amongst its citizens (Gurjar et.al). Therefore, for efficient resource allocation towards mitigating the effects of air pollution, it is imperative to quantitatively describe the air quality of a region. AQI (Air Quality Index) is one such method of doing so.

Computation of the AQI requires an air pollutant concentration over a specified averaging period, obtained from an air monitor or model. Taken together, concentration and time represent the dose of the air pollutant. Air pollutants vary in potency, and the function used to convert from air pollutant concentration to AQI varies by pollutant. Its air quality index values are typically grouped into ranges. Each range is assigned a descriptor, a color code, and a standardized public health advisory (Wikipedia, 2019).

Central Pollution Control Board is executing a nation-wide programme of ambient air quality monitoring known as National Air Quality Monitoring Programme, under which pollutant concentrations of the most common pollutants are collected and monitored periodically. (CPCB, 2019) This data is freely accessible, and hence can be obtained for analysis and AQI calculation. In this paper, we have obtained the pollutant concentration in Bandra, Mumbai, over a period of 12 months and analysed the AQI over this period. We have also analysed the seasonal variation of AQI and the reasons for this variation.

2 Objectives

- To calculate the AQI of Bandra, Mumbai for the period January 1st, 2018 to December 31st, 2018.
- To determine the major pollutant causing air quality drop, in order to determine suitable, targeted measures to treat the problem.
- To examine the seasonal variation of AQI in Mumbai, in order to determine the high-risk time frames.
- To suggest reasons for high AQI during certain time periods and explain the causes behind such occurrences.
- To suggest preventive and corrective measures in order to better control the AQI in the future and mitigate its effects.

3 Materials and Methodology

AQI is calculated from the pollutant concentration as follows:
The pollutant concentration is scaled based on the AQI Category under which

AQI Category, Pollutants and Health Breakpoints

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+

Fig. 1. AQI ranges and pollutant concentrations (Source: Wikipedia)

it falls. The concentration value is linearly interpolated to an index value using the formula:

$$I_i = \frac{I_{High} - I_{Low}}{B_{High} - B_{Low}} * (Cp - B_{Low}) + I_{Low}$$

where
B_{High}= Breakpoint concentration greater or equal to given concentration
B_{Low}= Breakpoint concentration smaller or equal to given concentration
I_{High} = AQI value corresponding to B_{High}
I_{Low} = AQI value corresponding to B_{Low}; subtract one from I_{Low}, if I_{Low} is greater than 50
C_p= Concentration of pollutant

The AQI is then calculated by

$$AQI = \max_i(I_i)$$

The pollutant concentration from the CPCB website was obtained for the Bandra, Mumbai station for the period from January 1, 2018 to December 31, 2018. Hourly data for PM10, PM2.5, SO_2, NO_2, CO and O_3 were obtained. The analysis was carried out using a Python script written to carry out this express purpose(Varambally, 2019). The script performed the following functions:

- Extract the 1-hour averages from the source file and seperate it based on the different pollutants.
- From the 1-hour averages, calculate the 24-hour average for PM2.5, PM10, SO_2 and NO_2 and the 8-hour averages for O_3 and CO.
- Calculate the air quality sub-indices for each day using the standards obtained from CPCB (CPCB, 2019)
- Using the sub-indices so obtained, calculate the AQI for each day.
- Calculate and plot the monthly average AQI values.

The 8-hour average was used instead of the 24-hour average for O_3 and CO. This is because the standards prescribed by CPCB for these pollutants are based on 8-hour concentration averages unlike the 24-hour concentration standards used for the other pollutants. In order to calculate the daily AQI, the maximum index value of O_3 and CO out of the three 8-hour windows were used.

A major issue faced was the lack of accurately recorded data in the data set. For the first quarter of the year, concentration data is missing except for CO concentration. Strictly speaking, AQI calculation cannot be done since the concentration of three pollutants (one of which should be either PM2.5 or PM10) is needed. However, the AQI values have been calculated for this period only using CO and hence, only give a rough estimate. Similarly, the concentration values for all the pollutants are missing from 2pm to 11pm for 18th May, 2018 (and numerous other instances) and so the AQI calculation was done with the remaining data. This might have resulted in inaccuracies creeping into the calculation; nevertheless, full attempts were made to completely utilise the data provided.

4 Conclusion

After execution, the script yields the following values of average monthly AQI (tabulated and graphed below):

Month	AQI Value
January	96(estimate)
February	79 (estimate)
March	93(estimate)
April	92(estimate)
May	87
June	72
July	68
August	67
September	82
October	115
November	145
December	149

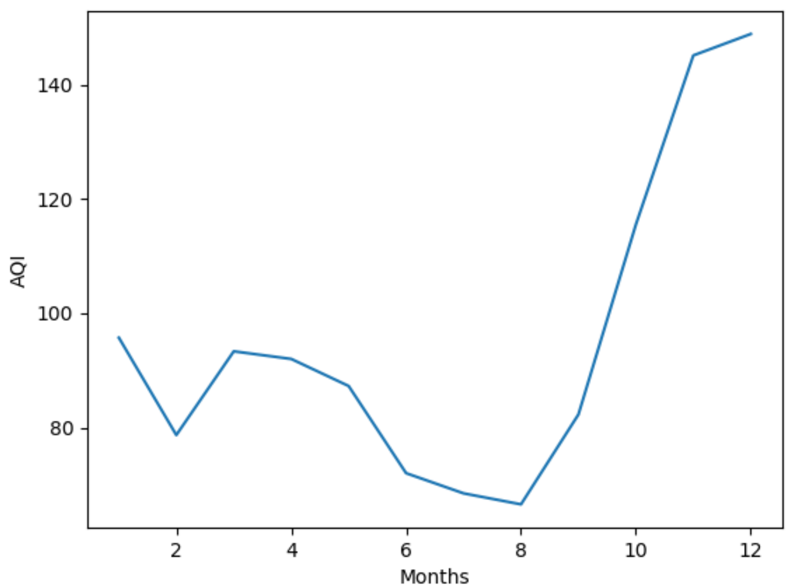


Fig. 2. Graph of Monthly AQI versus Month

The values and the graph indicate that the period from October to January are the most polluted periods of the year, with December being the most polluted month. We also notice that the AQI dips between June to September. That is, the air is most polluted during the winter and least polluted during the monsoon. During the monsoon, frequent rains washes down the air borne particulates, therefore July to September is cleaner period in the year. However winter months are calmer than other months. The calmer conditions facilitate more stability to atmosphere and results in slow dispersion of pollutants which leads to higher concentrations of pollutants in the ambient air. (Mamta, et. al)

The script can be slightly modified to reveal the primary pollutant, i.e. the maximum sub-index which is counted towards the overall Air Quality Index. It revealed that the primary pollutant from January to April was Carbon Monoxide (CO) and the pollutant from April to December was PM10, with the exception of June, August and September, when the primary pollutant was again CO. However, note that there is a major caveat in this reasoning because of the nature of the data presented; the pollutant concentration values were missing from January to April for all pollutants except CO, and hence, quite understandably, the major contributor to the index is CO. Nevertheless, CO is a major pollutant throughout the year, whose mitigation is important for air quality control.

The next page shows the seasonal variation of pollutant index vs month for different pollutants. Note that due to missing values, the values for many months is absent. Therefore, the graphs have been plotted only for the available months.

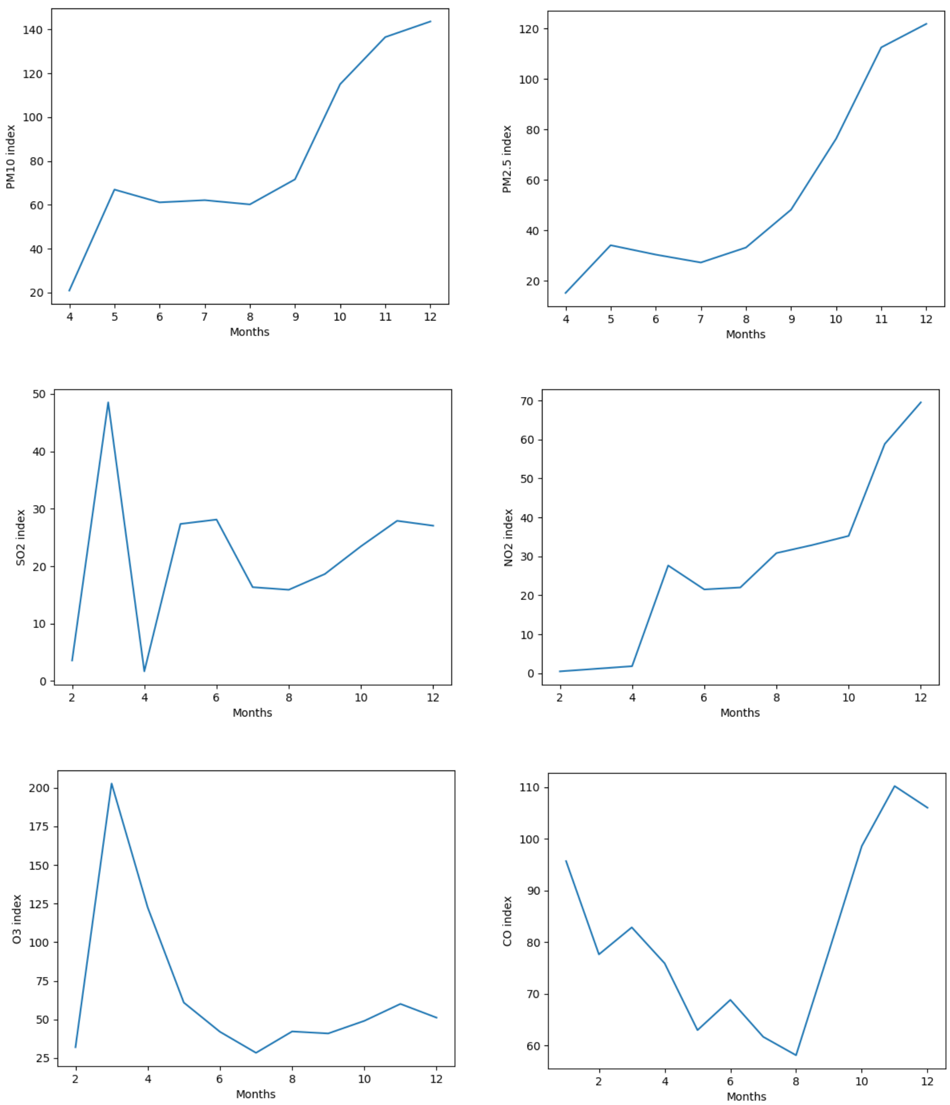
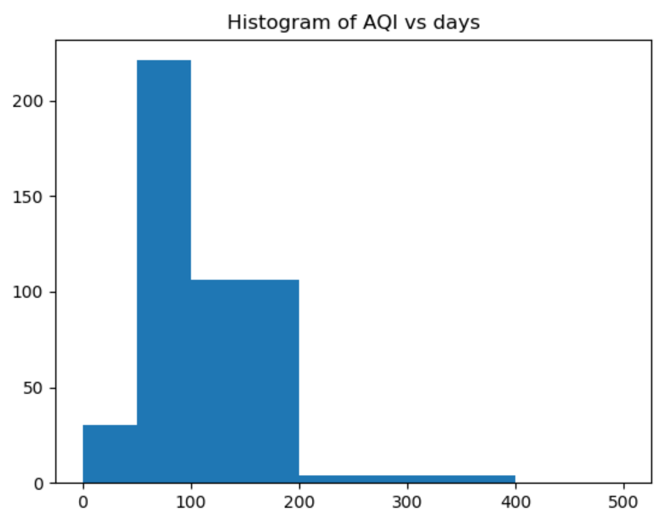


Fig. 3. Sub-indices of different pollutants in different months

We notice that SO_2 and NO_2 are non-contributing pollutants, while the main pollutants are PM2.5, PM10 and CO. The ozone levels were also high during the month of March. The reason for slightly higher ozone condition in Mumbai could be attributed to the prevailing weather conditions and the complex chemistry of Ozone formation, requiring hydrocarbons and nitrogen oxides in presence of sunlight(MPCB, 2014)

The break-up of AQI for different days can be given as follows:

AQI Category	Number of days
Good	30
Satisfactory	221
Moderately Polluted	106
Poor	4
Very Poor	4
Severe	0



It is to be noted that even though emissions in Mumbai are as high (if not higher) as Delhi, the AQI is considerably lower on average. This is because of the dispersing action of land breezes which carry suspended pollutants out into sea at night, thus mitigating their hazardous effects.

The most effective way of reducing air pollution in Mumbai would be to reduce CO and PM10 emissions, which are emitted by vehicular exhausts, industrial plants, construction sites, landfill incineration sites and aircrafts. Thus, a considerable improvement in air quality can be expected by imposing greater restrictions on such emissions.

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