ANALYSIS OF AIR POLLUTION IN THREE CITIES OF KERALA BY USING AIR QUALITY INDEX

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Abstract — Air pollution has an appalling effect on human health and our planet as a whole. This study quantifies air pollution using a parameter – Air Quality Index and compare the pollution of air in six major sites across Kerala, India (South over bridge and Eloor in Ernakulam district, Pettah and Veli in Thiruvananthapuram district, Chavara and Kadappakada in Kollam district). The significant differences in seasonal variation of pollutants in the three districts are also studied. The conclusion of the study shows: a) Air Quality Index in all these areas is predominantly determined by Particulate Matter concentration; b) Ernakulam district has the highest Air Quality Index among both industrial and residential areas and Kadappakada, Kollam has the lowest Air Quality Index among all the six areas studied; c) The air quality deteriorates during winter and summer because of limited pollutant dispersion.

Keywords — Air Pollution, Air Quality Index, Particulate Matter.

1. INTRODUCTION

Air is one of the fundamental elements for the sustenance of life. Air pollution could be defined as the addition of harmful substances into the air which may have a decremental effect on not only human life but the planet as a whole. The pollutant could be anything from the particles spat out when we sneeze to the carcinogenic chemicals emitted from industries. The critical air pollutants are – particulate matter (PM10), sulphur dioxide (SOx), nitrogen oxides (NOx), carbon monoxide (CO) and ozone (O3). The scientific study on the effect of air pollution on human health is awful. Prolonged exposure to pollutants can cause health problems ranging from eye irritation, pulmonary diseases, heart problems and even premature death. Thanks to the widespread awareness and campaigning, a lot of efforts for measurement and mitigation of the pollutants in the atmosphere are going on. Knowledge about the extent of air degradation is important for the citizens, especially for the sick and elderly. It is possible to measure the ambient air quality but the data corresponding to different pollutants from stations across the city or a state combines to form encyclopedic amounts, which is neither useful to the officials nor to the common man. Thus, to address this concern Air Quality Index (AQI) has been used. An AQI is defined as an overall scheme that converts each concentration of individual air pollution related parameters (SOx, NOx, PM10.) into sub-indexes, which are then compared with a predefined scale to determine the quality of air. Objectives of this paper are to: i. Analysis of the levels of Air pollutants (NO2, SO2, PM10) in the residential and industrial areas each in three districts of Kerala. ii. Find the Air Quality index and compare it with the National Ambient Air Quality Standards. iii. Evaluate the reasons for the deterioration of air quality.

2. RELATED WORK

A lot of research has been done to evaluate the ambient air quality of various places in India and hence air quality index was found out in order to show the intensity of air pollution in those places. A case study of Bangalore on a 24-hour basis by Krishna Reddy and Manjunath [1] reported that the industrial area was found to be the most polluted and fell under the moderately polluted category while the commercial and residential areas were satisfactory. Neethu P.S, Sindhu P (2017) made an analysis of PM10 concentration in ambient air of Thiruvananthapuram and Ernakulam during the period 2010 to 2015[2]. Statistical analysis revealed that the concentration of PM10 exceeded the National Ambient...
Air Quality Standards (NAAQS) during the study period. Prakash Mamata and Basin [3] studied the ambient air quality of Delhi and found out that Suspended Particulate Matter (SPM) was the major pollutant present at various sites considered for analysis in Delhi. Furthermore, similar studies were done by other researchers on the basis of ambient air quality [4, 5, 6, 7].

3. STUDY AREA

We analysed 24-hour averaged criteria pollutants (SO2, NO2 and PM10) during the year 2017 of six sites in three important districts of Kerala – Thiruvananthapuram which is the capital of the state, Ernakulam is known as the industrial capital of the state and Kollam which is famous for its historical importance and trade culture. South over the bridge(residential) and Eloor(Industrial) in Ernakulam, Pettah(residential) and Velichipadu(Industrial) in Thiruvananthapuram, Kadapakkad(residential) and Chavara(industrial) in Kollam were considered for the study. Kerala’s climate is tropical monsoon. The state receives seasonally excessive rainfall and experiences hot summers. The state is sandwiched between the Western Ghats and the Arabian Sea and this plays an important role in the climatic conditions that are prevalent all along the state. The seasons of Kerala can be divided into four namely- winter (Jan-Feb), summer (Mar-May), south-west monsoon (Jun-Sept) and north-east monsoon (Oct-Dec) as referred from Kerala State Action Plan 2014 [10, 11]. Due to the existence of Arabian sea, the state is extremely humid throughout the year.

4. MATERIALS AND METHOD

The data regarding the concentration of three main pollutants sulphur dioxide, nitrogen dioxide and respirable suspended particulate matter (below 10 microns) were collected from the Kerala State Pollution Control Board (KSPCB)’s Water and Air Quality Directory 2017. KSPCB monitors the ambient air quality at 30 locations in the state. Sulphur dioxide nitrogen dioxide and respirable suspended particulate matter (below 10 microns) are monitored regularly. 24-hour ambient air quality with a sampling frequency of two days per week. The concentrations of pollutants are expressed in microgram per cubic meter. The details of monitoring stations are shown in TABLE I.

5. AQI CALCULATION

In this study, the National Air Quality Index is used for the calculation of AQI. This method involves the formation of sub-indexes and then taking the aggregate of the sub-indexes. This aggregated value is then compared with those given in TABLE II, where the AQI values are divided into six categories according to Indian conditions. IND-AQI has 6 categories- Good, Satisfactory, Moderately polluted, Poor, Very poor and Severe. The equation for finding out the sub-index (Ip) for a given pollutant concentration (Cp); as based on ‘linear segmented principle’ is given as:

\[ I_p = \left\{ \frac{(I_{HI} - I_{LO})}{(B_{HI} - B_{LO})} \right\} \times (C_p - B_{LO}) + I_{LO} \] (1)

Where,

\[ C_p = \text{Actual ambient concentration of pollutant “P”}. \]
\[ B_{HI} = \text{Upper-end breakpoint concentration greater or equal to given } C_p. \]
\[ B_{LO} = \text{Lower-end breakpoint concentration smaller or equal to given } C_p. \]
**IHI** = The sub-index or AQI value corresponding to the breaking point **BHI**

**ILO** = The sub-index or AQI value corresponding to the breaking point **BLO**

**Ip** = AQI for pollutant P (rounded to the nearest integer).

After the sub-indexes are calculated, based on ‘linear segmented principle’.

AQI = Max (Ip) (where; p= 1, 2..., n; denotes n pollutants)

where,

- **Ip** = sub-index for pollutant p
- **n** = number of pollutants

### TABLE 1: DETAILS OF MONITORING STATIONS [8]

| District          | Station Name             | Category  | Latitude      | Longitude       |
|-------------------|--------------------------|-----------|---------------|-----------------|
| Ernakulam         | South over bridge        | Residential | 9°57'26.6" N | 76°20'34.4" E  |
|                   | Eloor                    | Industrial | 10°4'23.6" N | 76°18'9.95" E  |
| Thiruvananthapuram| Pettah                   | Residential | 8°29'651" N  | 76°55'761" E   |
|                   | Veli                     | Industrial | 8°29'529" N  | 76°55'764" E   |
| Kollam            | KMML Chavara            | Industrial | 9°00'02.0" N | 76°31'18.7" E  |
|                   | Kadapakkada             | Residential | 8°53'34.5" N | 76°36'26.9" E  |
6. RESULTS AND DISCUSSIONS

After analyzing ambient air quality data for the study period 2017 for the study areas considered. The 24-hour average concentration of sulphur dioxide, nitrogen dioxide and respirable suspended particulate matter for twelve months was plotted and studied. Ambient Air Quality Index for all the cases was plotted (Fig. 1, 2, 3, 4, 5, 6). Seasonal averages were calculated and plotted (Fig. 7, 8, 9, 10, 11, 12).

In the case of residential areas. South, Ernakulam has comparatively high Ambient Air Quality Index during the period of January and February (winter season) and it is between 75 to 95, which lie in the AQI category - satisfactory i.e. may cause minor breathing discomfort to sensitive people. During the months October and December (North-west monsoon) there is a slight increase in AQI values which lie in the AQI category - satisfactory. Rest of the months have AQI less than 51 with AQI category - good i.e. minimal impact on health. Pettah, Thiruvananthapuram has a slight increase in air quality index above 51 during March and April (summer). Rest of the months have AQI just below 51. Kadapakkada, Kollam has AQI values less than 50 throughout the year i.e. have minimal impact on health.

In the case of industrial areas. Eloor, Ernakulam the AQI values go above the 51 limits during the months December (post-monsoon), February (winter), April (summer) and a slight increase during January, March, May and November. Veli, Thiruvananthapuram the AQI values go above 50 during March (summer), April (summer), July (monsoon) and a slight increase during January, February and June.

| TABLE 2: AQI RANGES AND CATEGORIES |
|-------------------------------------|
| AQI       | Category Range      |
| 0 - 50    | Good                |
| 51 - 100  | Satisfactory        |
| 101 - 200 | Moderately satisfactory |
| 201 - 300 | Poor                |
| 301 - 400 | Very Poor           |
| 401 - 500 | Severe              |

| TABLE 3: HEALTH STATEMENTS FOR DIFFERENT AQI CATEGORIES |
|---------------------------------------------------------|
| AQI         | Associated Health Impacts                          |
| Good (0-50) | Minimum Impact                               |
| Satisfactory (51-100) | Sensitive people may experience minor breathing discomfort |
| Moderately polluted (101-200) | People with lung diseases, heart diseases, children and elderly may experience breathing discomfort |
| Poor (201-300) | Prolonged exposure may cause considerable breathing discomfort |
| Very Poor (301-400) | Prolonged exposure can cause respiratory illness and the situation can aggravate for people with lung and heart diseases |
| Severe (401-500) | May cause respiratory illness even on healthy people and serious effects on sick |
FIG. 1: AQI VS MONTHS GRAPH, SOUTH

FIG. 2: AQI VS MONTHS GRAPH, ELOOR

FIG. 3: AQI VS MONTHS GRAPH, PETTAH
KMML Chavara, Kollam increase in AQI happens during May(summer) and a slight increase during August and December.

In Ernakulam district, NO₂ levels are more in Eloor (industrial) than South(residential) whereas, SO₂ levels are very low throughout the year for both residential and industry. Thiruvananthapuram district has comparatively more concentration of NO₂ and SO₂ compared to Ernakulam and Kollam. Kollam has the lowest concentration of NO₂ and SO₂. In all the six areas the concentration of NO₂ and SO₂ are below the maximum allowed limit of National Ambient Air Quality Standards (NAAQS).

The AQI values are above the 50 limits mainly during post monsoon, winter, summer and low AQI values during Monsoon, with Kollam region being an exception. In Kollam, a noticeable increase in AQI happens only during summer in KMML Chavara region and during the rest of the months, AQI values lie in the good category. The seasonal analysis of pollutants shows relatively higher concentrations of pollutants during the winter season due to limited pollutant dispersion and lower concentrations of pollutants during the monsoon season (rainy season).
FIG. 6: Pollutants concentration vs months graph, 
South

FIG. 7: Pollutants concentration vs months graph, 
Pettah
FIG. 8: AQI VS MONTHS GRAPH, CHAVARA KMML

FIG. 9: POLLUTANTS CONCENTRATION VS MONTHS GRAPH, ELOOR
FIG. 10: POLLUTANTS CONCENTRATION VS MONTHS GRAPH, VELI

FIG. 11: POLLUTANTS CONCENTRATION VS MONTHS GRAPH, KADAPAKKADA

FIG. 12: POLLUTANTS CONCENTRATION VS MONTHS GRAPH, KMML CHAVARA
FIG. 13: COMPARISON OF AQI OF THREE RESIDENTIAL AREAS

FIG. 14: COMPARISON OF AQI OF THREE INDUSTRIAL AREAS
TABLE 4: AQI CATEGORIES FOR MONITORING STATIONS

| MONTHS | SOUTH OVER BRIDGE | ELOOR | PETTAH | VELI | KADAPAKKADA | KMML |
|--------|-------------------|-------|--------|------|-------------|------|
| JAN    | Satisfactory      | Satisfactory | Good   | Satisfactory | Good      | Good |
| FEB    | Satisfactory      | Satisfactory | Good   | Satisfactory | Good      | Good |
| MAR    | Good              | Satisfactory | Good   | Satisfactory | Good      | Good |
| APR    | Good              | Satisfactory | Good   | Satisfactory | Good      | Good |
| MAY    | Good              | Good    | Good   | Satisfactory | Good      | Satisfactory |
| JUN    | Good              | Good    | Satisfactory | Good   | Good      | Good |
| JUL    | Good              | Good    | Good   | Satisfactory | Good      | Good |
| AUG    | Good              | Good    | Good   | Good    | Satisfactory | Good |
| SEP    | Good              | Good    | Good   | Good    | Good      | Good |
| OCT    | Satisfactory      | Good    | Good   | Good    | Good      | Good |
| NOV    | Good              | Satisfactory | Good   | Good    | Good      | Good |
| DEC    | Satisfactory      | Good    | Good   | Good    | Good      | Satisfactory |

7. CONCLUSION

The highest concentration of PM10 was found in Ernakulam district. The concentration of PM10 was found in excess during the non-monsoon months. The excess of particulate matter in the ambient air can be attributed mainly to the ongoing construction activities in the industrial, residential and transportation sector during the time period. The highest vehicle population was recorded in Ernakulam district as referred from Kerala state Economic Review 2017 [9]. Several ongoing construction activities and upcoming developmental projects like phase two of Kochi metro were taking place during the study period, giving rise to dust pollution. The ambient air quality data pertaining to Ernakulam District show that sulphur dioxide and nitrogen oxides are consistently within limits. The Eloor supports the largest industrial belt in Kerala. In Eloor NO2 concentrations were high but within the limits.

In Thiruvananthapuram, there was not much seasonal variation and PM10 concentration showed a slight increase in Veli during summer and winter. In Thiruvananthapuram SO2 concentration, even though within the limits was relatively the highest, may be due to the presence of chemical industries. Thiruvananthapuram stands second in Vehicle population in Kerala [9] and by the number of medium and large-scale industries, Thiruvananthapuram ranks second among the districts of Kerala.

Kollam region did not show much seasonal variation and has low pollution throughout the year except in Chavara industrial area which has a slight increase in PM10 during summer.

Out of the six regions Kadapakkada, Kollam region has the best air quality. Kadapakkada residential area is closer to Mangrove forests of Asramam on the banks of Ashtamudi Lake. Green vegetation in Kollam is better preserved than in Ernakulam and Thiruvananthapuram - as referred from Forest Statistics 2016 [10] by Kerala forest Department- which provide a better carbon sink potential.

Climate Change in recent years is a severe threat and the problems owing to climate change have a huge dimension in the state. Climate change accelerates pollution issues into more complicated ones. The population is ever increasing and the forest areas are under threat. Coconut husk retting for production of coir is a major activity along the coastal areas of Kerala which generate methane along with sulfides. Major pollutant in all the six cases is PM10. SO2 and NO2 concentrations are low and have minimal impact. Vehicles and industries are one of the main reasons for the deterioration of air quality in Kerala.
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