A STUDY ON NATURAL SUBSIDENCE OF AIR POLLUTANTS IN PALAKKAD INDUSTRIAL AREA

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ABSTRACT

With the increase in population, pollution is increasing day by day due to industrialization and urbanization. Pollution is also caused due to natural phenomena such as volcanic eruption and forest fire. All of these aspects can affect human health directly or indirectly. This study reports the analysis of the ambient air in Palakkad district, Kerala utilizing air quality index (AQI). An air quality index (AQI) is formulated for Palakkad district for simplified general information and data clarification. The 24-hourly average concentrations of four critical pollutants, viz. Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2), Suspended particulate matter (SPM), and Respirable suspended particulate matter (RSPM), for two years 2018 and 2019 in the industrial area have been assessed for this analysis. The AQIs were computed using IND-AQI method. It has been observed that the AQIs values of SO2 and NO2 fall under 'good' categories. The calculated AQIs values of SPM and RSPM fall under ranging proportions. Thus the overall AQI was found under the category of 'moderate' and 'poor' due to RSPM and SPM, respectively. Thus, it is observed that SPM is a significant pollutant at the Palakkad district.

KEYWORDS: Ambient air quality, Air quality index, PM2.5, PM10, NO2, SO2, Kerala.

INTRODUCTION

The release of pollutants into the air is detrimental to human health and therefore the planet as a whole. After the Bhopal Tragedy, the govt of India enacted the Environment Protection Act of 1986 under Article 253 of the Constitution. They relate to the protection and improvement of the human environment and thus the prevention of hazards to living creatures, plants, etc. Burning fossil fuels releases an enormous quantity of polluted gases and it contributes to global climate change to a large extent. Studies show that in developing countries, air pollution has diminished visibility by 70 percent. India ranked 177th position out of 180 countries in the Environmental Performance Index in 2018.
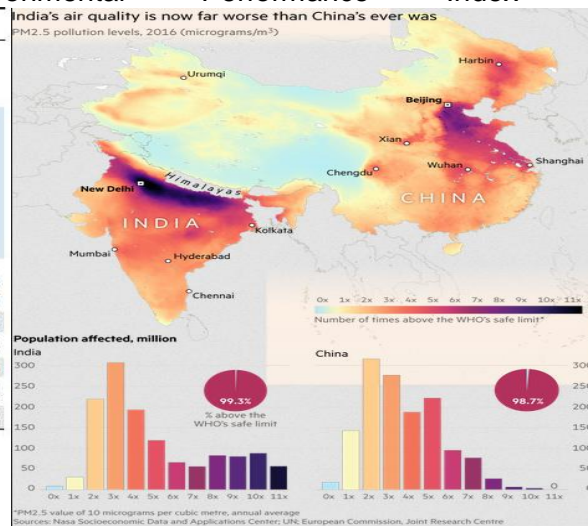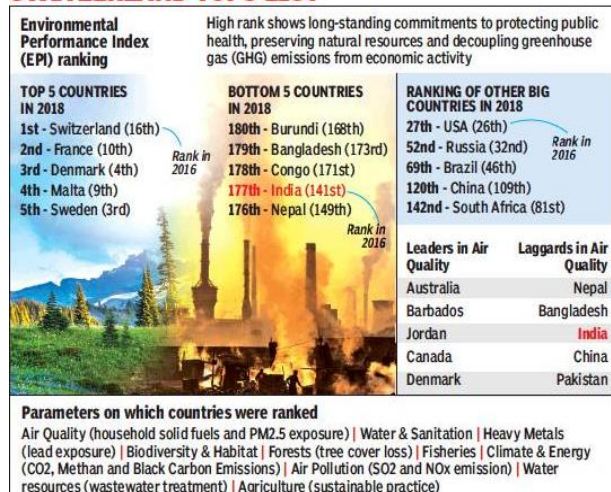
Any material including natural gas, gasoline, diesel fuel, LP, wood, oil, candle wax, tobacco smoke, cooking oils, and carpet fibres produce soot when they burn. Soot is formed by the incomplete combustion of materials containing carbon. The tiniest airborne particles in soot even they are gas or solids are particularly perilous because they'll penetrate the bloodstream, lungs, and worsen bronchitis, cause heart attacks and results in hasten death. When sunlight reacts with pollutant gases and fine particles in the atmosphere, smog is formed. Smog is a mix of smoke and fog which reduces visibility. It is common in industrial areas. Smog can irritate the eyes and throat and also damage the lungs, especially of individuals who work or exercise outside, children, and senior citizens. It's even worse for those who have asthma or allergies— these extra pollutants only intensify their symptoms and may trigger asthma attacks (Cadle et.al.1993).

While COVID-19 lockdown, designed to break the spread of coronavirus, has brought the country to a never-ending halt. With the closure of road traffic, automobiles, and industries, the atmosphere has become cleaner and is being purified every day. The Himalayan range in Himachal Pradesh, became visible from a distance of more than 250 km away, as a dip in air pollutant emission levels. Similar effects were seen across many cities in India. In New Delhi, PM 2.5 pollutants fell by 71 percent in just one week of COVID-19 lockdown. When nitrogen oxides and volatile organic compounds (VOCs) react to sunlight, a mixture of pollutants called Photochemical smog is formed creating a brown haze above cities.

AQI was calculated using IND-AQI specified by CPCB.AQI concept transforms weighted values of individual air pollutants into one number or set of numbers which can be widely used for air quality communication and higher cognitive process. This IND-AQI has 6 categories.

Category	Range
Good	0 - 50
Satisfactory	51 - 100
Moderately Polluted	101 - 200
Poor	201 - 300
Very poor	301 - 400
Severe	401 - 500

Various Categories of IND-AQI (National Air Quality Index, CPCB)

HEALTH HAZARDS

Every uncommon suspended material in the air, which causes problems in the normal function of the human organs, is defined as air toxicants. Most of the air pollution comes from particulate matters which are tiny particles less than 2 μm that the particles can easily penetrate the bloodstream and lungs and even affect the brain. The high levels of air pollution cause millions of deaths and hospitalizations every year.

A 2018 report by the World Health Organisation (WHO) reported that breathing in toxic air kills about 600,000 children every year under the age of 15 years and also it shortens the average Indian's life expectancy by more than four years. A 2017 report by the Centre for Science and Environment (CSE) revealed that 30 percent of all premature deaths in India are caused due to air pollution. Though every country in the world deals with air pollution to some extent, it is far worse in developing countries. Developing countries have many challenges that developed countries don't have to face, such as rapid and unregulated economic expansion, and as a result, their pollution problems are worse.

A healthy baby girl born in Delhi's Indraprastha Apollo Hospital on October 29. Kept in Hospital for 2 days because of Diwali. However, on October 31, the baby developed breathing trouble and had to be moved to the ICU. Doctors said, "The baby had perfectly developed lungs when she was born but is likely to suffer from bronchitis for life," Reason - High level of PM 2.5 on November 5 and 6,, reached 837µg/m3. (Safe limit for humans is 60µg/m3)

Chemical compounds like volatile organic compounds (VOCs) that are harmful to people's health react in the presence of heat and sunlight to create ground-level ozone or smog. This smog contributes to the greenhouse effect and inhaling in ground-level ozone is thought to cause inflammation of the airways, creating and exacerbating conditions like emphysema, bronchitis, and asthma. Both short term - and long-term exposure to ambient pollution in children and adults cause reduced lung function and respiratory infections and also may affect diabetes and neurological development in children. (Nakano T. at 2013), (Kampa M. at 2008)

STUDY AREA
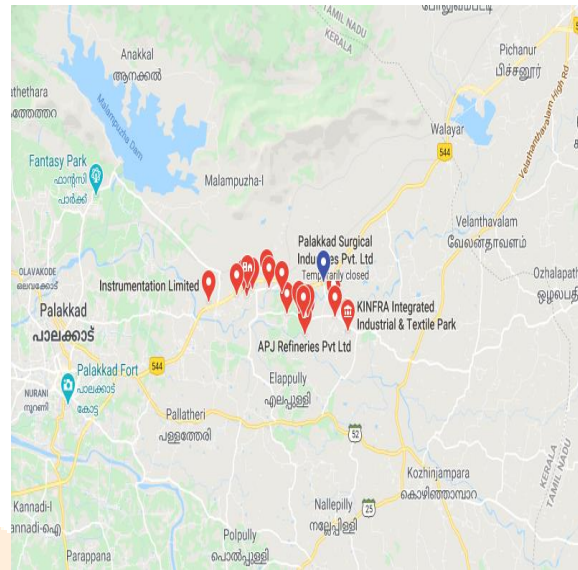
Palakkad is a town in the state of Kerala in India and it covered over an area of 26.60 km. It is the administrative headquarters of the District and lies between 10º 20' and 11º 14' north latitude and between 76º 20' and 76º 54' east longitudes. The Palakkad District is of 4480 sq.km. It is situated about 350 km north of Thiruvananthapuram, the capital of Kerala and 50km southwest of Coimbatore and 66 km northeast of Thrissur. As per Census 2011, the population of Palakkad district is 2,809,934. The population of Palakkad municipality is 130,955 ("District Census 2011" Census 2011).

Palakkad is the gateway to Kerala in the Western Ghats due to the presence of the Palakkad Gap. Western Ghats is a UNESCO World Heritage Site and is one of the eight hotspots of biological diversity in the world and so-called as the Great Escarpment of India. UNESCO says that the Western Ghats are older than the Himalayas. It has a huge proportion of the country's flora and fauna. They affect Indian monsoon weather by interrupting the rain-laden monsoon winds from the south-west during late summer.Palakkad district has numerous small rivers, which are tributaries of the Bharathapuzha River. The largest irrigation dam in the state is Malampuzha Dam near the Kanjikode area. Palakkad experiences a tropical wet and dry climate. Except for March and April being the hottest months, the temperature remains moderate throughout the year. During the South-West monsoon high amount of precipitation is received in Palakkad. July is the wettest month, and the total annual rainfall is around 211 cm.

Palakkad is well connected by roads. National Highway passes through the district are National Highway 544 from Salem to Ernakulam via Coimbatore, Palakkad, and Thrissur – Kozhikode National Highway 966 via Malappuram. Kerala faces heavy traffic at a rate of 10–15%, results in high pressure on the roads. The state's high population shows that the traffic density is nearly fourfold the national average. Kanjikode is located on the National Highway 544, about 10km from the state's largest checkpoint, Walayar, the Kerala-Tamilnadu border, and 35km from Coimbatore. Through this border, a large number of public and commercial vehicles pass in and out of Kerala.

Kanjikode is the largest prominent industrial area in Kerala. It is said to be one of the largest hubs of steel industries in the world. There are 3 industrial areas-old industrial areas (200 acres), New industrial area(450 acres), and Wise park(750 acres). There are 44 steel industries here, in an area of 7 sqkm. Companies like Indian Telephone Industries(ITI), Instrumentation Limited(IL), Fluid Control Research Institute, Patspin India Ltd, Pepsico, United breweries, Empee Distilleries, Marico, BEML, Rubfila International Ltd, Arya Vaidya Pharmacy (AVP), LPG bottling plant, etc. have production facilities. The only common Bio-Medical Waste Treatment and disposal facility of Kerala is located in Kanjikode. There are 3 higher secondary schools with more than 3000 students each and 4 primary schools and an Indian Institute of Technology (IIT Palakkad) are located in the periphery of the industrial area. There are many health centres and an early cancer detective centre in Kanjikode.

This study will be beneficial for meteorologists and climatologists to research its impact on temperature and rainfall. During this perspective, an attempt is being made to analyse the changing trends of air quality over the Kanjikode industrial area on an annual, seasonal, and monthly basis.

DATA AND METHODOLOGY

The Ministry of Environment and Forest (MoEF), Govt of India, vide gazette notification, G.S.R826 (E), dated 16.11.2009 has notified the National Ambient Air Quality Standards by amending the Environment (Protection) Rules 1986. The following are the major changes that have been affected.

1. As against three [(i) Industrial Area (ii) Residential, Rural & other areas (iii) Sensitive Area] areas, the new standards are applicable for only two areas viz. (i) Industrial, Residential, Rural, and other areas (ii) Ecologically Sensitive Area (Notified by Central Government).

2. The Industrial area, Residential, Rural, and other areas have been clubbed, Ecologically Sensitive areas to be notified by Central Government.

3. The new parameters included are particulate matter size less than 2.5 µm OR PM2.5 µg/M3, Ozone, ammonia (NH3), Benzene, Benzo(a)pyrene (BaP), Arsenic (As) and Nickel (Ni).

4. Ambient air quality data generated under the National Ambient Air Quality Monitoring Programme (NAMP) has been compared with revised national ambient air quality standards for the year 2010-11.

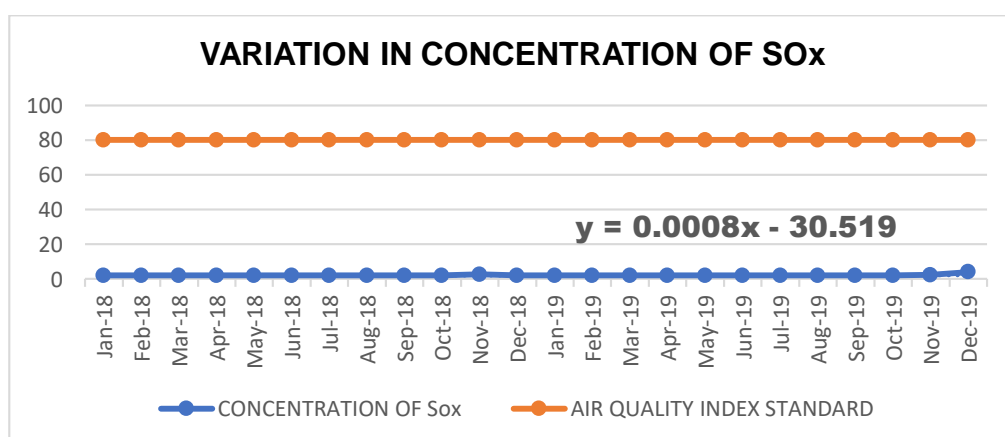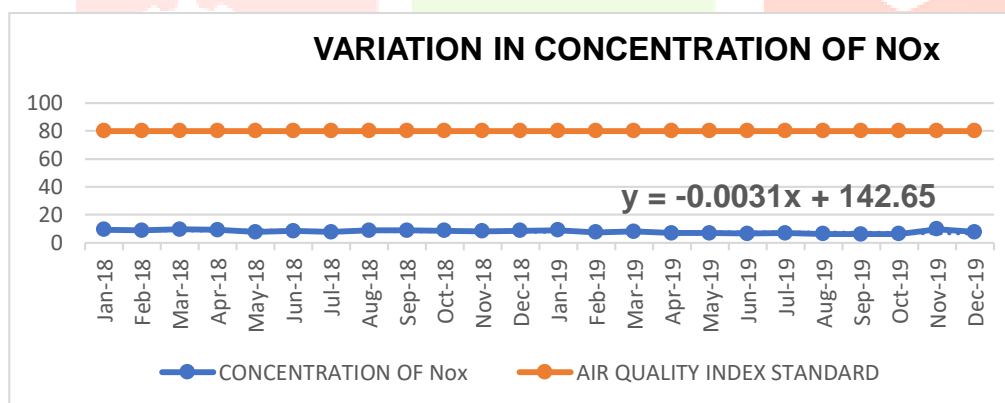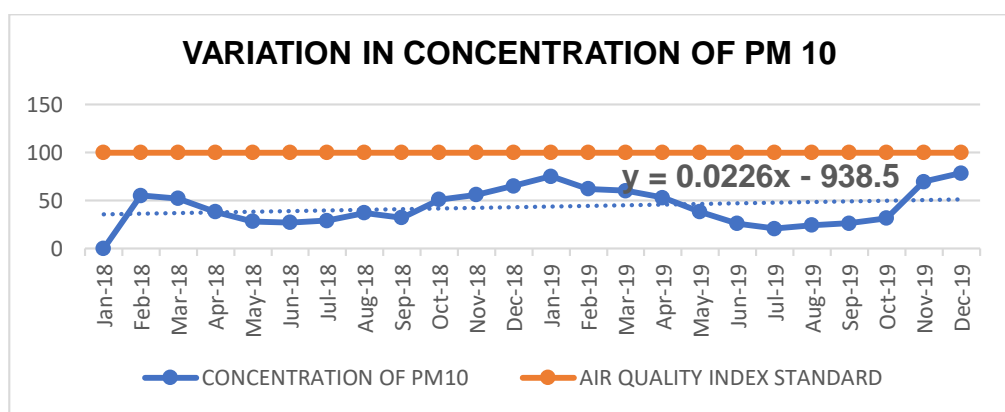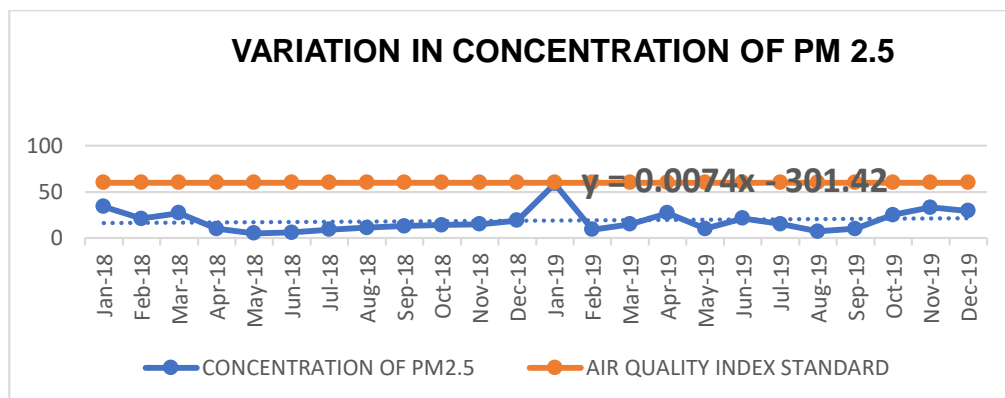| Pollutants	Time weighted average	Industrial, residential, rural and other areas	Ecologically sensitive area (notified by central government)	Methods of Measurement
Sulphur dioxide (SO₂), µg/m³	Annual*	50	20	Improved West and Gaeke Method
	24 hours**	80	80	Ultraviolet Fluorescence
Nitrogen dioxide (NO₂), µg/m³	Annual*	40	30	Jacob & Hochheiser modified (NaOH-NaAsO₂) method
	24 hours**	80	80	Gas Phase Chemiluminescence
Particulate matter (size less than 10 µm) or PM₁₀, µg/m³	Annual*	60	60	Gravimetric
	24 hours**	100	100	TEOM
				Beta attenuation
Particulate matter (size less than 2.5 µm) or PM₂.₅, µg/m³	Annual*	40	40	Gravimetric
	24 hours**	60	60	TEOM
				Beta attenuation
Ozone (O³) µg/m³	8 hours*	100	100	UV Photometric
	1 hour**	180	180	Chemiluminescence
				Chemical Method
Lead (Pb) µg/m³	Annual*	0.5	0.5	AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper
	24 hours**	1	1	ED-XRF using Teflon filter
Carbon Monoxide (CO) µg/m³	8 hours**	2	2	Non dispersive Infrared (NDIR) Spectroscopy
	1 hour**	4	4	
Ammonia (NH3), µg/m³	Annual*	100	100	Chemiluminescence
	24 hours**	400	400	Indophenol blue method
Benzene (C₆H₆), µg/m³	Annual*	5	5	Gas chromatography (GC) based continuous analyser
				Adsorption and desorption followed by GC analysis
Benzo(a) Pyrene (BaP) particulate only, ng/m³	Annual*	1	1	Solvent extraction followed by HPLC/GC analysis
Arsenic (As), ng/m³	Annual*	6	6	AAS/ICP Method after sampling on EPM 2000 or equivalent paper
Nickel (Ni), ng/m³	Annual*	20	20	AAS/ICP Method after sampling on EPM 2000 or equivalent paper

Note: * Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.
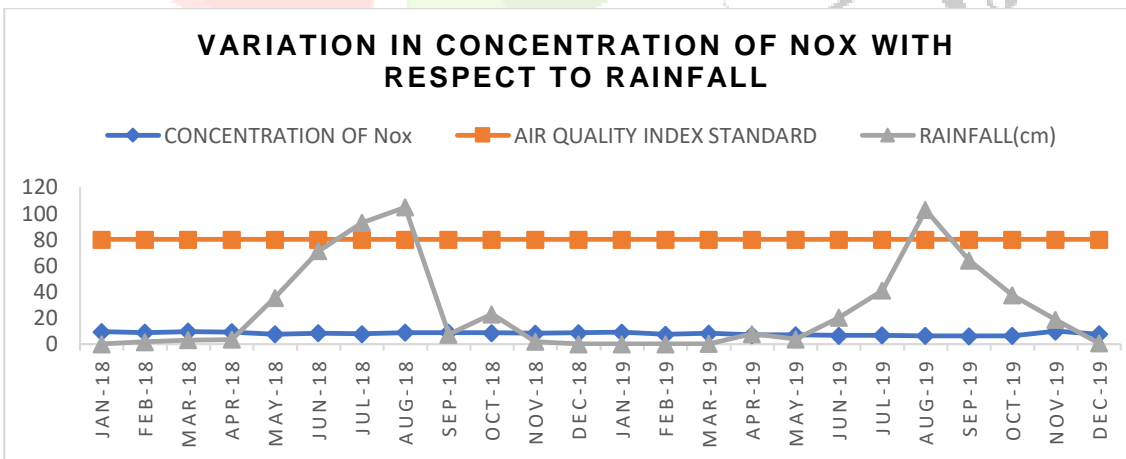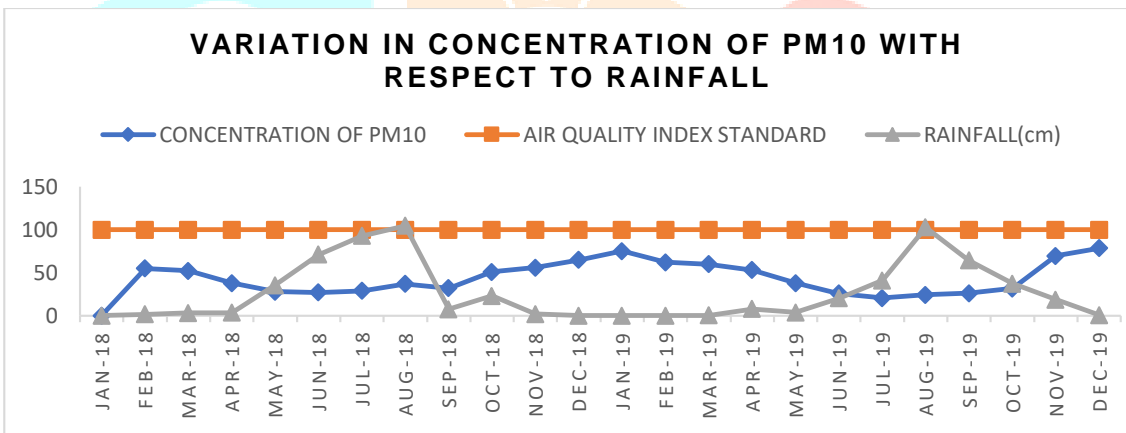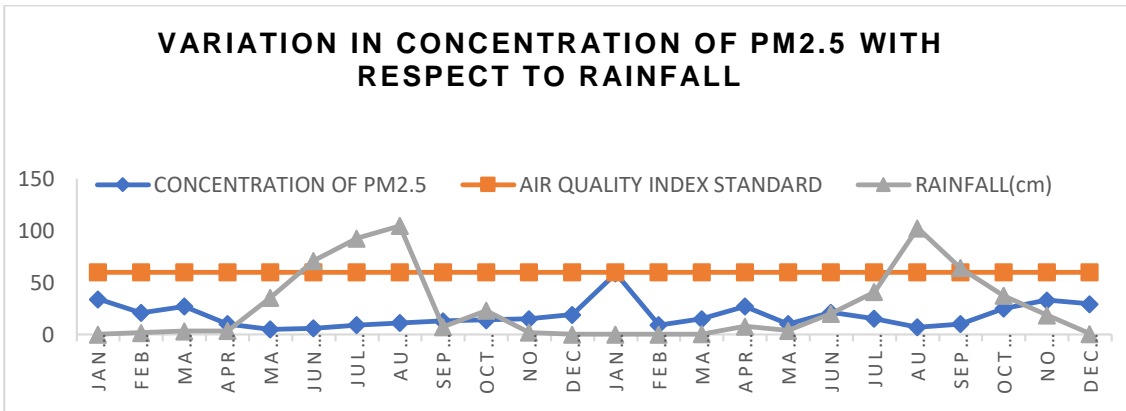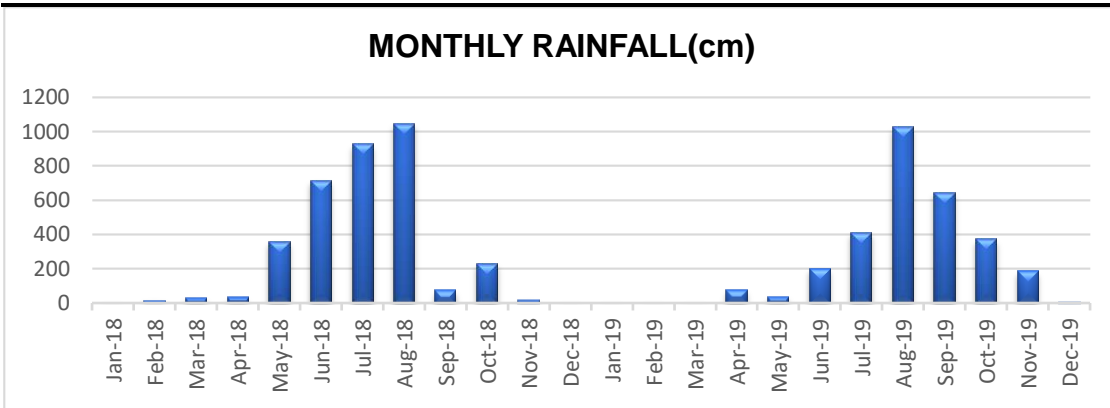
** 24 hourly or 8 hourly or 1 hourly monitored value, as applicable, shall be complied with 98% of the time, they may exceed the limits but not on two consecutive days of monitoring.
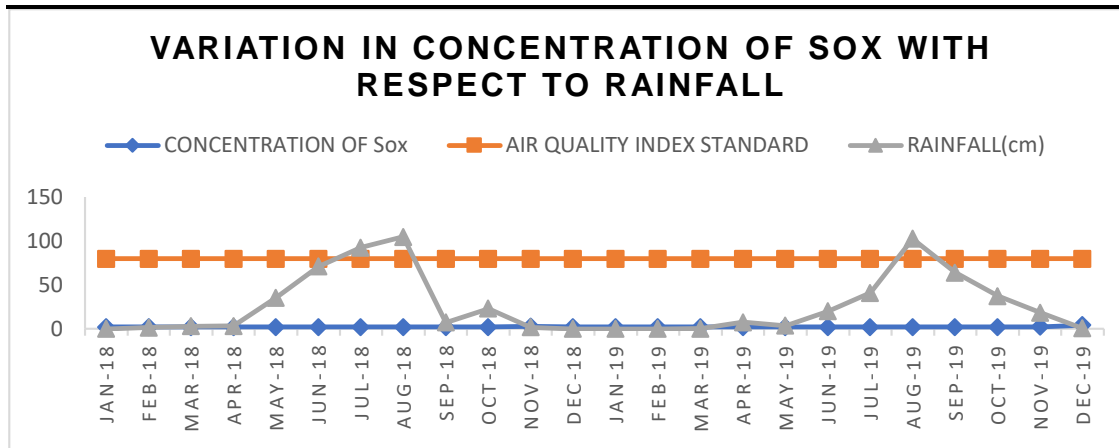
Sox, NOx, PM10, and PM2.5 monthly mean values were collected from Kerala State Pollution Control Board, for the period 2018,2019. The Kerala State Pollution Control Board is monitoring the Ambient Air Quality at Kanjikode in Palakkad district. Sampling was carried out using High volume samplers (HVS) and Respirable dust samplers (RDS). The sampling was done twice in a week and 104 samples in a year. The samples were examined using standard methods notified by the central pollution control board (CPCB). Meteorological parameters such as wind direction, rainfall data, population data published by the government of India (Census 2011), and vehicle population data were also used for this study. The month-wise temperature values regarding winter (January-February), pre-monsoon/summer (March-May), monsoon (June–September), post-monsoon (October–December), and annual values were calculated for this station. The seasons were classified according to the criteria given by India Meteorological Department. Gaseous pollutants namely SO2 and NO2 were collected on four hourly bases for 24hours by drawing airflow of 1L/min and were analyzed by West and Geake and Jacob and Hochheiser Method. Particulate matter SPM and RSPM were estimated by the gravimetric method. A known amount of air is drawn through pre-weighed glass fibre filter paper, GF/A at a flow rate of 0.8-1.3 m3/min on the 8-hourly basis for 24 hours. Concentrations of the pollutants were measured in micrograms/cubic meter (µg/m3). The AQI was calculated using IND-AQI here. The trends are tested at a 99% level of confidence.

RESULTS AND DISCUSSIONS

The daily average concentrations were calculated. The corresponding graphs of the concentration of each pollutant with time were plotted. The study shows that the minimum and maximum concentration of PM10 was 20.6 & 78.5 µg/m3. The minimum and maximum concentration of PM2.5 was 5 & 59 µg/m3. The minimum and maximum concentration of SO2 was 2 & 4.1 µg/m3. The minimum and maximum concentration of NO2 was 6.1 & 9.7 µg/m3. The overall AQI values of SOx and NOx fall under "good condition" (0-50), while PM10& PM2.5 fall under "satisfactory conditions" (51-100).

VARIATION IN CONCENTRATION OF PM 2.5

$y = 0.0074x - 301.42$

CONCENTRATION OF PM2.5 — AIR QUALITY INDEX STANDARD

VARIATION IN CONCENTRATION OF PM 10

$y = 0.0226x - 938.5$

CONCENTRATION OF PM10 — AIR QUALITY INDEX STANDARD

VARIATION IN CONCENTRATION OF NOx

$y = -0.0031x + 142.65$

CONCENTRATION OF Nox — AIR QUALITY INDEX STANDARD

VARIATION IN CONCENTRATION OF SOx

$y = 0.0008x - 30.519$

CONCENTRATION OF Sox — AIR QUALITY INDEX STANDARD

MONTHLY RAINFALL(cm)

VARIATION IN CONCENTRATION OF PM2.5 WITH RESPECT TO RAINFALL

VARIATION IN CONCENTRATION OF PM10 WITH RESPECT TO RAINFALL

VARIATION IN CONCENTRATION OF NOX WITH RESPECT TO RAINFALL

VARIATION IN CONCENTRATION OF SOX WITH RESPECT TO RAINFALL

TRENDS IN PM 2.5

The permissible concentration of PM2.5 in industrial are is 60 µg/m3. It is observed that PM 2.5 is decreasing from the months of January-May in the year 2018. On the other hand, the months of June 2018-January 2019 show an increasing trend. It is decreasing from the month of February 2019-May 2019. In the months of June-December show an increasing trend in the year 2019. The highest rate of increase is reported during the month of January 2018 & 2019, while the highest rate of decrease is observed during the month of June 2018 & August 2019. PM2.5 decreases gradually in the pre-monsoon and monsoon periods. It gradually increases during post-monsoon and gets peakier in winter monsoon.

TRENDS IN PM10

The permissible concentration of PM10 in the industrial area is 100 µg/m3. It is observed that PM10 is increasing from the months of January-March in the year 2018. On the other hand, the months of April-June show a decreasing trend in the year 2018. It is increasing from the month of July 2018- March 2019. In the months of April-September show a decreasing trend in the year 2019. In the month of October-December, it shows an increasing trend significantly. The highest rate of increase is reported during the month of December 2018 & 2019, while the highest rate of decrease is observed during the month of June 2018 & July 2019. PM10 is increased in post-monsoon, pre-monsoon, and winter monsoon and decreases in monsoon seasons.

TRENDS IN NOx

The permissible concentration of NOx in the industrial area is 80 µg/m3. It is observed that NOx is decreasing from the months of January-July in the year 2018. On the other hand, the months of August-December show an increasing trend in the year 2018. It is decreasing from the month of January to October in the year 2019. In the months of November-December show an increasing trend in the year 2019. The highest rate of increase is reported during the month of November, while the highest rate of decrease is observed during the month of September.

TRENDS IN SOx

The permissible concentration of Sox in the industrial area is 80 µg/m3. It is observed that Sox is similar in all months and there is a small increase in November 2018. In the year 2019 also shows that the concentration levels increase only in the months of November and December. The highest rate of increase is reported during the month of November in 2018 and December in 2019. Sox is increased during the end of post-monsoon and at the starting of the winter monsoon.

RELATION WITH METEREOLOGICAL PARAMETERS

Meteorology plays an important role in the distribution of air pollution. Air pollutants are influenced by seasonal changes as well as meteorological factors like temperature, wind direction, wind speed, precipitation, and turbulence. The result indicates that there is an increase in SPM during winter, pre-monsoon, and post-monsoon season and decrease during the monsoon season. SPM is higher during the winter as well as summer seasons, and to some certain extent during the post-monsoon season. As a result of less rainfall in the winter season, the removal of atmospheric aerosol particles by rainfall is reduced. During the summer season, the climate is very warm. SPM is decreased in the monsoon season due to wet weather, as it is removed from the atmosphere by precipitation. This shows the relationship between rainfall, wind frequency, and SPM. During winter, pre-monsoon and post-monsoon season, quiet days frequencies are more. This might lead to an increase in SPM concentration. During monsoon season, wind frequencies are more. The greater the wind speed, results in higher turbulence, and hence dispersion

of pollutants is high and it leads to a decrease in SPM concentration. The precipitation and direction of wind cause a reduction in SPM in the environment.

RELATION WITH SOCIO-ECONOMIC PARAMETERS

Socio-economic parameters indirectly play an important role in influencing pollutants concerning the annual population and vehicular data. There are 3 higher secondary schools with more than 4000 students each and 4 primary schools are located in the periphery of the industrial area. There are many health centres and early cancer detective centre in Kanjikode. With the increase in population, it is observed that there is also an increase in vehicular pollution every year. All these factors might have led to a rise in air pollution.

CONCLUSION

The AQIs were calculated to assess the ambient air quality at Kanjikode industrial area during the year 2018 & 2019. The overall AQI can give a clear view about ambient air concentration and the critical pollutant responsible for air quality which can be modest for each citizen to realize. The AQI was calculated using Indian Air quality Index (IND-AQI). The study concludes that Sox & Nox are in good condition. It is likely that right now the levels of both the pollutants, PM10 & PM2.5 have slightly increased from the ambient concentration in all seasons except monsoon seasons. However, PM10 and PM2.5 show a significant increasing trend during the winter season. Kanjikode area is a stronger case for continuous monitoring of ambient air quality due to the upcoming of many industrial hubs. While there is a decrease in particulate matter during monsoon season due to high precipitation. The removal of atmospheric aerosol particles by rainfall is reduced in winter due to less rainfall, thereby results in high particulate matter. It is also observed that during winter, pre-monsoon, and post-monsoon seasons quiet days frequencies are high leading to an increase in SPM concentration.

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