VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"Jnana Sangama", Belgaum-590 014

A Dissertation Project Report on

"Trend Analysis of Air Pollution in Bangalore & Effectiveness of Control Measures"

Submitted in partial fulfilment for the award of the degree of BACHELOR

OF ENGINEERING IN

CIVIL ENGINEERING

BY

Ranjith M Gowda	**1CR16CV050 S**
Sohith	**1CR16CV052**
Shashank Reddy N	**1CR16CV059**

U nder the guidance of

Dr. Soundarya. N

DEPARTMENT OF CIVIL ENGINEERING

CMR INSTITUTE OF TECHNOLOGY

ITPL MAIN ROAD BENGALURU-560 037

2019-2020

C.M.R. INSTITUTE OF TECHNOLOGY

(#32, AECS Layout, IT Park Road, Bengaluru-560 037)

Department of Civil Engineering

Certificate

This is to certify that the project work entitled ***"Trend Analysis of Air Pollution in Bangalore & Effectiveness of Control Measures"*** *has been successfully completed by Mr. Ranjith M Gowda* (USN 1CR16CV050), Mr. S Sohith (USN *1CR16CV052), Mr. Shashank Reddy N (USN 1CR16CV059), bonafide students of CMR Institute of technology in partial fulfilment of the requirement for the award of degree of Bachelor of Engineering in Civil Engineering of the* ***"VISVESVARYA TECHNOLOGICAL UNIVERSITY",*** *Belgaum during the academic year 2019-2020. It is certified that all corrections indicated for internal assessment has been incorporated in the Report. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said Degree.*

Dr. Soundarya. N	Dr. Asha M Nair	Dr. Sanjay Jain
(Associate Professor)	HOD	Principal
	Department of Civil Engineering	CMR Institute of Technology
	CMR Institute of Technology	

Name of the Examiners	External Viva	Signature with date
1.		
2.		

C.M.R. INSTITUTE OF TECHNOLOGY

(#32, AECS Layout, IT Park Road, Bengaluru-560 037)

Department of Civil Engineering

DECLARATION

We, **Mr. Ranjith M Gowda, Mr. S Sohith, Mr. Shashank Reddy N**, bonafide students of CMR Institute of Technology, Bangalore, hereby declare that dissertation entitled **"Trend Analysis of Air Pollution in Bangalore & Effectiveness of Control Measures"** has been carried out by us under the guidance of **Dr. Soundarya. N (Associate Professor)**, Department of Civil Engineering, CMR Institute of Technology, Bangalore, in partial fulfilment of the requirement for the award of degree of Bachelor of Engineering in **Civil Engineering** of the Visvesvaraya Technological University, Belgaum during the academic year 2017-2018. The work done in this dissertation report is original and it has not been submitted for any other degree in any university.

Ranjith M Gowda

(1CR16CV050)

S Sohith

(1CR16CV052)

Shashank Reddy N

(1CR16CV059)

ABSTRACT

Bangalore's population is estimated to be around 1crore. Bangalore is classified as one of India's 100 'non-attainment cities' which means it does not meet the CPCB's National Ambient Air Quality Standards. This paper discusses the Air Pollution trends in Bangalore for a period of 15 years from 2004 to 2019. The effects of CPCB and KSPCB's rules and initiatives on the air pollution level in the control, abatement and monitoring is also discussed vastly. A huge amount of data was collected and hence PYTHON was used to clean, sort & group data and to get a relevant graph for the analysis. The graphs were plotted to understand the trends and analysis of the control measures were done. This paper paves way to a deeper understanding of the success and failures of various control measures, which will act as a guide for future implementations of control measures in other cities as well.

ACKNOWLEDGEMENT

The satisfaction that accompanies the successful completion of any task would be incomplete without mentioning of the people who made it possible. Many responsible for the knowledge and experience gained during the work course.

We would like to express my deep sense of gratitude to our principal Dr. **SANJAY JAIN**, **CMR INSTITUTE OF TECHNOLOGY COLLEGE, BANGALORE** for his motivation
and for creating an inspiring atmosphere in the college by providing state of art facilities for preparation and delivery of report.

Our sincere thanks to **Mrs. ASHA M NAIR** , Head of Department Civil Engineering CMRIT, Bangalore who shared her opinions and experiences through which we received the required information crucial for the project.

We consider it a privilege and honor to express our sincere gratitude to our internal guide **Dr.Soundarya N**, Associate Professor Department of Civil Engineering for her valuable guidance throughout the tenure of this project work.

We would also like to thank **The Teaching & Non-Teaching Staff** of Civil Engineering Department, who have always been very cooperative and generous. Conclusively, we also thank all others who have done immense help directly or indirectly during our project.

Ranjith M Gowda

(1CR16CV050)

S Sohith
(1CR16CV052)
Shashank Reddy N
(1CR16CV059)

LIST OF FIGURES

LIST OF TABLES

CONTENTS

Trend Analysis of Air Pollution in Bangalore& Effectiveness of Control Measures

Dr. Soundarya. N[1], Ranjith M Gowda[2], S Sohith[3], Shashank N Reddy[4]

[1] Associate Professor, CMR Institute of Technology, Bengaluru,

[2, 3, 4] Final Year Civil Engineering, CMR Institute of Technology, Bengaluru

Abstract

Bangalore's population is estimated to be around 1crore. Bangalore is classified as one of India's100 'non-attainment cities' which means it does not meet the CPCB's National Ambient Air Quality Standards.This paper discusses the Air Pollution trends in Bangalore for a period of 15 years from 2004 to 2019. The effects of CPCB and KSPCB's rules and initiatives on the air pollution level in the control, abatement and monitoring is also discussed vastly. A huge amount of data was collected and hence PYTHON was used to clean, sort & group data and to get a relevant graph for the analysis. The graphs were plotted to understand the trends and analysis of the control measures were done. This paper paves way to a deeper understanding of the success and failures of various control measures, which will act as a guide for future implementations of control measures in other cities as well.

Keywords: Air Pollution, Bangalore, PYTHON, Trend Analysis, Control measures, KSPCB, CPCB

1. Introduction

Indian cities are considered as one of the most populated cities in the world.The concentration does not satisfy the values of WHO.Usually it's the developing countries that face major air pollution and India is regarded as one of the developing countries in the world.According to the survey,around 41 mega cities will be formed in the next decade and the population in those cities are estimated to be around 46million which is considered vast.According to the data provided by WHO there are about 2million premature deaths due to air pollution as the concentrations of SO_2,$NO_x$and PM10 are a major concern as they cause various effects in human body such as lung cancer, throat problem, damage to brain and death is a few cases compared to the previous

centuries and decades the life expectancy is decreasing.This shows the effect of air pollution on human life.

2. Study Region

Bangalore, capital of Karnataka has a population of more than 10 million making it a mega city and third most populated city in India.It is located in Southern India, on the Deccan plateau at an elevation of 920m above the mean sea level, highest among the major cities in India.The major industrial areas in Bangalore are Peenya,Jigani,ITPL and Doddanekkundi industrial area.Bangalore is known for its wide range of different types of industries like IT,Automobile,mining,R&D knowledge,silk,steel production,electronics and communication,tourism etc.Road accessibility to other states,traffic congestion and emissions are the most influential factors for the pollution in Bangalore.The study area is divided into 3 sub categories: 1.Industrial areas: Graphite India, KHB&Peenya, 2.Residential areas: AMCO Batteries&Yeshwanthpur and 3.Sensitive areas: Victoria Hospital&Bangalore University. These areas are shown in Fig No. 1.

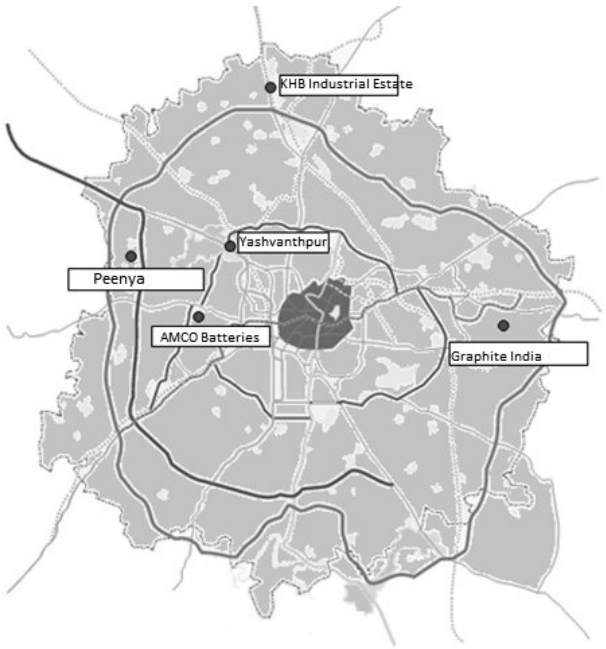


Fig No. 1 Bengaluru Region Map (Source: Karnataka 2016)

3.Methodology

The following were the methodologies used

- Data Collection
- Grouping and Aggregating Using PYTHON
- Trend Analysis& analysis of methods adopted by KSPCB & CPCB in pollution control

Data Collection

About 98% of data collected by the Ministry of environment and forests and Central pollution control board were accurate.The equipment used were field equipment and the monitoring sites adhered to NAMP guidelines for monitoring sites.The data was collected for an average of 24 hours every month later compiled and cleaned before analysing it using Python programming language

Trend Analysis Using PYTHON

Python is a software designed for data analysis it was used to clean, sort, group data for the analysisit is used in many fields such as Astronomy, Artificial Intelligence, Biology and economics.It is now even used in civil engineering too.Few of the applications of python used in civil engineering arePopulation forecasting for urban planning, water & sewerage supply system, Predicting traffic trends etc.

Data Analysis

Asper CPCB the concentration ranges of the pollutants based on the notification standards and area classes can be calculated through the Exceedance Factor - EF (CPCB 2006).

$$EF = \frac{Observed\ Annual\ Mean\ Concentration\ of\ a\ Criterion\ Pollutant}{Annual\ Standard\ for\ the\ Respective\ Pollutant\ and\ Area\ Class} \textbf{... (Eqn 1)}$$

Eqn 1 was used to find EF for the values.Annual average levels of SO_2, NO_x and PM10 collected at the monitoring stations as well the Exceedance Factor calculated is shown in the Table Nos. 2, 3, 4, 6, 7, 8, 9, 10 & 11. The results have been expressed as Low, Moderate. High and Critical. Criteria for these are as shown in Table No. 1.

Table No. 1 Air Quality Levels

Range	Air Quality Levels	Abbreviation used
<0.5	Low Pollution Level	L
0.5 – 1.0	Moderate Pollution Level	M
1.0 – 1.5	High Pollution Level	H
>1.5	Critical Pollution Level	C

4.Results and Discussions

The results were tabulated based on the pollutants and the analysis is discussed as below.

i. NO_X Levels

NO and NO_2, are artificially generated pollutants and the sum of their concentrations is referred to as nitrogen oxides and are expressed as NO_x.NO_x emissions result from all types of combustion sources and motor vehicle exhausts due to burning of petrol, diesel, and liquefied petroleum gas (LPG) and compressed natural gas (CNG).

Health Impacts

Exposure to NO_x, is linked to adverse respiratory effects and airway inflammation in healthy people, and increased respiratory symptoms in people with asthma.This can either induce or worsen respiratory diseases, or aggravate existing heart disease, leading to increased hospital admissions or even premature death (WHO, 2011).

Industrial Areas

From Table No. 2 and Fig No. 2, it can be noted that in Graphite India region, there was a decreasing trend, with a value of 26.06% in the years 2004-2006. There was a surge of 7% by the year 2009. Later on the trend started decreasing till 2013, but there was a sharp increase of 9.5% in the year 2014. There was again a high peak of 23.4% in the year 2017, the trend started continuously decreasing for the following years.In KHB region, there was a decrease in the trend same as seen in Graphite India with 32.02% in the years 2004-2006. There was a peak of 12.4% by the year 2009. Later the trend started decreasing till 2016. A surge of 45.56% was seen in the year 2017, later the trend kept decreasing in the next years that followed.In Peenya region, an increase was noted with a value of 9.26% and 18% in the years 2005 & 2009 respectively. The

trend started decreasing and dropped by 32.6% in year 2015, a peak of 43.8% was observed in the year 2016, and later the trend started decreasing in the years that followed.

Table No. 2 Industrial Areas: NO_x Levels (Annual Average), EF and Air Quality Levels

Year	Graphite India			KHB			Peenya		
	Levels	EF	Air quality	Levels	EF	Air quality	Levels	EF	Air quality
2004	53.33	1.33	H	52.45	1.31	H	42	1.05	H
2005	49.53	1.24	H	43.87	1.10	H	45.89	1.15	H
2006	39.14	0.98	M	35.65	0.89	M	34.73	0.87	M
2007	40.67	1.02	H	39.17	0.98	M	38.64	0.97	
2008	41.88	1.05	H	39.98	1.00	M	41.00	1.02	H
2009	41.65	1.04	H	38.44	0.96	M	38.32	0.96	M
2010	37.90	0.95	M	35.60	0.89	M	36.40	0.91	M
2011	32.60	0.82	M	34.17	0.85	M	29.10	0.73	M
2012	30.75	0.77	M	30.25	0.76	M	29.90	0.75	M
2013	29.51	0.74	M	29.23	0.73	M	29.60	0.74	M
2014	32.64	0.82	M	30.31	0.76	M	32.04	0.80	M
2015	23.02	0.58	M	17.05	0.43	L	20.22	0.51	M
2016	21.10	0.53	M	15.50	0.39	L	36.00	0.90	M
2017	30.8	0.77	M	28.56	0.71	M	32.97	0.82	M
2018	32.5	0.81	M	31.3	0.78	M	31.66	0.79	M
2019	25.9	0.65	M	27	0.68	M	27.8	0.70	M
Standards: 40 µg/m3									

Cont...

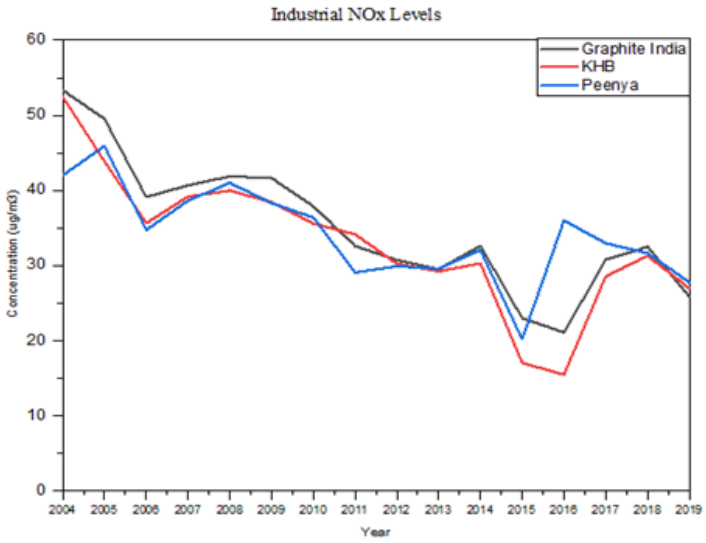


Fig No. 2 Industrial Areas: NO_x Levels, EF and Air Quality Levels

Residential Areas

From Table No. 3 and Fig No. 3 it can be observed that, in AMCO Batteries, there was an increasing trend from year 2005 &reached a peak of 9.4% by year 2008-2009. A sharp increase of 11.6% was seen in year 2014, the trend started decreasing and dropped by 38.5% in the year 2016, a sudden increase of about 42.7% was observed in the year 2017. The trend started decreasing later on.In Yeshwanthpur region, it has been an increasing trend from the year 2005 & reached a peak by the year 2008-2009 with an increment percentage of 10.4%. A surge of 8.06% was observed in year 2014, later the trend started decreasing and dropped by 26.7% in the year 2016, again there was an increase of 64.3% the next year i.e. 2017. The trend started decreasing later on.

Table No. 3Residential Areas: NO_x Levels (Annual Average), EF and Air Quality Levels

Year	AMCO batteries			Yeshwanthpur		
	Levels	EF	Air quality	Levels	EF	Air quality
2004	51.12	1.28	H	No Data	-	-
2005	44.16	1.10	H	No Data	-	-
2006	36.19	0.90	M	36.43	0.91	M
2007	38.01	0.95	M	39.08	0.98	M
2008	39.97	1.00	M	40.71	1.02	H
2009	38.26	0.96	M	40.69	1.02	H

2010	34.50	0.86	M	37.20	0.93	M
2011	31.16	0.78	M	34.34	0.86	M
2012	30.91	0.77	M	30.66	0.77	M
2013	29.21	0.73	M	29.61	0.74	M
2014	32.87	0.82	M	32.19	0.80	M
2015	20.13	0.50	L	21.73	0.54	M
2016	20.20	0.51	M	22.60	0.57	M
2017	35.30	0.88	M	35.10	0.88	M
2018	32.16	0.80	M	32.00	0.80	M
2019	28.16	0.70	M	28.00	0.7	M
Standards: 40 µg/m^3						

Fig No. 3Residential Areas: NO_x Levels, EF and Air Quality Levels

Sensitive Areas

From Table No. 4 and Fig No. 4 it can be observed that, In Bangalore University region, the data set had values from the year 2011 after setting up of the Air quality monitor in that region. Ever since the trend has been decreasing from the year 2011 till 2016, later on the trend showed an increase by 47.7% and remained the same for 2017&2018. The trend later on started decreasing.In Victoria Hospital region, trend has been decreased from the year 2004-2006 by 29.74%. Later it has increased by 15.12% by 2008-2009. A surge of 36.53% was observed in year 2017. Then later on the trend started decreasing.

Table No. 4Sensitive Areas: NO_x Levels (Annual Average), EF and Air Quality Levels

Year	Bangalore university			Victoria hospital		
	Levels	EF	Air quality	Levels	EF	Air quality
2004	No Data	-	-	50.00	1.25	H
2005	No Data	-	-	41.76	1.04	H
2006	No Data	-	-	35.13	0.88	M
2007	No Data	-	-	38.47	0.96	M
2008	No Data	-	-	40.46	1.01	H
2009	No Data	-	-	37.65	0.94	M
2010	No Data	-	-	33.40	0.84	M
2011	18.46	0.46	L	26.37	0.66	M
2012	17.34	0.43	L	29.89	0.75	M
2013	18.30	0.46	L	28.75	0.72	M
2014	16.38	0.41	L	30.54	0.76	M
2015	21.13	0.53	M	22.57	0.56	M
2016	17.50	0.44	L	23.00	0.58	M
2017	33.30	0.83	M	33.30	0.83	M
2018	33.50	0.84	M	31.75	0.79	M
2019	25.50	0.64	M	25.00	0.63	M
Standards: 40 µg/m3						

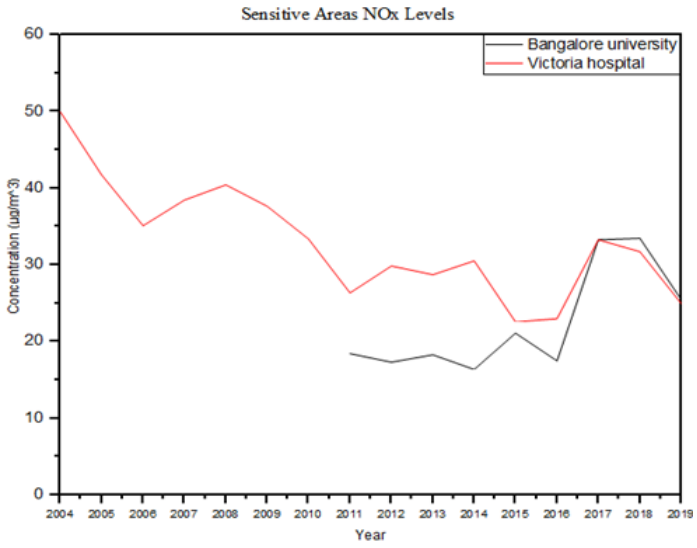


Fig No. 4 Sensitive Areas: NO_x Levels, EF and Air Quality Levels

Analysis of the Effectiveness of the Control Measures on NO_x Levels

Analysis of NO_x from three areas i.e. Industrial, Residential & Sensitive Areas shows that the levels of NO_x in years '2004-2006' was decreasing wherein the values exceeded the standard value of 40 $\mu g/m^3$in years 2004&2005.One of the reason contributed for the decrease is that, an action plan had been prepared by the Government wherein new three wheelers in Bangalore had to be registered only with Bifuel mode. Also for the existing 3 wheelers time span was given upto March 2005 to switch over to Bifuel mode.(KSPCB 2003- 2004)This was done to encourage LPG as an alternative fuel for Autos which were growing in numbers as per Table No. 5.Also, two continuous ambient air quality monitoring stations were established, one at Sanegoravanahalli and the other at city railway station.And sixmanualambient air quality stations at KHB, AMCO Batteries, Yeshwanthpur, Peenya, Graphite India, Victoria hospital. (KSPCB 2003- 2004). This year KSPCB started to regulate discharge of air emissions from Industries and factories through Water & Air Acts by issuing consents. Conditions such on the emission standards were imposed, clear directions on maintenance of pollution control systems, stack emission standards & submission of reports were to be specified in the consent order (KSPCB 2003- 2004). Laterin all the three areas, there was a spikein the years 2008-2009.The number of registered vehicles kept increasing from 2004, particularly over the years 2007-2009 almost 5.46 lakh new vehicles were registered as per Table No. 5 and Fig No. 5.This value is being complemented by the increase in population growth rate by 4.10% between the years 2005 to 2010 (As per world population review). As motor vehicle exhaust emissions area major contributor to NO_x, this noticeable increase in vehicular traffic could have contributed to the significant increase in level in all areas till 2009.

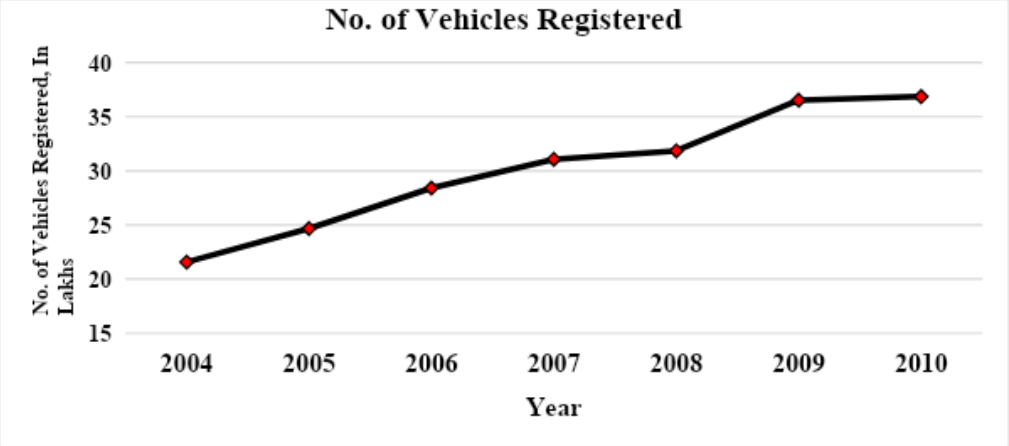
Table No.5 Vehicle Registrations in Bangalore

Year	2wheeler	Cars	Autos	Buses	Trucks	Tractors	Others	Total Vehicles (In lakhs)
2004	15.86	3.36	0.74	0.34	0.68	0.20	0.28	21.57
2005	18.11	3.87	0.80	0.37	0.85	0.23	0.31	24.67
2006	20.74	4.54	0.91	0.39	0.92	0.29	0.46	28.41
2007	22.32	5.27	0.95	0.48	1.10	0.31	0.45	31.07

2008	22.64	5.53	0.96	0.49	1.19	0.32	0.54	31.85
2009	26.08	6.46	1.06	0.42	1.29	0.32	0.69	36.53
2010	25.47	7.24	0.93	0.73	1.38	0.13	0.78	36.86

Source: Bangalore traffic Police website& RTO, bangaloretrafficpolice.gov.in

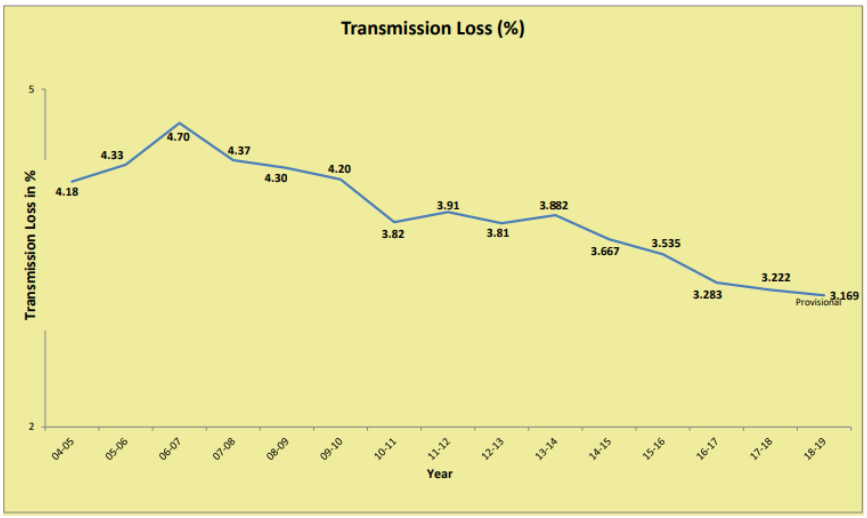
Fig No. 5 Vehicle Registrations in Bangalore



The pollution trend started decreasing later on from 2009, there were a few initiatives taken by the Karnataka State Pollution Control Board such as, ban on 10yr-old commercial vehicles and 15yr-old private vehicles.Also it can be noted from Fig No. 5that the number. of Motor vehicles have significantly increased and the pollution levels have reduced as per Fig No. 2, Fig No. 3 and Fig No. 4, one possible explanation for this could be the announcement of National Auto Fuel Policy (NAFP) in the year 2010 made BS- IV vehicles mandatory in 13 cities of which Bangalore was a part of it. The advantage of BS- IV is it reduces the NO_x and HC emissions by 23-60% on comparing with the emissions of BS- III.Initially it can be noted that the effects weren't so drastic but as years progressed the measures gave positive results in NO_x Emissions. Thedelay in the effects might be due to issues faced in the implementation stage (Emission Standards, 2009), such as exemptions for Taxi manufacturers & Garbage trucks weren't available of BS- IV. Another major reason might be people utilizing the loop hole in the registration process, NAFP had banned registration of new BS- III vehicles inside Bangalore, and hence people registered it outside Bangalore and started using the BS-III vehicles within the city limits. From the Fig No. 2, Fig No. 3 and Fig No. 4it can be noted that the reduction of NO_xin the years 2011 can be attributed to the beginning of the metro services on 20 Oct 2011 from Baiyappanahalli to MG road (BMRC). Even though so many initiatives proved efficient till the year 2013 there was a spike in the year 2014 in all three regions. It was mainly due to the power

outages faced by the city which ranged from 2-6 hours a day. The state of Karnataka faced a major power shortfall due to the sudden breakdown and in operation of the two thermal power plants in Bellary & Raichur. There was a shortfall of 950MW to the state because of this. Karnataka Government's decision on invoking Section 11 of The Electricity Act, which makes it mandatory for power generating firms to sell only to ESCOM was stayed by Kerala & Andra Pradesh High courts. Therefore private generators stopped the promised supply of 650 MW to the state. UPCL – Udupi Power Corporation Limited stopped 600MW supply as they faced coal shortages (Times of India).Also from Fig No. 6it can be seen that the Transmission Loss which started to decrease from 2007 saw an increase in 2013-2014(KPTCL Statistics). When the state was already facing power shortages, this transmission loss got cumulated to the suffering and hence, people and companies were forced to depend on Diesel Generator (DG) Sets for power when power gets interrupted. Use of Diesel generator sets causes a lot of pollution especially NO_x pollution.

Fig No. 6 Transmission Loss Percentage



Source: KPTCL Statistics

In the year 2015, an initiative was taken up by KSRTC as per directives of the Government to take curb the pollution. The initiative was to run 10 Biofuel busses in the pilot project to check the effectiveness in reducing the pollution. The pilot project was successful as it reduced 5000 litres of diesel use in just one month and also reduced CO, CO_2, NO_x and PM. This shows a high

potential for bio-fuel from Jatropa plant to reduce pollution levels. But the problem was in the Jatropa farming, as it wasn't a farmer friendly crop. Firstly, machines cannot be used for picking the seeds and hence, labour became a demand. Secondly the leftovers of the plant cannot be used as an animal fodder as they are poisonous to animals. Hence, a very good alternative for diesel failed. Later on the trend was decreasing from year 2017in all the areas and the reasons attributed are,ban of sales of BS-III vehicles and introduction of BS-IV vehiclesacross the country has contributed a lot for the fall in NO_x levels (The Hindu, 2017). The implementation of BS- IV vehicles on a national wide scale has sealed the loophole discussed in the year 2009.In the same year it was decided to improvise inspection and maintenance of buses (KSPCB 2017-2018).Though there were increase and decrease in the trend over 15years, after 2005 the trend was always under the permissible levels 40 $\mu g/m^3$in all three regions.

II. SO_2 Levels

Sulphur dioxide (SO_2), a colourless, bad-smelling, toxic gas SO_2, is emitted during the burning of fossil fuels such as coal, oil, and diesel or other materials that contain sulphur. Sources include power plants, metals processing and smelting facilities, and vehicles. Diesel vehicles and equipment have long been a major source of sulphur dioxide.

Health Impact

Sulphur dioxide, can contribute to respiratory illness by making breathing more difficult, especially for children, the elderly, and those with pre-existing conditions. It also causes irritation of the eyes on exposure. Longer exposures can aggravate existing heart and lung conditions, coughing, aggravation of asthma, chronic bronchitis and respiratory tract infections.

Industrial Regions

SO_2 levels of industrial areas Graphite India, KHB and Peenya from 2004-2019 are shown in Table No. 6 and Fig No. 7. In Graphite India the levels have remained well below the standards all throughout the 15 years chosen for this study.In the year 2004 the levels was 8.75$\mu g/m^3$ which reduced by 1.37% the next year 2005. There was an increase by 161% in the year 2006 and later there was a decrease by 22.7% in the year 2007. The trend started decreasing till the year 2010 and it reached 16.5$\mu g/m^3$. There was an increase again in the year 2011 to 19.65$\mu g/m^3$ by 19%

and since 2012 it started decreasing by 89% till 2018 and has remained constant till the year 2019. KHB's SO_2 level was at 10µg/m^3 in the year 2004 and decreased by 12% in the year 2005. There was an increase by 116.3% in the year 2006 i.e. 19.06µg/$m^3$and it was the highest level recorded in the time period considered for this study. Then the trend saw a gradual decrease from the year 2007 to 2010 by 23.4%. There was an increase again in the year 2011 to 18.29µg/m^3 by 25.27%. Since then till 2017 there has been a decrease by 89% as it reached 2µg/m^3 and has remained constant till 2019.Peenya region's SO_2 levels have been decreasing and increasing from time to time. In the year 2004 the level was 9.28µg/m^3 and it decreased by 5% the following year. Again there was an increase in the year 2006 to a concentration level of 17.78µg/m3 i.e. 101.8% and decreased till the year 2008 by 16%. In the year 2009 it increased again by 6.76% and gradually started decreasing till 2017 by 87.44% and has remained constant since till 2019.

Table No.6 Industrial Areas: SO_2 Levels (Annual Average), EF and Air Quality Levels

Year	Graphite India			KHB			Peenya		
	Levels	EF	Air quality	Levels	EF	Air quality	Levels	EF	Air quality
2004	8.75	0.18	L	10.00	0.20	L	9.28	0.19	L
2005	8.63	0.17	L	8.81	0.18	L	8.81	0.18	L
2006	22.52	0.45	L	19.06	0.38	L	17.78	0.36	L
2007	17.41	0.35	L	16.41	0.33	L	17.24	0.34	L
2008	15.48	0.31	L	14.71	0.29	L	14.92	0.30	L
2009	16.57	0.33	L	14.83	0.30	L	15.93	0.32	L
2010	16.50	0.33	L	14.60	0.29	L	15.43	0.31	L
2011	19.65	0.39	L	18.29	0.37	L	15.79	0.32	L
2012	16.21	0.32	L	15.55	0.31	L	15.61	0.31	L

2013	15.04	0.30	L	14.00	0.28	L	14.83	0.30	L
2014	14.57	0.29	L	12.85	0.26	L	14.24	0.28	L
2015	4.95	0.10	L	4.69	0.09	L	5.05	0.10	L
2016	3.80	0.08	L	3.60	0.07	L	2.00	0.04	L
2017	3.8	0.076	L	2	0.04	L	2	0.04	L
2018	2	0.04	L	2	0.04	L	2	0.04	L
2019	2	0.04	L	2	0.04	L	2	0.04	L
Standards: 50 µg/m3									

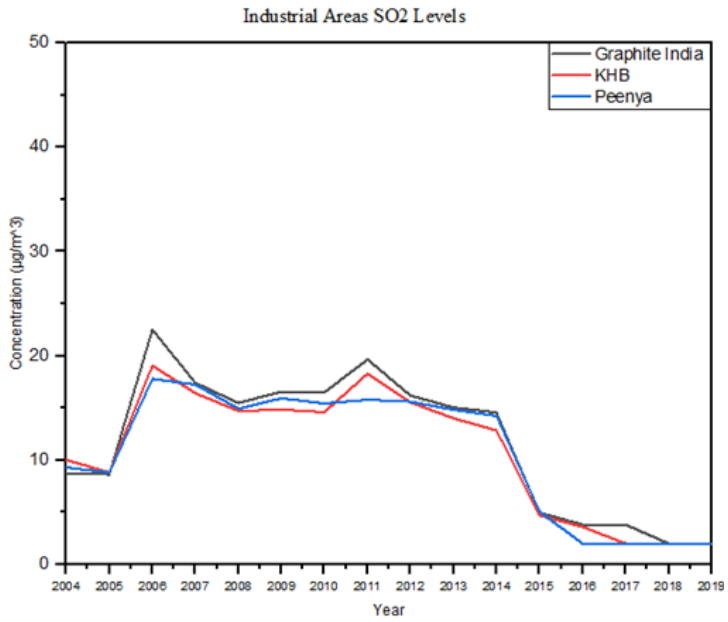


Fig No. 7 Industrial Areas: SO_2 Levels, EF and Air Quality Levels

Residential Areas

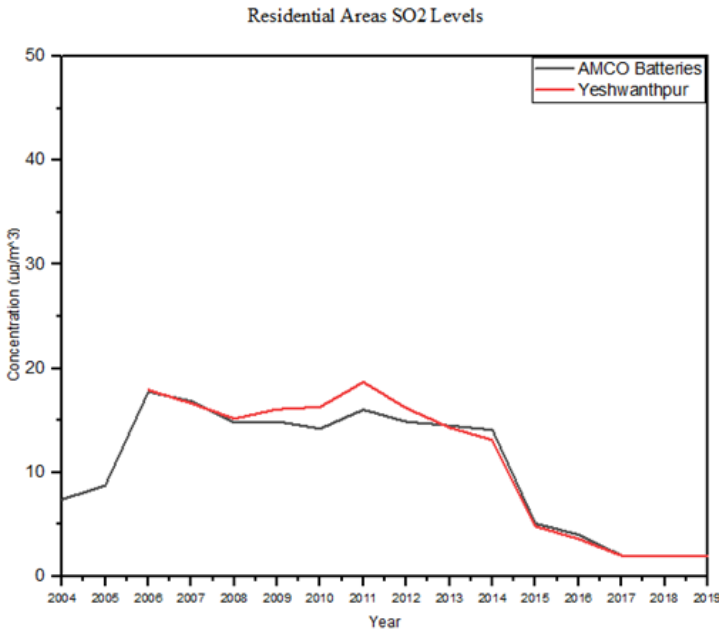
SO_2 levels in the residential areas, AMCO Batteries and Yeshwantpur are shown in the Table No. 7 and Fig No. 8. In AMCO Batteries, SO_2 levels in the year 2004 was 7.40µg/m^3. It increased till the year 2006 by 139.8%. Later it started decreasing till the year 2010 by 20%. It increased in the year 2011 again by 12.88%. Later on it started decreasing again and reached 2µg/m^3 in the year

2017 i.e. 87.5%. It remained constant since then till 2019.Yeshwantpur's SO_2 levels in the year 2006 was found to be 17.93µg/m^3 and decreased for the following two years by 15.4%. It started increasing in the year 2009 and continued till 2011 when it reached 18.68µg/m3 i.e. by 23.13%. The highest level in the assumed period was in the year 2011. Since then the levels started decreasing and reached 2µg/m^3i.e. reduced by 89.29% in the year 2017. Since then the levels were constant till 2019.

Table No. 7 Residential Areas: SO_2 Levels (Annual Average), EF and Air Quality

Year	AMCO batteries			Yeshwanthpur		
	Levels	EF	Air quality	Levels	EF	Air quality
2004	7.40	0.15	L	No Data	-	-
2005	8.75	0.17	L	No Data	-	-
2006	17.75	0.36	L	17.93	0.36	L
2007	16.85	0.34	L	16.64	0.33	L
2008	14.77	0.30	L	15.17	0.30	L
2009	14.88	0.30	L	16.08	0.32	L
2010	14.20	0.28	L	16.30	0.33	L
2011	16.03	0.32	L	18.68	0.37	L
2012	14.86	0.30	L	16.17	0.32	L
2013	14.50	0.29	L	14.32	0.29	L
2014	14.09	0.28	L	13.09	0.26	L
2015	5.09	0.10	L	4.81	0.10	L
2016	4.00	0.08	L	3.60	0.07	L
2017	2.00	0.04	L	2.00	0.04	L
2018	2.00	0.04	L	2.00	0.04	L
2019	2.00	0.04	L	2.00	0.04	L
Standards: 50 µg/m3						

Fig No. 8 Residential Areas: SO_2 Levels, EF and Air Quality Levels



Sensitive Areas

SO_2 levels in sensitive areas, Bangalore University and Victoria hospital are shown in the Table No. 8 and Fig No. 9. The SO_2 levels in the areas of Bangalore Universitywas constant from the year 2011-2015 at 8.05µg/m^3, no monitoring stations were available in the area to record data before 2011. This was the highest level recorded in this area. Later on it decreased in the following year by 61.7% as it touched 3.80µg/m^3 in the year 2016. In the years 2017-2019 the area recorded the lowest value at 2µg/m^3.The SO_2 level in Victoria hospital in the year 2004 was 7.52µg/m^3 and it increased till the year 2006 by 138.16%. Later the trend decreased till the year 2011 by 30.4% and there was a slight increase in the year 2012 by 5.22%. From 2012-2017 it decreased drastically by 84.73% and has remained constant till 2019.

The trend showed that the values fell below the prescribed levels of 50µg/m^3.

Table No. 8 Sensitive Areas: SO_2 Levels (Annual Average), EF and Air Quality Levels

Year	Bangalore university			Victoria hospital		
	Levels	EF	Air quality	Levels	EF	Air quality
2004	No Data	-	-	7.52	0.15	L
2005	No Data	-	-	9.04	0.18	L
2006	No Data	-	-	17.91	0.36	L

2007	No Data	-	-	16.77	0.34	L
2008	No Data	-	-	15.09	0.30	L
2009	No Data	-	-	14.39	0.29	L
2010	No Data	-	-	13.30	0.67	M
2011	8.05	0.16	L	12.45	0.25	L
2012	8.05	0.16	L	13.10	0.26	L
2013	8.05	0.16	L	12.59	0.25	L
2014	8.05	0.16	L	12.50	0.25	L
2015	8.05	0.16	L	4.83	0.10	L
2016	3.80	0.08	L	4.00	0.08	L
2017	2.00	0.04	L	2.00	0.04	L
2018	2.00	0.04	L	2.00	0.04	L
2019	2.00	0.04	L	2.00	0.04	L
Standards: 50 µg/m3						

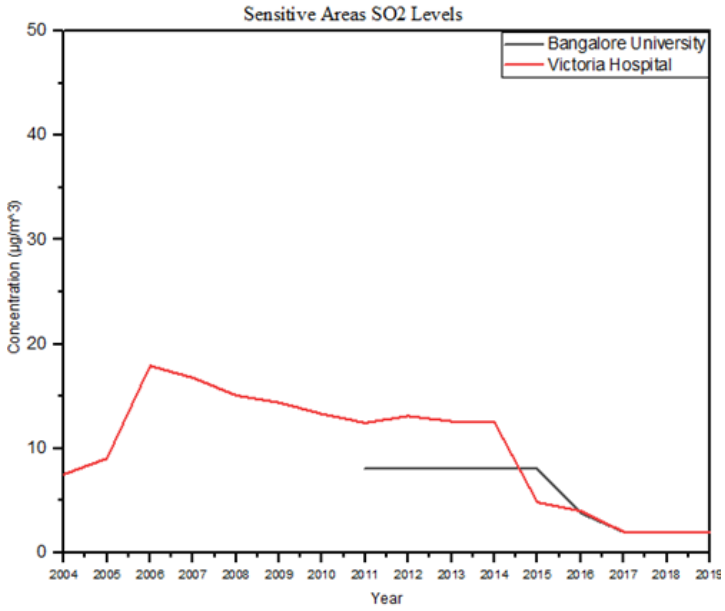


Fig No. 9 Sensitive Areas: SO_2 Levels, EF and Air Quality Levels

Analysis of the Effectiveness of the Control Measures on SO_2 Levels

Trend of SO_2 pollutant in all the 3 areas have been gradually increasing from 2004 and has reached the peak in 2006. Four meetings were held in New Delhi by the Central Pollution Control Board in the year 2004 to make decisions on the ways to reduce the amount of pollutants in some of the most populated cities of India that included Bangalore. The following decisions were approved in those meetings, Firstly approval for National Emission Standards for Pesticide

manufacturing industry. Secondly approval for the Emission Standards for sulphuric acid plants. One such plant Srinivasa Industrial chemicals is located in Peenya was established in 1990. Lastly, Approval for effluent and emission standards for petroleum oil refineries.One such refinery is Bhuruka Gases Ltd,established in 1974 and located in Doddanekkundi Industrial area.After all the regulations were made, the amount of pollutants decreased in small amounts but in the following year 2005, the sales of vehicles were increased by 14**%** as per Annual report KSPCB and there was an increase of SO_2level in the residential and sensitive areas (KSPCB 2005-2006) .The amount of SO_2 was recorded the highest in 2006.This was mainly due to traffic congestion in Bangalore and the Bangalore Metropolitan Region Development Authority made a decision to spend 6000 crores on development of Arterial ring roads, radial roads and 30000 crores on townships coming up at Hosakote, Ramanagar, Magadi and Kanakapura. Also in the year 2006, few decisions were made by the central board to reduce pollution in major polluted Indian cities as stated, the Board approved the Environmental Standards and Code of Practice for Pollution Prevention for Sponge Iron Plants. There's one such plant Prakash Sponge Iron Pvt Ltd located in Jayanagar. Also the board approved the proposal of National Emission Standards for Common Hazardous Waste Incinerator. To help Small Scale Industry units which have Diesel Generator Sets as the only source of power, the board had submitted proposal to Government to fix consent fee based on Kilo Volt Ampere rating rather than capital investment. In the year 2007 the Control Board started funding to create awareness on pollution control. The board approved an expenditure of Rs. 1, 75,000/- towards advertisements on televisions. Two such programs were aired on Doordarshan and India Today on how to control pollution in the environment. There was another meeting held on 12-04-2008by the Central Pollution Control Board and the following measures were announced like levying of sampling and analysis charges for the analysis of Water, Soil, Hazardous Waste and Air, limiting storage time for storage of incinerable hazardous wastes by the Hazardous Waste Treatment, Storage and Disposal Facility for Incineration Operators. These measures can be attributed to the decrease in pollution in the next years.Also a few months before the Deepavali festival which was celebrated on 17th October 2009 the KSPCB has displayed hoardings in all the districts in the State depicting the ill effect of bursting of crackers on environment and health of people. In spite of all these awareness measures on 21st October 2009 KSPCB reported an increase in air pollution by 7% from 15.48μg/m^{3}of the previous year to 16.57μg/m^3 (KSPCB,2008-2009) during this festive season as

compared to the previous year. A major problem started when the amounts of pollutants started increasing again in the residential areas in following year 2010. The main reason was due to the pollutants released by the vehicles were increasing and in the year 2010 Bharat Stage III was introduced nationwide and soon the amount produced started decreasing in sensitive area in the year 2011,whereas in the industrial and residential areas the SO_2 levels increased lightly. Hence, the government made a decision to scrap vehicles that are more than 10 years old due to the increase in pollutants.Namma metro was introduced in the year 2011, which considerably reduced the amount of pollutants from vehicles (KSPCB 2011-2012). In the year 2012, Latest Pollution Control Systems in small scale industries was made mandatory (KSPCB 2011-2012).Some types of air pollution control equipment applied to industrial applications and which utilize one or more methods of air pollutant removal or reduction mentioned above include: Scrubbers, Air filters, Cyclones, Electrostatic Precipitators, Mist Collectors, Incinerators, Catalytic reactors, Bio filters. About 65, 00,00 saplings were planted in the State to help greening of industrial areas and open spaces to create a green belt which acts as a Carbon sink, this success encouraged. The board, in the year 2011, had also encouraged Small Scale Industrial Establishment to adopt latest Pollution Control Systems by helping them to speed up the process of giving permissions and low interest loans. In the same year workshops on Awareness creation and promotion of Clean Development Mechanism in industrial sectors have been conducted for industrial sectors for better compliance with pollution Control laws and also for upgradation of pollution Control technologies. The sectors covered were Dairy industries, Sponge iron, plastics, hazardous waste recyclers and desiccated coconut industries. It also motivated Schools and NGO's to take up Greening initiatives. As the board achieved a success in the sapling plantation in the year 2011encouraged KSPCB to mandate a condition to provide 33% of the entire project area of the industry to be utilised for green belt and therefore about 13, 47,583 saplings were planted in the year 2013- 2014 (KSPCB 2013-2014). In the year 2013, CPCB updated the list of Red, Orange & Green category of activitieswith a view to bring uniformity in classification across the entire country and for the grant of consent, and other related activities (KSPCB 2013 – 2014). This was done to further reduce the pollutants and the effects are visibly noticeable in Fig No. 7, Fig No. 8 and Fig No. 9. The Central Pollution Control Board held a meeting on 26-06-2014 to discuss the strategies to even more reduce the pollutants and a few approvals made for the major polluted cities are, Approval of the

Development of Uniform National Air Quality Index and approval to revise the Environmental Standards for Brick Kilns. Few such kilns are located in Bangalore, such as Basant Brick Kiln located in Sarjapur road,Keerthi Brick Works located in Bannerghatta Road. In the year 2016 there was a decrease in the SO_2 trend. As per the directions of KSPCB, Board has taken steps to ban individual incinerators within the City limits, and announces a fine of 25000 for each case of burning (The Hindu, 2016). The meeting of the Central Pollution control Board on 08-07-2016 paved way for the following initiatives, awareness programmes were conducted in Schools and public places like Malls , initiated by the Central Board with the help of the State Government across India, introduction and awareness creation on Eco- friendly Ganesha Festival and Deepavali.In the year 2017,BS IV norms were enforced in the country which helped in decrease of SO_2 levels. SO_2 pollution drastically reduced in the year 2017. Another meeting was held on 06-05-2017 by CPCBto even more minimize the pollution and the following approvals were made:Approval of 'Pet Coke' as Approved Fuel under Section 2(d) of the Air (Prevention and Control of Pollution Act, 1981). Pet cokes are used in electrical power plants and cement kilns. They are typically high in heating values and they don't produce ash when burnt.They are used an alternative for coal because coal ash will be produced during the combustion of coal which is harmful when they settle in water bodies and also burning of coal leads to SO_2pollution(CPCB 2017).It can be concluded that due to control measures implemented by CPCB and KSPCB the levels of SO_2 pollutant for all the three areas in the period 2004-2019 were within the permissible limitsof 50 $\mu g/m^3$.

III. PM 10 Levels

PM10 refers to particulate matter that has diameter size of <10 microns. Automobile exhausts and road dust are considered as main sources of PM10. Table Nos. 9, 10 and 11shows the PM10 levels of 7 sites which were under consideration in Bangalore over the years 2004-2019.The Energy Research Institute (TERI 2007) conducted a study which concluded that 50% of Bangalore's PM10 is covered by dust. (TERI 2007) A multi transit rail system (MTRS) was proposed for Bangalore which improved the public transport system. It began its first construction phase of project in 2007. The city witnessed more widening of roads and construction activities also increased, which lead to increase in dust level in the city. This may be considered as large contribution to elevated levels of PM10 at various locations.

Health Impacts

These course particles have been identified to have direct harmful effect on morbidity and mortality rates. According to WHO's study, it confirmed that increase in PM10 by 10µg/m^3, 50µg/m^3 and 100µg/m^3 resulted in increased mortality rates of 1%, 3-6%, 10-17% in multiple cities. If this mortality rates are decoded to Bangalore's level of PM10, then expected increase in mortality rates in Graphite and YPR would be 10-17%, 8% in AMCO residential area and 6-9% in Peenya and Victoria (WHO 2008).

Table No. 9 Industrial Areas: PM 10 Levels (Annual Average), EF and Air Quality Levels

	Graphite India			KHB			Peenya		
Year	Levels	EF	Air quality	Levels	EF	Air quality	Levels	EF	Air quality
2004	72.21	1.20	H	61.67	1.03	H	67.09	1.12	H
2005	73.27	1.22	H	55.54	0.93	M	82.14	1.37	H
2006	157.78	2.63	C	54.21	0.90	M	77.86	1.30	H
2007	124.31	2.07	C	77.41	1.29	H	86.30	1.44	H
2008	161.01	2.68	C	70.86	1.18	H	123.32	2.06	C
2009	172.52	2.88	C	63.67	1.06	H	64.59	1.08	H
2010	122.00	2.03	C	56.00	0.93	M	74.00	1.23	H
2011	120.27	2.00	C	186.85	3.11	C	102.73	1.71	C
2012	156.39	2.61	C	175.38	2.92	C	104.08	1.73	C
2013	137.48	2.29	C	134.97	2.25	C	128.31	2.14	C

2014	230.32	3.84	C	99.29	1.65	C	132.79	2.21	C
2015	180.43	3.01	C	123.68	2.06	C	131.64	2.19	C
2016	189.00	3.15	C	109.00	1.82	C	117.00	1.95	C
2017	118.93	1.98	C	109.18	1.82	C	101.6	1.69	C
2018	114.5	1.91	C	105	1.75	C	84	1.40	H
2019	93.36	1.56	C	96.1	1.60	C	92.6	1.54	C
Standards: 60 µg/m3									

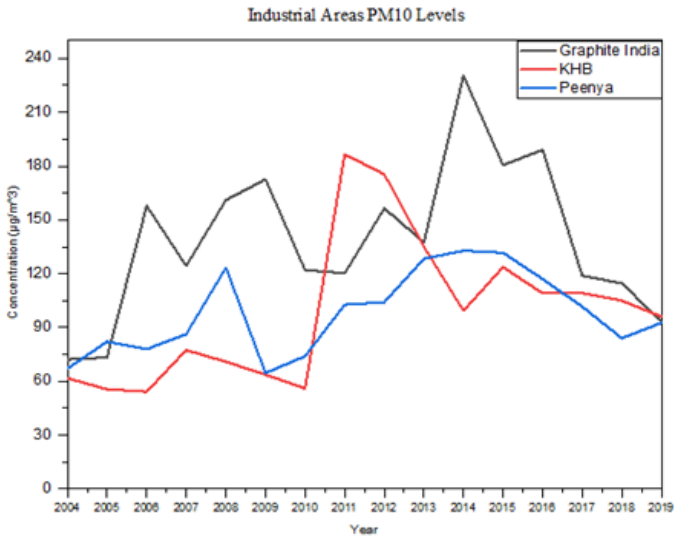


Fig No. 10 Industrial Areas: PM 10 Levels, EF and Air Quality Levels

Industrial Areas

From Table No. 9 and Fig No. 10, it can be observed that, in Graphite India in the years 2004 - 2009 there was an increasing trend from 120% to 288%. In the year 2010 a decrease of 84% was noted. In the years 2011 - 2016 again saw an increasing trend from 200% to 315% but from the year 2017 - 2019 a decreasing trend from 196% to 155% from the standards set were observed. In KHB Industrial Estate 2004 - 2006 there was a decreasing trend from 102% to 90% but in the year 2007 increase of 39% was noted. From the year 2008 - 2010 there was a decreasing trend

from 118% to 93% but in the year 2011 an increase of 217% can be observed. From the year 2012 - 2019 there was a decreasing trend from 291% to 160% from the standards set. In Peenya Industrial Estate 2004 - 2008 there was an increasing trend from 111% to 205% but in the year 2009 a decrease of 98% was noted. From the year 2010 - 2015 an increasing trend from 123% to 218% was noted. From the year 2016 - 2019 we saw a decreasing trend from 195% to 153% from the standards set.

Table No. 10Residential Areas: PM 10 Levels (Annual Average), EF and Air Quality Levels

Year	AMCO batteries			Yeshwanthpur		
	Levels	EF	Air quality	Levels	EF	Air quality
2004	83.87	1.40	H	No Data	-	-
2005	66.64	1.11	H	No Data	-	-
2006	40.15	0.67	M	54.54	0.91	M
2007	62.01	1.03	H	64.43	1.07	H
2008	76.11	1.27	H	103.72	1.73	H
2009	67.22	1.08	H	240.74	3.68	C
2010	65.00	1.12	H	221.00	4.01	C
2011	53.59	0.89	M	114.88	1.91	C
2012	138.49	2.31	C	111.24	1.85	C
2013	169.79	2.83	C	105.01	1.75	C
2014	228.26	3.80	C	114.51	1.91	C

Cont...

2015	135.74	2.26	C	128.22	2.14	C
2016	119.00	1.98	C	105.00	1.75	C
2017	88.00	1.47	H	88.40	1.47	H
2018	102.66	1.71	C	104.70	1.75	C
2019	91.00	1.52	C	79.50	1.33	H
Standards: 60 µg/m3						

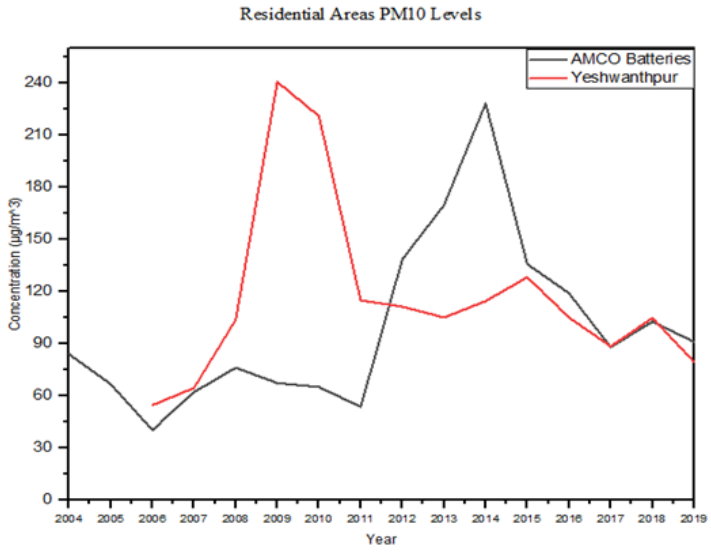


Fig No. 11Residential Areas: PM 10 Levels, EF and Air Quality Levels

Residential Areas

From Table No. 10 and Fig No. 11, in AMCO Batteries 2004 - 2006 there was a decreasing trend from 138% to 66% but in the year 2007 an increase of 47% was noted. The years 2008 - 2011 shows a decreasing trend from 126% to 88% whereas in the years 2012 to 2014 an increasing trend from 230% to 380% was noted. From the year 2015 - 2019 there was a decreasing trend from 225% to 151% from the standards set. In Yeshwanthpur, in the years 2006 - 2010 there was an increasing trend from 90% to 368% but from the year 2011 to 2013 a decreasing trend was observed from 190% to 175%. The years 2014 - 2015 an increasing trend from 190% to 213%

was observed. In the years, 2016 - 2019 there was a decreasing trend from 175% to 131% from the standards set was noted.

Table No. 11 Sensitive Areas: PM 10 Levels (Annual Average), EF and Air Quality Levels

Year	Bangalore University			Victoria Hospital		
	Levels	EF	Air quality	Levels	EF	Air quality
2004	No Data	-	-	57.56	0.96	M
2005	No Data	-	-	56.21	0.94	M
2006	No Data	-	-	65.89	1.10	H
2007	No Data	-	-	67.55	1.13	H
2008	No Data	-	-	66.14	1.10	H
2009	No Data	-	-	60.92	1.02	H
2010	No Data	-	-	59.00	0.98	M
2011	41.78	0.70	M	39.65	0.66	M
2012	40.61	0.68	M	101.56	1.69	C
2013	41.40	0.69	M	104.63	1.74	C
2014	46.29	0.77	M	121.66	2.03	C
2015	67.67	1.13	L	123.91	2.07	C
2016	113.00	1.88	C	102.00	1.70	C
2017	74.60	1.24	H	63.30	1.06	H

2018	70.00	1.17	H	70.16	1.17	H
2019	61.58	1.03	H	54.16	0.90	M
STANDARDS: 60 µg/m^3						

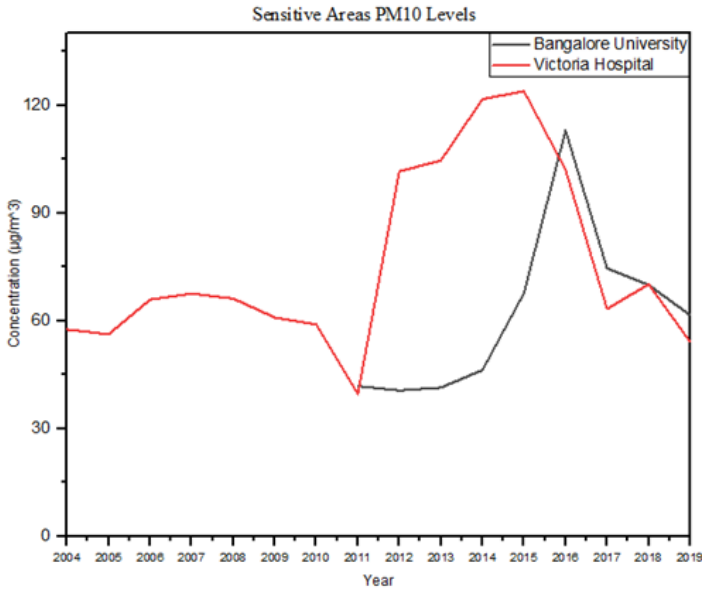


Fig No. 12Sensitive Areas: PM 10 Levels, EF and Air Quality Levels

In Bangalore University 2011 - 2016 there was an increasing trend from 68% to 188% but from the year 2017 - 2019 a decreasing trend from 123% to 101% from the standards set was observed. In Victoria Hospital 2004 - 2007 there was an increasing trend from 95% to 111% but from the year 2008 - 2011 a decreasing trend from 110% to 65% was noted but in the year 2012 to 2015 an increasing trend from 168% to 205% was detected. From the year 2016 - 2019 a decreasing trend from 170% to 90% from the standards set was noted.

Analysis of the Effectiveness of the Control Measures on PM10 Levels

From the Table No. 9 and Fig No. 10 it is clear that the industrial area of Graphite India, KHB Industrial Estate and Peenya Industrial Estate has seen alarmingly high levels of PM10 over the last 15 years (2004-19), with an air quality classification of critical in most of the years. The levels of PM10 were never below the recommended standard for the area over all the sixteen years. We can note that the levels of PM10 started to increase by many folds in all the areas from

2010 drastically. In the year2006 to help Small Scale Industry units which have Diesel Generator Sets as the only source fuel, the board had submitted a proposal to the Government to fix consent fee based on Kilo Volt Ampere rating rather than capital investment as then practiced, effect of this decision can be seen in the year 2007 in the industrial area of KHB. This step taken was not so successful in the industrial areas of Peenya and Graphite (KSPCB 2005- 2006). Construction work of Namma Metro Bangalore Phase 1 started in April 2007 (The metro rail guy), this added to the existing traffic congestion in Bangalore which was a major reason for increase in PM10 levels.From the Table No. 10 and Fig No. 11 it is evident that the PM10 levels in the residential areas of Yeshwanthpur and AMCO batteries is alarmingly high in the years (2008-2019) and (2012 -2019) respectively. 2008 onwards was the years where Indian economy saw a boost due to expansion of industries and IT companies due to which the need for more homes and offices was created which resulted in the construction dust which is one of the major reason of PM10. In the year 2011 there were many measures taken by the Board such as Greening of Industrial areas by creating a green belt. About 65, 00, 00 saplings were planted in the entire state. Workshops were conducted for industrial sectors for better compliance with pollution Control laws and also for upgradation of pollution Control technologies. Though these measures taken, there was still no decrease in PM10 levels but there was increase. These measures weren't successful in reducing PM10 Levels.Application of diesel oxidation catalyst (DOC) & diesel particulate filter (DPF) to Buses and DG sets of capacity greater than 12kW was introduced in the year 2011 (KSPCB 2011-2012). DOC & DPF are devices to reduce emissions from diesel engines, they treat the exhaust before releasing into the atmosphere. These don't have a major effect in reducing NO_x levels but are good in curbing the emissions of PM10 Levels.In the same year mandatory usage of latest Pollution Control Systems in small scale industries were imposed. This was a major help in reducing the PM10 levels in 2012 in the areas of Graphite and KHB. As in case of 2012 also took up Greening of industries and industrial areas in the State by planting about 1 crore saplings and promotion of Clean Development Mechanism in industrial sectors (KSPCB 2011- 2012). The board also initiateda survey of polluting activities in the state (KSPCB 2011- 2012).In the year 2011 it was observed that there was a huge increase in PM10 levels in AMCO batteries area, hence as a preventive measure to stop a sudden surge in the pollutants levels in the already high trend noticed, during the month of Deepavali KSPCB has displayed hoardings in all the areas in Bangalore depicting the ill effect of bursting of crackers

on environment and health of people.As in case of 2012 there were many awareness programs taken up by the board like awareness programmes in schools in involving NGO's to take up Green initiatives, bring out documentary films on environmental issues (KSPCB 2011-2012). In the years 2011 to 2012 KSPCB had increased the green cover by planting 1, 65,00,000 samplings in Bengaluru city where empty spaces are available on roadsides, industrial premises, and public parks also public awareness programmes were launched for air pollution control and proper vehicle maintenance (KSPCB 2011- 2012). India's GDP in 2014, or 38 per cent of India's total IT exports and created 73,000 new jobs in IT which clearly reflects in drastic increase of PM10 levels in IT areas like Graphite Indiadue to traffic congestion and new building construction (The Hindu Business Line, 2014). In some Industries old technology and infrastructure is still being used which are not efficient to reduce investment that generate a large amount of waste (KPCB Guidelines).Due to awareness programs done in 2012, the year 2013 saw many Engineering College & Other Educational Institution in Karnataka showing interest in taking up R&D Projects, monitoring of air quality, carrying out surveys and other related works. And Centre for Infrastructure, Sustainable, Transportation and Urban Planning (CiSTUP) has given a proposal to set up a Bengaluru Air Quality Monitoring Cell, which includes research on monitoring and modelling the pathways of Air Pollutants in the Urban Environment, develop Air Quality Index Air Quality Management System for Bengaluru and also carryout epidemiological research on Air Quality on human health and capacity building. In 2016 as per the directions of CPCB, Board has taken steps to ban individual incinerators within the City limits, and announces a fine of 25000 for each case of burning. This measure was very effective in reducing PM10 levels, which can be seen in all the areas. Steps topromote battery operated vehicles like operation of e-rickshaw vehicles the Government accorded sanction for issue of 5000 Electric Auto rickshaw permits under "Karnataka Electric Vehicle Policy 2017" (Karnataka Road Transport ministry).In the year 2018, Centre for Science & Environment,CSEhad found that pollution level has risen 30% during the usage of Diesel Generator sets. Uninterrupted 24*7 power supply is the clear option to reduce the use of Diesel Generator sets at various Industrial establishments. The Lack of effective policies and poor enforcement drive (Conserve-Energy) allowed many industries to bypass laws made by the pollution control board and in most industrial townships, unplanned growth of industries were seen. Bangalore IT sector contributed $45 billion to

Even in Sensitive areas major chunk of PM10 Pollutant comes from Vehicles and construction dust as noted in the years 2015- 2018 in Bangalore University & 2012- 2017 in Victoria hospital as per Table No. 11 and Fig No. 12. Therefor to mitigate this,as per road Transport ministry's new CMVR- Central Motor vehicle rules 2018, it is mandatory to carry construction debris or other goods in a closed container or at least covered by plastic sheets. The BBMP and Government of Karnataka had taken up the responsibility to make sure this is achieved. Other than this sweeping the streets using mechanical suction vacuum cleaner and sprinkling water to suppress the dust emission was started in the year 2019 (Deccan chronicle).KSPCB also handles Facebook and twitter pages to provide real time information and spread awareness as social media is a strong tool to spread awareness.There are many groups initiated by public like 'Jhatkaa' which has almost 4,000 common people involved in Campaigns against air pollution and campaigns for clean air quality in the city has been the focus of Jhatkaa.org for three years. They are implementing small as well as big campaigns (Bengaluru Citizen Matters)

5. Conclusions

Trend analysis was done using PYTHON open source software.The analysis of control measure pointed the fact that, effective planning and creating awareness is the key to reduce air pollution in Bangalore. Traffic control can be achieved by proper planning and widening of the existing roads. Standardization of speed breakers is also the need of the hour. The role of public and industries in adhering to standards can be greatly improved by creating awareness and strict control and monitoring techniques must be enforced. Non - compliance must be strictly dealt with.

6. Limitations

Nature of pollutants tends to differ spatially due to factors such as meteorological conditions and wind speeds. Hence, the present study can be improvised by using spatial interpolation techniques using special softwares like Arc GIS and GIS by creating a valid prediction surface.

References

- Bengaluru Citizen Matters: https://bengaluru.citizenmatters.in/organisations-working-on-air-quality-in-bangalore-23290

- BMRC: www.bmrc.co.in

- Conserve- Energy: https://www.conserve-energy-future.com/causes-effects-of-industrial-pollution.php

- CPCB, Annual Report 2017

- Deccan Chronicle: https://www.deccanchronicle.com/nation/current-affairs/010519/time-to-clear-the-air-bengalurus-action-plan-to-beat-pollution.html

- Karnataka Road Transport ministry: Five-year plan agenda by Karnataka state Road Transport Ministry

- Karnataka 2016: Districts, Cities, Towns and Outgrowth Wards – Population Statistics in Maps and Charts,*February 2016*

- KPTCL Statistics: https://kptcl.karnataka.gov.in/storage/pdf-files/statistics/Tr.%20Loss.pdf

- KSPCB, Annual report 2003- 2004

- KSPCB, Annual report 2005- 2006

- KSPCB, Annual report 2008-2009

- KSPCB, Annual report 2011- 2012

- KSPCB, Annual report 2013- 2014
- KSPCB, Annual Report 2017-2018
- TERI 2007," Mobility for Development (M4D) - A Case Study of Bangalore," *World Business Council for Sustainable Development (WBCSD)*, Bangalore
- The Hindu Business Line, 2014: https://www.thehindubusinessline.com/info tech/%E2%80%98Bangalore-will-become-the-world%E2%80%99s-largest-IT-cluster-by -2020%E2%80%99/article20909098.ece
- The Hindu, 2016: https://www.thehindu.com/news/national/NGT-bans-open-waste-burning/article16928115 .ece
- The Hindu, 2017: https://www.thehindu.com/news/national/sc-orders-freeze-on-sale-registration-of-bs-iii-v ehicles-from-april-1/article17728104.ece
- The metro rail guy: https://themetrorailguy.com/bangalore-metro-phase-1-information-map/
- Times of India: https://timesofindia.indiatimes.com/city/bengaluru/Karnataka-to-face-two-hour-long-pow er-cuts-daily/articleshow/34706488.cms
- World Health Organisation, 2008, "Air Quality and Health," World Health Organisation, Geneva

- World population review: https://worldpopulationreview.com/world-cities/bangalore-population/