ISSN : 2454-9150 Vol-09, Issue-01, Apr 2023

The Air Quality Assessment in Peenya Industrial Area, Bengaluru

Mahantesh Laxman Shivaratri[1], Rekha H. B.[2]

[1]PG Student, [2]Associate Professor, Dept. of Civil Engineering, UVCE, Bangalore University, Bengaluru, 560 056, Karnataka, India

Abstract **Air is one of the essential natural resources for the existence and survival of entire life on planet earth. All forms of life that include plants and animals depend on air for their basic survival. So in this paper we studied air pollution in Peenya Industrial Area, Bengaluru, which is one of the industrial area in Bengaluru. This metropolitan area has been experiencing worsening environmental conditions as a result of its fast development. The objective of this paper was to critically analyze the air pollution trend from 2013-2022 at Peenya Industrial Area, Bengaluru on various meteorological factors that contribute to air pollution. This study was to undertake to evaluate the trends of air quality for the past 10 years. The AQI and EF are calculated and compared with standards and state levels of pollution in the study area. We predicted the future trends of various pollutants such as Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Suspended Particulate Matter (PM_{10}), Suspended Particulate Matter ($PM_{2.5}$), and NH_3. By using a data analytics Time-series modeler for forecasting we predicted the future values of the pollutants. The result shows that there is a drastic increase in PM_{10} concentration levels, and $PM_{2.5}$ are increased showing the increased pollution in Peenya Industrial Area. The air quality status was found to be varying from moderate to satisfactory for the sensitive group category from the health impact point of view.**

Key Words: Air Pollution, Trend, AQI, EF, SPSS, Multilayer, Time series Modeller etc,

I. INTRODUCTION

Air is one of the most essential natural resources for the existence and survival of entire life on planet earth. Air is essential for all living things, including plants and animals. Thus, all living organisms need a good quality of air that is free of harmful gases to continue their life. According to the world's worst polluted places by Blacksmith Institute in 2008, two of the worst pollution problems in the world are urban air quality and indoor air pollution[1].

With the increasing population, automobiles and industries are polluting the air at an alarming rate. Both short-term and long-term health impacts from air pollution are possible. Eye, nose, and throat irritation, headaches, allergic responses, and upper respiratory infections are some of the short-term health impacts. Lung cancer, brain damage, liver disease, kidney illness, heart disease, and respiratory disease are a few long-term health impacts. The effects of air pollution are observed to be worse among the elderly and young children. Additionally, it adds to the ozone layer's reduction, which shields the planet from the sun's ultraviolet rays. The development of acid rain, which damages plants, soils, rivers, and wildlife, is another unfavourable result of air pollution. Haze, eutrophication, and global climate change are a few other environmental repercussions of air pollution. Hence, air pollution is one of the most alarming concerns for us today[1].

Bengaluru's Peenya industrial region, one of the oldest and largest in Southeast Asia, was founded in the late 1970s by the Karnataka Small Industries Development Corporation. However, the region's high air pollution levels are a result of the concentration of industrial facilities. The Peenya industrial cluster, which has approximately 2,000 businesses, is classified as a badly polluted area and ranks 32nd overall on the Comprehensive Environmental Pollution Index (CEPI) (severe pollution is indicated by a score between 50 and 70). Of the 2,101 industries, 334 are in the red category, meaning they contribute the most to pollution, while 473 are in the orange category, according to the Karnataka State Pollution Control Board (KSPCB). Engineering with surface treatment, spray painting, pharmaceutical research and development, service stations, electroplating, garment washing, dyeing, and printing industries are the most polluting. There is no evidence that the Peenya industrial region is likewise polluted with hazardous heavy metals, despite the fact that the pollution levels in the entire city have increased as a result of it. According to the standards set for ambient air quality, lead,

 DOI : 10.35291/2454-9150.2023.0083

ammonia, sulphur dioxide, nitrogen dioxide, and particulate matter are the main air pollutants monitored in the industrial cluster.

The main objectives of the study are (1) Data collection from the Karnataka State Pollution Control Board for the study region in Peenya Industrial Area, Bengaluru on air pollutants such as NH_3, PM_{10}, $PM_{2.5}$, NO_2, and SO_2. (2) Data collection from the Indian Meteorological Department (IMD), including temperature, relative humidity, wind speed, and rainfall. (3) Calculation of Air Quality Index (AQI) and Exceedance Factor (EF) for the study area. (4) Analysis of Data and achieving the best prediction model for the obtained data using SPSS software. (5) To study health implications caused by different air pollutants and suggest remedial measures.

Category	Industry classification & Numbers			Total Number of Industries
	Large	Medium	Small	
Red	40	14	280	334
Orange	58	26	389	473
Green	100	79	1115	1294
Total	198	119	1784	2101

II. Study Area

Bengaluru is the capital of Karnataka and one of the major metropolitan cities for industrial expansion. It is situated on the Deccan plateau in Karnataka's south-eastern region. The metropolitan city has a total area of 741 km^2. It is India's largest city and one of the fastest growing, with a population of about 9,645,551 according to the 2011 census and it is located at 12.967 ^{0}N and 77.567 ^{0}E. It is the nation's leading information technology exporter and is popularly known as the "Silicon Valley of India" and also the "Garment capital of India". Due to its high average elevation of 900 m (2,953 feet), the city usually enjoys a more moderate climate throughout the year, compared to other cities in India. The Figure 1 shows the location of the map of the study area [11].

The below maps figure 1 and figure 2 showing the geographical boundaries of the industrial cluster identified and the impact zone (2 Sq.kms), and the location of major industries in the cluster and the surrounding villages of the impact zone are presented in Maps I to III. Peenya is the name of an Industrial area Estate in Bengaluru city, Karnataka, India. It is considered to be one of the oldest and largest Industrial areas in Southeast Asia. Peenya lies on Bengaluru- Mangalore highway (NH-48). Small, medium, and large-scale industries are all housed there. Peenya industrial estate was established in the late 1970s by the Karnataka Small Scale Industries Development Corporation (KSSIDC) as stage I, II, and III. Karnataka Industrial Area Development Board (KIADB) developed I, II, III, and IV Phase Industrial Areas and the total extent of the area is around 40 sq Km. To promote and protect small-scale entrepreneurs, Peenya Industries Association was established in the year 1979[11].

It is considered to be the biggest in Asia with about 800 sheds constructed for housing the small units. The industrial area is known for manufacturing and production engineering, electrical goods such as CNC machines tools or die-casting dies and moulds of transformers, motors and generators, textile(silk), hydraulics and machine tool industries. Popular companies in India like 3D concept tooling, ace designers, Wipro technologies, ABB, and Bharat Fritz Werner, have their factories at Peenya. The Peenya Industrial Estate and Area have employed around 5.0 lakh people out of which 2.5 lakh is women employees.

Table 1: Total Number of Industries in Peenya Industrial Area

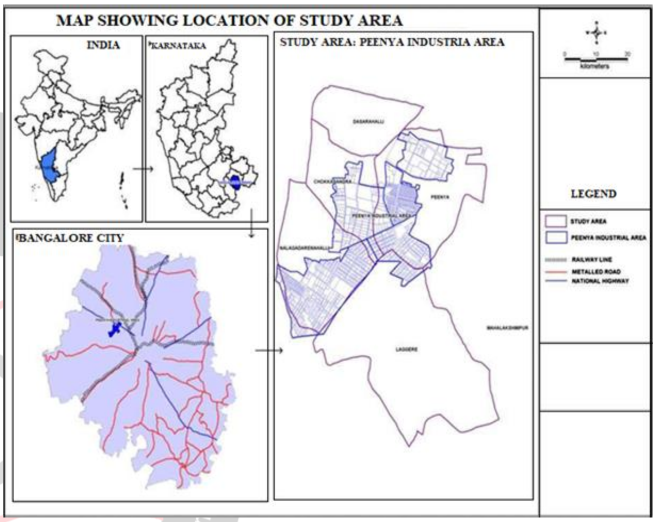


Figure 1: Shows the Location of the Map of the Study Area (**Source:** K-GIS https://kgis.ksrsac.in/kgis/downloads.aspx)

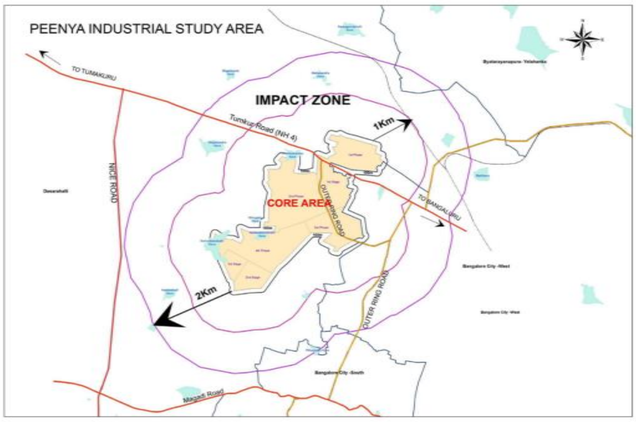


Figure 2: Showing Peenya Industrial Study Area

The above table 1 reveals that there are 54 Large & Medium Red category industries and 84 Large & Medium Orange category industries in the study area and 280 & 389 Small Red & Orange category industries respectively which are significant from a pollution point of view. The major activities are engineering with surface treatment, spray

 DOI : 10.35291/2454-9150.2023.0083

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-09, Issue-01, Apr 2023

painting, R & D on pharma, service station, electroplating, garment washing, dyeing, and printing industries[11].

III. MATERIALS AND METHODOLOGY

3.1 Air Quality Data

The air quality data is collected from Karnataka State Pollution Control Board (KSPCB). KSPCB started functioning after its constitution by the State Government on 21/09/1974. Since 2004, the Head Office of the State Board is functioning at 'Nisarga Bhavan', Thimmaiah Road, 7th 'D' Cross, Shivanagar, Bengaluru- 560 079. Three Zonal Offices and ten Regional Offices of the Board are located in Bengaluru. The Central Pollution Control Board (CPCB) located at 'Parisara Bhavan', No.49, Church Street, Bengaluru. One Zonal Office and Regional Office are located in Urban Eco Park, Peenya, Bengaluru.

3.1.1 Ten years of monthly average and Ten years of Annual Average were collected for the Continuous Ambient Air Quality Monitoring Stations (CAAQMS) at "Nisarga Bhavan", Thimmaiah Road, 7th 'D' Cross, Shivanagar, Bengaluru- 560 079.

1. Urban Eco Park, KSPCB Office, Peenya

The air pollutants such as SO_2, NO_2, PM_{10}, $PM_{2.5}$ and NH_3 data were collected from 2013-2022.

3.2 METEOROLOGICAL DATA

The monthly average of Ten years of meteorological data has been collected for the following parameters from Indian Meteorological Department (IMD) (Website: http://dsp.imdpune.gov.in/)

1. Annual Average Rainfall
2. Mean Temperature
3. Mean Relative humidity
4. Wind velocity.

1.3.3 DATA TRANSFORMATION

Normalization of samples: For trend analysis and forecasting of a particular pollutant is done by using Statistical Package for Social Sciences (SPSS) Software. For that purpose in this study used normalized data for modelling purpose. The data model is susceptible to overflows in the network because of irregularities in the values or weights. To remove these irregularities the range transformation method of normalizing all the values in the range of [0, 1] is applied. The range normalization function is as below:

$$X_{Normalization} = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

Where, X normalization is the normalized value, X_i is the i^{th} value passed, and X_{min} and X_{max} are the minimum and maximum value for X_i value.

3.3 METHODOLOGY

The Figure 3 shows the complete methodology adopted in the present study.

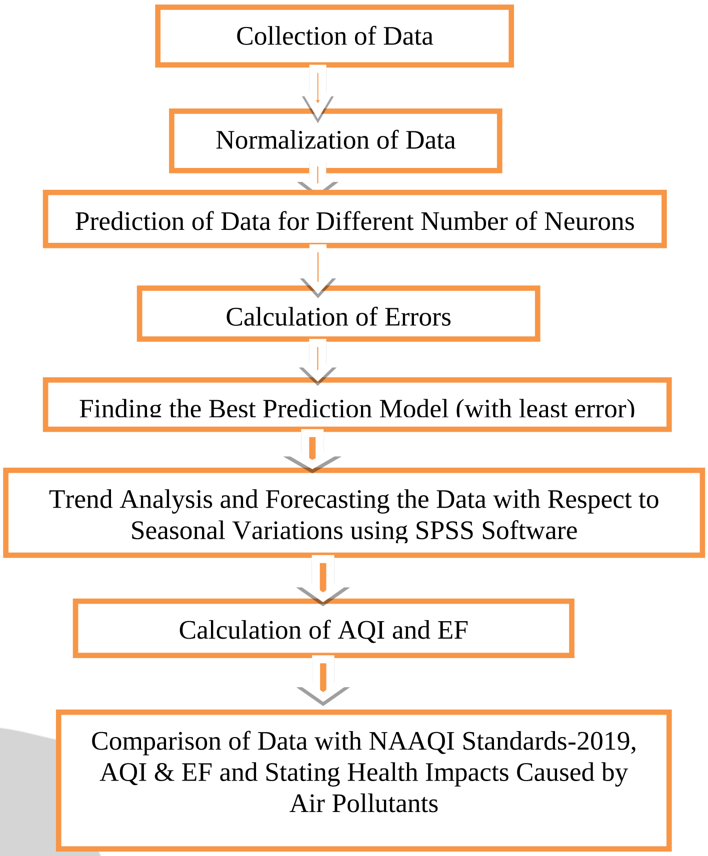


Figure 3: Methodology Flow Chart

3.3.1 CALCULATION OF AQI (AIR QUALITY INDEX)

Generally, only when at least three pollution codes are provided, one of which must be either $PM_{2.5}$ or PM_{10}, is the air quality index (AQI) offered. Otherwise, analysing AQI is not possible; correspondingly a minimum of 16 hours of data is compulsorily required for calculating the sub-index. The index of specific pollutants is derived mainly from the physical measurement of pollutants like SO_2, NO_2, PM_{10}, $PM_{2.5}$ and NH_3. The AQI is calculated using a variety of equations and methodologies. A mathematical algorithm is used in the current study to assess the air quality index (AQI) for each location within the study area.

$$\text{AIR QUALITY SUB} - \text{INDEX } (AQI_{SUB}) = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}} * (C_p - BP_{Lo}) + I_{Lo}$$

Where,

I_{Hi} : AQI with respect to BP_{Hi}

I_{Lo} : AQI with respect to BP_{Lo}

BP_{Hi} : Maximum breakpoint concentration

BP_{Lo} : Minimum breakpoint concentration

C_p : Actual concentration of pollutant

Briefly, an AQI is useful for (i) the general public to know the air quality in a simplified way, (ii) a politician

 DOI : 10.35291/2454-9150.2023.0083

ISSN : 2454-9150 Vol-09, Issue-01, Apr 2023

to invoke quick actions, (iii) a decision maker to know the trend of events and to chalk out corrective.

For calculation of AQI sub-index, we need breakpoints those breakpoints are find out by using Table 2. After calculating AQI sub-index, AQI values are find out from the sub-indexes of different pollutants. Maximum of all different pollutant sub-index values are considered as AQI. Based on that the health effects are stated by using table 3.

Table 2: Breakpoints for AQI Scale 0-500

AQI Category (Range)	PM_{10} 24-hr (µg/m³)	$PM_{2.5}$ 24-hr (µg/m³)	NO_2 24-hr (µg/m³)	O_3 8-hr (µg/m³)	CO 8-hr (mg/m³)	SO2 24-hr (µg/m³)	NH_3 24-hr (µg/m³)	Pb 24-hr (µg/m³)
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2	41-80	201-400	0.6-1.0
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800	801-1200	2.1-3.0
Very Poor (301-400)	351-430	121-250	281-400	209-748	17.1-34	801-1600	1201-1800	3.1-3.5
Severe (401-500)	430+	250+	400+	748+	34+	1600+	1800+	3.5+

(**Source:** http://www.cpcbenvis.nic.in)

Table 3: Health Statements for AQI Categories

Sl. No	Range	Category	Possible Health Impacts
1	0-50	Good	Minimal Impact
2	51-100	Satisfactory	Minor breathing discomfort to sensitive people
3	101-200	Moderate	May cause breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease Children and older adults
4	201-300	Poor	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease
5	301-400	Very Poor	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases
6	>401	Severe	May cause respiratory effects even on healthy people and serious health effect on people with lung/heart diseases

(**Source:** http://www.cpcbenvis.nic.in)

3.3.2 CALCULATION OF EXCEEDANCE FACTOR (EF)

"Proportion of the yearly average concentration of a poll utant and its particular standard" is what EF stands for.

The Concentration ranges for the different pollutants, based on the Notification Standards and the area classes described by the Central Pollution Control Board (CPCB), can be calculated through an Exceedance Factor (EF) as follows;

$$\text{Exceedance Factor (EF)} = \frac{\text{Observed annual mean concentration of a creterion pollutant}}{\text{Annual Standard for the respective pollutant and area class}}$$

Based on the equation, air pollution can be classified into four criteria as shown in table 4;

Table 4: Standards of pollutant Levels based on EF range

Level of Pollution	EF Range	Label
Critical Pollution	>1.5	C
High Pollution	1.0-1.5	H
Moderate Pollution	0.5-1.0	M
Low Pollution	<0.5	L

3.3.4 CREATING A MULTILAYER PERCEPTRON NETWORK

From the menu of SPSS software choose:

Analyze > Neural Networks > Multilayer Perceptron...

1. One variable is selected as dependent variable the one which has to be predicted.
2. All other variables are selected as factor or covariate and these are considered to be independent variables.

Normalized option is used because its values range from 0 to 1.

Partitions

For developing the ANN model, the data were divided into two sets. 70% of the data for the whole training set, followed by 30% of the whole data for testing [3].

Architecture

For this study, automatic architecture is used so that the required number of neurons can be assigned. Automatic architecture selection uses the default activation functions for the hidden and output layers [3].

The number of Hidden Layers:

A multilayer perceptron can have one or two hidden layers. For this study, one hidden layer is used with the number of hidden neurons 2, 4, 6, 8, 10, and 12. The output with the neuron number which has less error is considered to be the best output. The errors such as Mean Absolute Error, Root Mean Square Error and Relative Errors are calculated by using below formulae.

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|P_i - M_i|$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_i - M_i)^2}$$

$$RE = \frac{1}{n}\sum_{i=1}^{n}\frac{|P_i - M_i|}{M_i}$$

Training

Batch training is often preferred because it minimizes the total error. It is most useful for "smaller" datasets. Gradient descent is used as an optimization algorithm; the initial learning rate and the momentum are chosen as 0.3 and 0.2 respectively for this project.

Output: The required categories are ticked to display them in the output.

Trend Analysis and Forecasting

Using SPSS software forecasting is done by choosing time series modeller option.

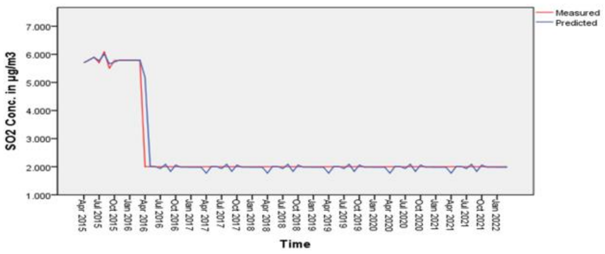
IV. RESULTS AND DISCUSSION

4.1 SO_2

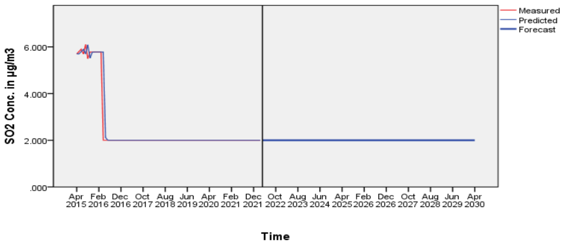
The AQI Sub-index of SO_2 is between 0-40 which comes in the 'Good' category from 2013-2022. The Exceedance Factor (EF) of SO_2 is less than 0.5 in 2013-2022, which indicates low pollution. The Ambient Air concentration of SO_2 (Annual 24 hours) is between 50-80 for Industrial, Residential, Rural, and Other Areas. So, the SO_2 concentration is not the most contributing pollutant in the calculation of the AQI index. So the trend of concentration of SO_2 pollution is not much contributing to the overall air pollution of the Peenya Industrial Area. The graph 1 shows the measured & predicted values of SO_2 and graph 2 show the predicted & forecasted values of SO_2.

DOI : 10.35291/2454-9150.2023.0083

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-09, Issue-01, Apr 2023



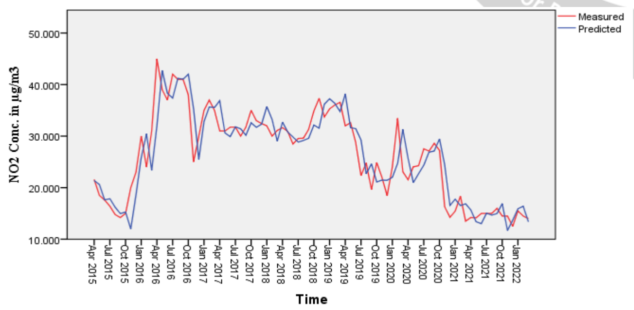
Graph 1: Showing Variation between Measured and Predicted Values for SO_2



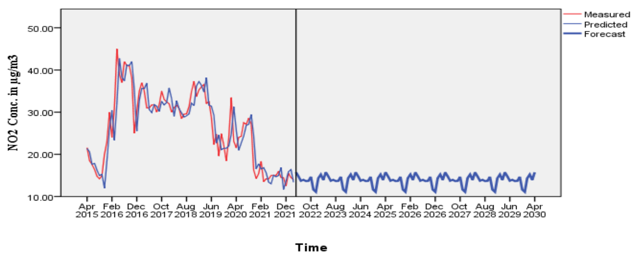
Graph 2: Showing Predicted and Forecasted Values for SO_2

4.2 NO_2

The AQI Sub-index of NO_2 is between 0-40 which comes in the 'Good' category from 2013-2016, 2017-18 and 2019-22, except 2016-17 and 2018-19 the AQI Sub-index of NO_2 is in between 40-80 which comes in 'Satisfactory' category. The Exceedance Factor (EF) of NO_2 is in between 0.5-1 in 2013-21, which indicates moderate pollution and from 2019-22 the EF value is less than 0.5, which indicates low pollution. The Ambient Air concentration of NO_2 (Annual 24 hours) is between 40-80 for Industrial, Residential, Rural, and Other Areas. So, the NO_2 concentration is not the most contributing pollutant in the calculation of the AQI index. So the trend of concentration of NO_2 pollution is not much contributing to the overall air pollution of the Peenya Industrial Area. The graph 3 shows the measured & predicted values of NO_2 and graph 4 show the predicted & forecasted values of NO_2.



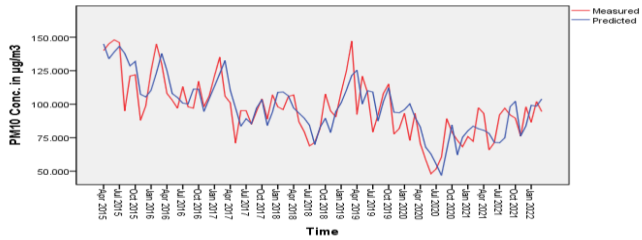
Graph 3: Showing Variation between Measured and Predicted Values for NO_2



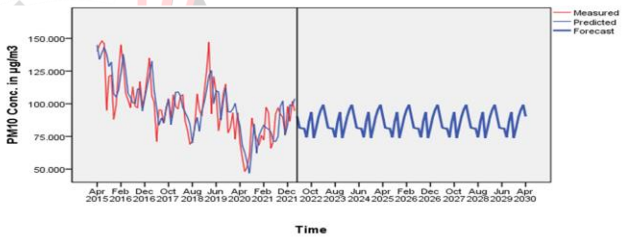
Graph 4: Showing Predicted and Forecasted Values for NO_2

4.3 PM_{10}

The AQI Sub-index of PM_{10} is between 101-250 which comes in the 'Moderate' category in 2013-17 and the AQI Sub-index of PM_{10} from 2017-22 is between 51-100 which comes in the 'Satisfactory' category. The Exceedance Factor (EF) of PM_{10} is greater than 1.5 in 2013-20, which indicates critical pollution and from 2020-22 the EF value is between 1-1.5, which indicates high pollution. The Ambient Air concentration of PM_{10} (Annual 24 hours) is between 60-100 for Industrial, Residential, Rural, and Other Areas. So, the PM_{10} concentration is one of the major contributing pollutants in the calculation of the AQI index. So the trend of concentration of PM_{10} pollution is one of the major contributing pollutants to the overall air pollution of the Peenya Industrial Area. The graph 5 shows the measured & predicted values of PM_{10} and graph 6 show the predicted & forecasted values of PM_{10}.



Graph 5: Showing Variation between Measured and Predicted Values for PM_{10}



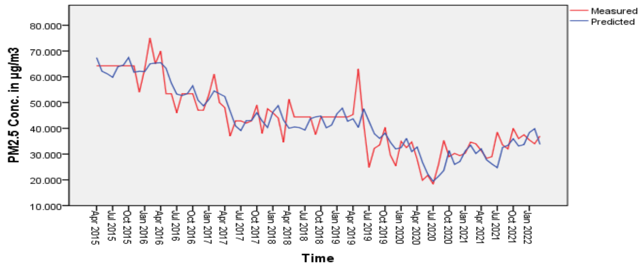
Graph 6: Showing Predicted and Forecasted Values for PM_{10}

4.4 $PM_{2.5}$

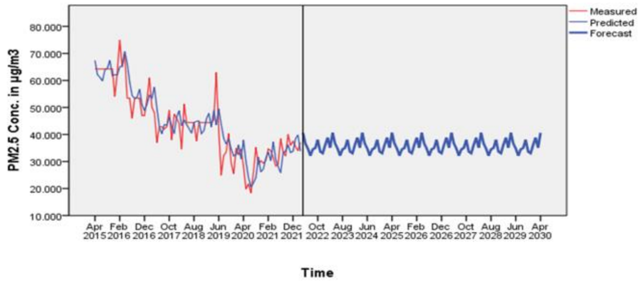
The AQI Sub-index of $PM_{2.5}$ is between 91-120 which comes in the 'Poor' category in 2015-16, the AQI Sub-index of $PM_{2.5}$ from 2016-20 is between 61-90 which comes in the 'Moderate' category and AQI Sub-index of $PM_{2.5}$ is from 2020-22 is in between 31-60 which comes in 'Satisfactory' category. The Exceedance Factor (EF) of $PM_{2.5}$ is greater than 1.5 in 2015-16, which indicates critical pollution and from 2016-19 the EF value is in between 1-1.5, which indicates high pollution and from 2019-22 the EF value is in between 0.5-1, which indicates moderate pollution. The Ambient Air concentration of $PM_{2.5}$ (Annual 24 hours) is between 40-60 for Industrial, Residential, Rural, and Other Areas. So, the $PM_{2.5}$ concentration is one of the most contributing pollutants in the calculation of the AQI index. So the trend of concentration of $PM_{2.5}$ pollution is one of the most contributing pollutants to the overall air pollution of the

 DOI : 10.35291/2454-9150.2023.0083

Peenya Industrial Area. The graph 7 shows the measured & predicted values of $PM_{2.5}$ and graph 8 show the predicted & forecasted values of $PM_{2.5}$.



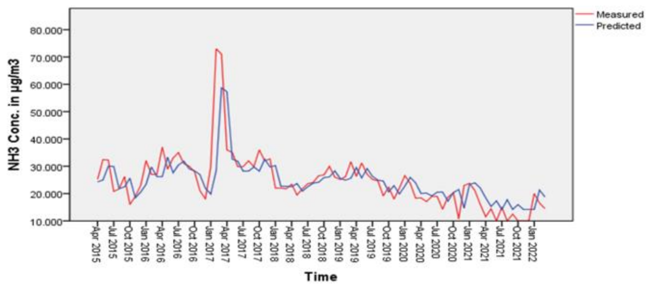
Graph 7: Showing Variation between Measured and Predicted Values for $PM_{2.5}$



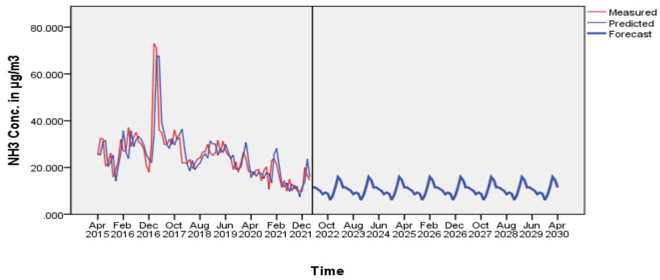
Graph 8: Showing Predicted and Forecasted Values for $PM_{2.5}$

4.5 NH_3

The AQI Sub-index of NH_3 is between 0-200 which comes in the 'Good' category in 2015-22. The Exceedance Factor (EF) of NH_3 is less than 0.5 in 2015-22, which indicates low pollution. The Ambient Air concentration of NH_3 (Annual 24 hours) is between 100-200 for Industrial, Residential, Rural, and Other Areas. So, the NH_3 concentration is not a much-contributing pollutant in the calculation of the AQI index. So the trend of concentration of NH_3 pollution is not much-contributing pollutant and it is decreasing year by year to the overall air pollution of Peenya Industrial Area. The graph 9 shows the measured & predicted values of NH_3 and graph 10 show the predicted and forecasted values of NH_3.



Graph 9: Showing Variation between Measured and Predicted Values for NH_3



Graph 10: Showing Predicted and Forecasted Values for NH_3

Table 3: Showing different pollutants and AQI values from 2013-22

YEAR	AQI Index	Breakpoints for AQI Scale	AQI Status
2013-14	115.63	101-200	Moderate
2014-15	126.72	101-200	Moderate
2015-16	116.89	101-200	Moderate
2016-17	105.50	101-200	Moderate
2017-18	95.18	51-100	Satisfactory
2018-19	97.45	51-100	Satisfactory
2019-20	94.58	51-100	Satisfactory
2020-21	70.36	51-100	Satisfactory
2021-22	88.16	51-100	Satisfactory

4.6 EFFECTS OF AIR POLLUTION BASED ON NAAQI

The Observed AQI values are in the range between 101-200, which comes in moderate category in 2013-2017 and from 2017-2022 the AQI values are in the range between 51-100 which comes in satisfactory category. So the overall impacts are reduced year by year. During 2013-2017, the effects breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease Children and older adults because the AQI values are in between 101-200. During 2017-2022, the effects are minor breathing discomfort to sensitive people because the AQI values are in between 51-100.

1. **Effects of SO_2:** The effects of human are respiratory illness, visibility impairment and aggravate existing heard and lung diseases. The effects on environment and property are acid rain and aesthetic damage.
2. **Effects of NO_2:** The effects of human are irritates the nose and throat, increase susceptible to respiratory infections. The effects on environment and property are precursor of ozone formed in the troposphere, form atmospheric fine particulate matter burden as a result of oxidation to form nitrate aerosol.
3. **Effects of PM_{10}:** The effects are minor breathing discomfort to sensitive people and may cause breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease children and older adults (Anitha K. Chinnaswamy et. al, 2016).
4. **Effects of $PM_{2.5}$:** The effects of human are oxidative stress, respiratory symptom such as irritation of the airways, coughing, or difficulty in breathing, decreased lung function, aggravated asthma, chronic bronchitis,

 DOI : 10.35291/2454-9150.2023.0083

irregular heartbeat, cardiopulmonary disorders, and premature death in people with heart or lung disease. The effects on environment and property are aesthetic damage and visibility reduction (Anitha K. Chinnaswamy et. al, 2016).

5. **Effects of NH_3:** The effects of human are irritation to skin, eyes, throat and lungs and cause coughing, burns, lung damage and death may occur after exposure to very high concentrations of ammonia. The effects on environment and property are odour problem.

4.7 Remedial measures

From analysis we found that the major pollution is due to automobiles compared to industries even though the study area is industrial sector. So some of the methods to control vehicular pollution as follows,

1. **Ride a bike or walk**: If you are only going a short distance, consider riding a bike or walking instead of driving. You can get exercise and enjoy the fresh air while getting where you need to go!

2. **Take public transit**: If you need to go somewhere that is along a bus or light rail line, consider taking public transit instead of going in a car.

3. **Car pool**: When going to school or work, try to car pool together with other people who are headed in the same direction. You can save money and reduce the amount of fuel burned at the same time.

4. **Avoid idling**: When idling, you waste fuel by burning it when you aren't moving. If you will be in the same spot for more than a minute or two, consider turning off your vehicle's engine (as long as it is safe to do so).

5. **Use alternative fuels**: Alternative fuels are cleaner than regular gasoline or diesel. Alternative fuel vehicles include electric vehicles and flex-fuel vehicles that can use ethanol blends. Most new electric vehicles now have a range of over 100 miles, which meets most people's daily commuting needs.

V. CONCLUSIONS

The major pollutant that contributes to the pollution of the Peenya Industrial Area is RSPM out of SO_2, NO_2, $PM_{2.5}$, PM_{10}, and NH_3. Overall air pollution of different air pollutants is in the moderate to satisfactory category in terms of the AQI index. We can conclude with evidence that the particular matter (PM_{10}) in Peenya Industrial Area has been over the standard limits at an alarming rate. While SO_2, NO_2 and NH_3 are within the standard limits causing not much harm to the environment around us. It is found that SPM values were very high in all directions on and around NH 48, which is due to the addition of ground dust by the movement of vehicles due to poor maintenance of roads and construction activities in the vicinity of industrial areas & stone cutting and stone polishing industries etc.,

Exceedance Factor (EF) is one of the tool similar to AQI to compare the quality of air pollution, here the EF of pollutants SO_2, NO_2, and NH_3 comes in low to moderate category and RSPM's EF is high to critical category.

SO_2, NO_2, $PM_{2.5}$, PM_{10} & NH_3, relative humidity, wind velocity, temperature, and rainfall are taken as inputs, and outputs are drawn using the different number of neurons in the hidden layers such as 2, 4, 6, 8, 10 & 12. The neuron which gives less error is considered to be the best prediction. The R^2 values for SO_2, NO_2, PM_{10}, $PM_{2.5}$, & NH_3, are 0.899, 0.808, 0.744, 0.789, and 0.761 respectively. the R^2 values for the forecasted graphs; the closer the value is to one, the better and more accurate the prediction.

ANN proves to be an effective model for Forecasting. AQI values are calculated for Forecasted data for the Peenya Industrial Area, Bengaluru, it can be observed that AQI values are showing an increase in trend up to 2013-2017 later it starts in decreasing trend because some strict actions taken by the government for industries to reduce the air pollution in the study area.

The AQI values in the study area are showing a constant in trend even though the study area represents an Industrial area with more industries with more emissions because of some actions taken by the government to reduce air pollution and almost all industries have their own air treatment plants like wet scrubbers, Bag Filters, Cyclone Dust Collectors, Acoustics Enclosures and Dust Suppressors. So that even though the study area is industrial area the pollution is majorly due to transportation sector itself because the raw materials and final products are transported by using roads so that the dust and other RSPM are abundant in nature.

This ANN-based forecasting model is fast and less resource intensive and can be used for the generation of daily forecasts. The forecasts generated through the demonstrated model can be used for scientific purposes and also to take short-term corrective actions for air quality management in highly polluted cities. The model can be replicated in other cities after the required setup, optimization, and validation and become a very useful tool for emergency planning and short-term air quality management.

REFERENCES

[1] Gaganjot Kaur Kang, Jerry Zeyu Gao, Sen Chiao, Shengqiang Lu, And Gang Xie (2018) **"Air Quality Prediction: Big Data And Machine Learning Approaches"**, International Journal Of Environmental Science And Development, Vol. 9, No. 1

[2] A.K. Chinnaswamy[1], R.N.G. Naguib[2], Q.T. Nguyen[2], L.O. Olayanju[1], N. Trodd[3] et. al. **"Air Pollution in Bengaluru, India: A Six-Year Trend and Health Implication Analysis"**, International Journal Of

 DOI : 10.35291/2454-9150.2023.0083

Environmental Science And Development, Vol. 19, No. 3/4.

[3] Azman Azid1, Hafizan Juahir, Mohd Talib Latif, Sharifuddin Mohd Zain, Mohamad Romizan Osman(2013), **"Feed-Forward Artificial Neural Network Model For Air Pollutant Index Prediction In The Southern Region Of Peninsular Malaysia",** Journal Of Environmental Protection", Vol. 4, No. 1-10.

[4] Kevin Gurney (2004), **"An Introduction To Neural Networks",** UCL Press Limited Is An Imprint Of The Taylor & Francis Group This Edition Published In The Taylor & Francis E-Library.

[5] Mahadevappa Harish, (2012), **"A Study on Air Pollution by Automobiles in Bengaluru City".** Management Research and Practice, Vol. 4 Issue 3 (2012) Pp: 25-36.

[6] Enzo Grossi(2009), **"Artificial Adaptive Systems and predictive medicine: a revolutionary paradigm shift, Grossi Immunity & Ageing 2010",** 7(Suppl 1):S3

[7] **National Air Quality Index (2019)**, Control of Urban Pollution System CUPS/ B2/ 2019-20

[8] S. Harinath[1] AND Usha N Murthy[2], (2010), **"Air Quality Index in Industrial Areas of Bengaluru City - A Case Study, India".** Civil Engineering Department, Bengaluru University, Bengaluru, India.

[9] Shobitha Sunil[1], Maria Thomas[2], Ramesh B. S.[3] and Dr. Jayarama Reddy[3*], (2021), **"Studies on the Air Pollution and AQI Of Bengaluru City, India".** Volume 5, Issue 1. 2021, ISO 9001:2015 Certified Journal.

[10] **World Health Organisation, "Air Quality and Health,"** World Health Organisation, Geneva, 2008.

[11] **SPCB, "Peenya Industrial Action Plan-2020"**

 DOI : 10.35291/2454-9150.2023.0083