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Monitoring, Analysis and Modelling of Ambient Air Quality Status at Indoshell Mould Ltd., Sidco, Coimbatore using Artificial Neural Network

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ABSTRACT

Nowadays, the advancement in technologies and the industrial revolution has led to generation of tremendous amount of wastes thereby polluting the environment. The Air quality changes due to various activities taking place in the environment, but the most important factor is the growth of industries. The environment can incorporate only a limited amount of contaminates without any significant ill effects. However, when the amount of contaminants exceeds beyond the limits, significant effects are observed. This proposed paper focused on the prevailing air quality at Indoshell Mould Limited, SIDCO (Small Industrial Development Corporation) Industrial Estate, which is located at a distance of approximately 7 km from the Coimbatore city. The estate consists of more than 250 industries, both small and large scale industries. Emissions from these industries results in air pollution. The main aim of this project is to monitor and analyse the ambient air quality status for the concentration of air pollutants (PM_{10}, $PM_{2.5}$ and TSPM) and to develop a model for the Air Quality Indices using Artificial Neural Network (ANN). The concentration of PM_{10} was found to be exceeding its threshold value for few days during the monitoring period. In ANN, the error in the predicted values was less than 8%, indicating the developed model is perfect. The R^2 value for this model is 0.9709.

Keywords: ANN, PM_{10}, $PM_{2.5}$, SIDCO and TSPM

I. INTRODUCTION

Air is one of the important constituents of nature, which is responsible for the survival of any form of life on this planet. It is also important for maintaining the ecological balance. Pollution, on the other hand, is the contamination and deterioration of the environment by releasing undesirable constituents into the atmosphere, which are lethal to the various forms of life, and also disturbs the stability and the ecological balance of the surroundings.

In every city, the levels of pollutants are getting worse because of the rapid industrialization, increased usage of vehicles, energy consumption, and burning of wastes. Hence, the situation is alarming a careful planning for the future industrial developments. For comprehensive analysis of air quality, environmental monitoring should be continued for a minimum of 1 year, taking into account all the seasons to cover the entire range of changing weather conditions and emission patterns. However, the extensive monitoring program is often time consuming and expensive, and, therefore, applications of air pollution models often get preference in practice. Further, the applicability and precision of air quality simulation models are only evaluated through comparison with monitored data, and, therefore, both these techniques go on simultaneously. Again, mere environmental data is often not sufficient for citizens to assess the severity of air pollution. Information regarding levels and potential health risks of air pollution presented in a simple and understandable format is more appreciated by general people. In this aspect, application of AQI (Air Quality Index) is quite reasonable. The AQI is commonly used to indicate the severity of pollution. With pre-identified parameters, AQI shows the overall status of air pollution in a particular area.

II. METHODS AND MATERIAL

A. Study Area

In Coimbatore District, Kurichi is located at 10°55'11" N latitude and 76° 57'35"E longitude comprising of Industrial Cluster. This Industrial cluster is located at a distance of 7 km from Coimbatore Corporation. In Kurichi, two Industrial estates exist, which are developed by SIDCO and Private. This Industrial cluster spreads over an area of about 180 acres. This cluster comes under the administrative jurisdiction of Kurichi Municipality. This industrial cluster is located on the National Highway from Coimbatore to Pollachi.

The Ambient Air quality status had been monitored in Indoshell Mould Ltd. in the SIDCO industrial cluster. The Air quality data includes the concentration of $PM_{2.5}$, PM_{10} and TSPM. The monitoring station is located at 10° 56' 11.48" N latitude and 76° 58' 33.99" E longitude.

B. Air Quality Indices (AQI)

'Air Quality Index' can be defined as a scheme that transforms the values of individual air pollution related parameters into a single number or a set of numbers from which the quality of prevailing air can be predicted. AQI were arrived using the formula,

$$AQI = \frac{1}{3}\left[\frac{PM_{2.5}}{SPM_{2.5}} + \frac{PM_{10}}{SPM_{10}} + \frac{TSPM}{STSPM}\right] * 100$$

where $SPM_{2.5}$, SPM_{10} and STSPM represents the ambient air quality standards for $PM_{2.5}$, PM_{10} and TSPM respectively. Based on the AQI obtained, the pollution levels are classified as shown in Table I.

TABLE I : Classification of Pollution level based on AQI

Sl. No.	Air Quality Index	Remarks
1	0 – 25	Clean Air
2	26 – 50	Light Air pollution
3	51 – 75	Moderate Air Pollution
4	76 – 100	Heavy Air Pollution
5	> 100	Severe Air Pollution

III. RESULTS AND DISCUSSION

A. Data

The location of Indoshell Mould Ltd., falls under the upstream side of the wind direction. This is located at 10°56'11.48"N and 76°58'33.99"E, latitude and longitude respectively. There are no major industries present on the upstream side of this location. The concentrations of the pollutants for the monitoring period (January – March 2016) are given below in Table II. The monitoring has been carried out randomly 2 days for a week in the months of January, February and March.

TABLE III : Pollutant Concentrations

Sl. No.	Date	$PM_{2.5}$ µg/m^3	PM_{10} µg/m^3	TSPM µg/m^3	AQI	Remarks
1	04.01.2016	27.3	80.8	197.6	55.26	MAP
2	05.01.2016	34.3	91.9	202.5	63.21	MAP
3	12.01.2016	33.3	93.9	225.7	64.87	MAP
4	14.01.2016	32.3	85.9	155.4	56.93	MAP
5	19.01.2016	35.4	94.9	172.3	62.77	MAP
6	20.01.2016	37.4	97.0	199.2	66.36	MAP
7	26.01.2016	30.3	81.8	192.9	56.96	MAP
8	28.01.2016	33.3	93.9	171.0	61.23	MAP
9	02.02.2016	36.4	100.0	194.5	66.50	MAP
10	05.02.2016	31.3	74.7	149.3	52.26	MAP
11	08.02.2016	21.2	60.6	117.2	39.80	LAP
12	11.02.2016	30.3	82.8	178.3	56.33	MAP
13	16.02.2016	37.4	91.9	139.5	60.70	MAP
14	18.02.2016	30.3	84.8	140.6	54.49	MAP
15	24.02.2016	27.3	78.8	192.9	54.27	MAP
16	25.02.2016	33.3	87.9	162.1	58.61	MAP
17	01.03.2016	38.4	98.0	195.1	66.99	MAP
18	03.03.2016	33.3	85.9	143.2	56.68	MAP
19	07.03.2016	30.3	77.8	159.8	53.41	MAP
20	12.03.2016	31.3	81.8	175.1	56.34	MAP
21	17.03.2016	43.4	102.0	271.1	76.20	HAP
22	18.03.2016	28.3	76.8	125.6	49.67	LAP
23	23.03.2016	27.3	79.8	121.8	49.87	LAP
24	25.03.2016	29.3	78.2	177.3	54.15	MAP
25	28.03.2016	25.3	76.1	181.3	51.47	MAP
26	29.03.2016	31.3	83.2	179.6	57.11	MAP

***LAP** - Light Air Pollution ; **MAP** – Moderate Air Pollution ; **HAP –** Heavy Air Pollution

B. Discussion

The concentration of $PM_{2.5}$ ranges from 21.2 µg/m^3 to 43.4 µg/m^3. The concentration of PM_{10} ranges from 60.6 µg/m^3 to 102.0 µg/m^3. The concentration of TSPM ranges from 117.2 µg/m^3 to 271.1 µg/m^3. The AQI value ranges from 39.8 to 76.2. It is clear that the concentrations of $PM_{2.5}$ and TSPM were found to be below their threshold values. But, the PM_{10} concentration was around the threshold value of 100 $\mu g/m^3$ for few days in the monitoring period. The AQI values indicate that this station is subjected to moderate and light air pollution.

C. ANN Modelling

The trained network is fed with the testing data that is not exposed to the architecture. The weight at the final iteration is assigned to the input parameters of the architecture, and the output is obtained. The difference between the observed and predicted concentrations denotes the accuracy of the model.

A large number of set of data are necessary to develop a good ANN model. Monitoring of air pollutant has yielded numerous sets of data. Using results obtained in the air quality monitoring, ANN models were developed. The dependent variable was AQI. The following parameters were taken as the independent variables.

X_1 – Concentration of $PM_{2.5}$ in $\mu g/m^3$
X_2 – Concentration of PM_{10} in $\mu g/m^3$
X_3 – Concentration of TSPM in $\mu g/m^3$

In this study, there are 3 input layers, one output layer and 2 hidden layers. The architecture of ANN model is shown in Figure 1.

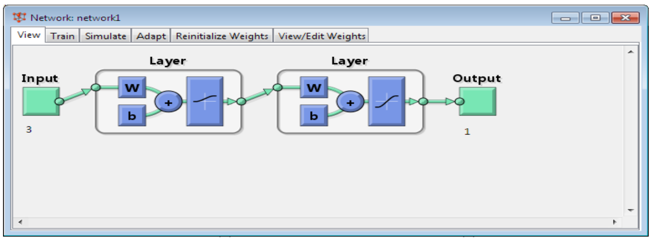

Figure 1. Architecture of ANN

ANN model has been developed, using 26 sets of data. Among 26 sets of data, 13 sets were used for training and the remaining 13 sets were used for validation. The input of the ANN model is shown in Table III.

TABLE III : ANN Input data and Output

Sl. No.	INPUT				OUTPUT
	$PM_{2.5}$	PM_{10}	TSPM	AQI observed	AQI Predicted
1	27.3	80.8	197.6	55.26	54.44
2	34.3	91.9	202.5	63.21	61.46
3	33.3	93.9	225.7	64.87	65.42
4	32.3	85.9	155.4	56.93	56.87
5	35.4	94.9	172.3	62.77	59.25
6	37.4	97.0	199.2	66.36	66.53
7	30.3	81.8	192.9	56.96	57.01
8	33.3	93.9	171	61.23	58.09
9	36.4	100.0	194.5	66.50	62.63
10	31.3	74.7	149.3	52.26	50.78
11	21.2	60.6	117.2	39.80	39.80
12	30.3	82.8	178.3	56.33	56.70
13	37.4	91.9	139.5	60.70	61.12
14	30.3	84.8	140.6	54.49	55.86
15	27.3	78.8	192.9	54.27	54.17
16	33.3	87.9	162.1	58.61	57.55
17	38.4	98.0	195.1	66.99	67.89
18	33.3	85.9	143.2	56.68	56.71
19	30.3	77.8	159.8	53.41	54.52
20	31.3	81.8	175.1	56.34	56.80
21	43.4	102.0	271.1	76.20	76.20
22	28.3	76.8	125.6	49.67	48.84
23	27.3	79.8	121.8	49.87	51.62
24	29.3	78.2	177.3	54.15	55.43
25	25.3	76.1	181.3	51.47	52.71
26	31.3	83.2	179.6	57.11	57.14

The ANN model was successfully developed for the monitoring period. Final weights were recorded. The Regression plot to this model was also recorded as given in Figure 2. The R^2 value for this model is 0.9709. The final weights is given in Table IV. The difference between the observed and predicted AQI by this model is about 2%. The error in the predicted values was less than 8%, indicating the developed model is perfect.

Table IVV: ANN Input data and Output

iw{1,1} – weight to layer 1 from input1		
[1.9376	-2.0991	0.97114;
1.2116	1.084	-1.032;
-2.3271	1.3502	0.86334;
1.6207	-0.9214	2.2046;
-0.4852	1.7881	1.3585;
-1.0298	-1.3977	1.844;
-0.9131	0.02104	2.7738;
-0.161	2.557	-1.0904;
2.6477	0.29119	2.4724;
0.87292	0.94424	-2.2888]

lw{2,1} – weight to layer									
[3.9668	5.9744	-0.9246	5.8427	13.2226	-10.213	-1.3076	0.77821	2.1324	-3.0134]

b{1} – Bias to layer 1
[-3.0298;
-3.9257;
2.5689;
-2.1164;
3.3808;
-3.0953;
-2.5922;
2.4452;
-2.9787;
4.1923]

B{2} – Bias to layer 2
[-3.7211]

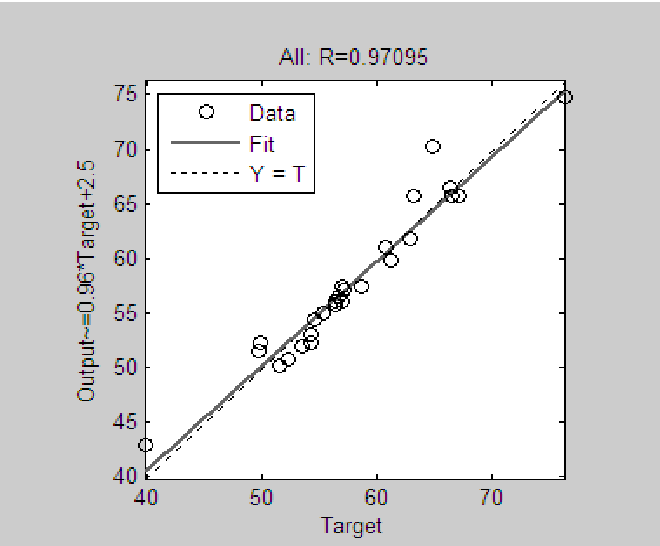

Figure 2. Regression Plot

IV. CONCLUSION

The Indoshell Mould Ltd. in SIDCO, Coimbatore has installed some essential air pollution control measures. But the results of monitoring show that PM_{10} values exceed the limits for few days. The average AQI of the Indoshell Mould Ltd. for the monitoring period is 58. It indicates that the industry comes under Moderate Air Pollution. Therefore, proper preventive measures must be taken to ensure healthy life for the people surviving in the housing unit nearby SIDCO, Coimbatore. The ANN models developed shall be useful for researchers for further investigation.

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