International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 05 | May 2020 www.irjet.net p-ISSN: 2395-0072

DEVELOPMENT OF PREDICTION MODEL FOR VEHICULAR EMISSION AT SELECTED INTERSECTION OF AHMEDABAD CITY

Chetan Gothaliya[1], Dr. P. J. Gundaliya[2], Prof. J. S. Kamble[3]

[1]M.E. Student, Dept. of Civil Engineering, L.D. College of Engineering, Gujarat, India
[2]Professor, Dept. of Civil Engineering, L.D. College of Engineering, Gujarat, India
[3] Assistant Professor, Dept. of Civil Engineering, L.D. College of Engineering, Gujarat, India

---***---

Abstract - *Vehicular traffic is one of the main reasons for air pollution in urban areas. Vehicular emission causes 60% to 80% of the air pollution. It is because of rapid and unplanned urbanization. In a rapidly urbanizing country, like, India, the transportation sector is growing rapidly and the numbers of vehicles on Indian urban roads are increasing at an insignificant rate per annum which consequently creates congestions at intersections. It is now generally recognized that many of substances directly emitted by vehicles in the ambient air represent a serious hazard for human health and also causes respiratory and cardiovascular diseases and cancer. Many researchers found to predict vehicular emission and developed model which predict various pollutants like CO, PM_{10}, NO_2, SO_2, and $PM_{2.5}$. This study is an attempt to develop a mathematical model to predict vehicular emissions at selected intersection in an urban area of Ahmedabad, India, by collecting vehicular emission data statically at selected intersection. A mathematical linear regression model will be developed to predict the emission in ambient air as a function of traffic volume.*

Key Words: **Vehicular Emission, Air Quality, Traffic intersection, Mathematical model**

1. INTRODUCTION

Transport infrastructure such as highways, road networks and tolls have an importance in the economy of a country as they provide accessibility services to citizens and goods [1]. The construction of these infrastructures is vital for any developing country. However, emissions from road traffic are one of the main sources of air pollution in urban areas due to vehicle exhaust. Ahmedabad is a major city which has a population of more than 6.5 million and busy traffic over the whole city areas also very large congestion on many intersections. In particular, the traffic volume during peak hours significantly increased in most of the city areas. At traffic intersection vehicles spend a longer time due to queuing and the acceleration and deceleration phase they go through are more polluting than steady speed cruising. Therefore, the residents, students, businessmen, and drivers might be exposed to various vehicular emissions produced from road traffic vehicles. In urban environments and especially in those areas where population and traffic density are relatively high, human exposure to hazardous substances is expected to be significantly increased. This is often the case near busy traffic points in city center, where urban situation may contribute to the creation of poor air dispersion conditions giving rise to contamination hotspots. This study analyzed the concentrations of CO, PM_{10}, NO_2, SO_2, $PM_{2.5}$ obtained from traffic intersection in Ahmedabad city and the correlations between the pollutants concentrations and traffic volumes. A comprehensive study on the prediction of vehicular emissions at urban traffic intersection was found to be limited in the existing literature. This explains the need for the current study.

2. MODELING METHODOLOGY

In this study authors selected two intersections, which might represent major traffic volume in Ahmedabad city, for emission samplings as follow: a heavy traffic rotary at near RTO office its call RTO-circle shown in fig.-1 and another is a heavy traffic signalized intersection which is Shah alam cross road at maninagar area shown in fig.-2. Emission sample was collect near the intersection from real time on board vehicular emission monitoring system i.e. SAFAR(system of air quality weather forecasting and research) and also from CPCB India's real time air pollution monitoring station during 10:00AM to 06:00PM period in sampling day. At RTO circle Emission data was collect by manually from SAFAR real time air quality monitoring LED-display. Emission sample collected in terms of one hour average in milligram per cubic meter during entire eight hour. CO sample collected in terms of one hour average CO in microgram per cubic meter. Traffic volume has been counted using a manual counter and also by videography based on vehicle types, such as two wheeler (2W), three wheeler (3W), four wheeler (4W), light commercial vehicle (LCV) and heavy commercial vehicle (HCV). Traffic volume data was converting into PCU per hour. At both intersection traffic volume and Emission data was collect by simultaneously with help of two data linear regression model was developed using Microsoft excel and then after correlate observed and predicted data for validation of prediction model. At RTO circle emission measurement station located at 40m away from the center of the rotary and at Shah Alam cross road intersection emission measurement station located at 325m away from the center of the intersection.

There was two days consider for the study one is week day i.e. Monday and another is week-end day i.e. Sunday.

Fig -1: Arial photograph of RTO circle

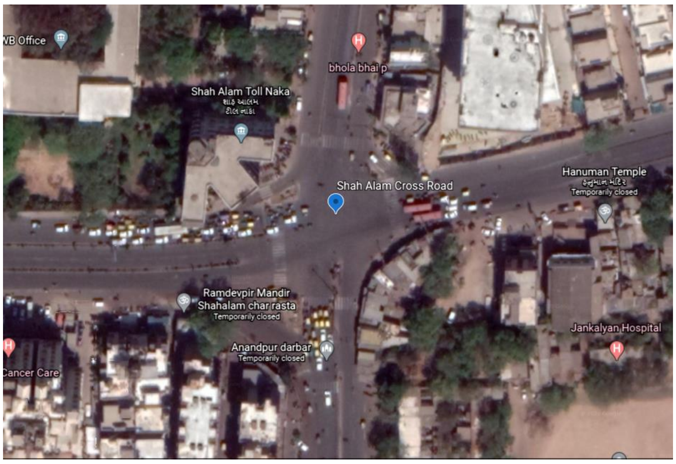

Fig -2: Arial photograph of Shah alam cross road

3. RESULT AND DISCUTION

The LR model generated a statistical equation based on the input parameters i.e. traffic volume and concentration of vehicular emission. Regression model of various emission for week day of RTO Circle (Rotary) traffic intersection shown in table 1 also for week end day shown in table 2. Regression model of various emissions for week day of Shah alam cross road signalized traffic intersection shown in table 3 also for week end day shown in table 4.

Table -1: LR Model for week day at RTO circle

Vehicular emission	LR model
$PM_{2.5}$	Traffic $PM_{2.5}$=0.008*(Traffic Volume) +0.63
PM_{10}	Traffic PM_{10} =0.013*(Traffic Volume)+35.49
NO_2	Traffic NO_2 =0.001*(Traffic Volume) + 3.435
SO_2	Traffic SO_2 = 0.001*(Traffic Volume) - 0.885
CO	Traffic CO = 0.195*(Traffic Volume) - 5.205

Table -2: LR Model for week-end day at RTO circle

Vehicular emission	LR model
$PM_{2.5}$	Traffic $PM_{2.5}$=0.008*(Traffic Volume) +1.13
PM_{10}	Traffic PM_{10} = 0.014*(Traffic Volume)+35.5
NO_2	Traffic NO_2 = 0.001*(Traffic Volume) +2.85
SO_2	Traffic SO_2 = 0.009*(Traffic Volume) + 2.79
CO	Traffic CO = 0.21 *(Traffic Volume)- 64.541

Table -3: LR Model for week day at Shah alam cross road

Vehicular emission	LR model
$PM_{2.5}$	Traffic $PM_{2.5}$=0.008*(Traffic Volume) + 2.04
PM_{10}	Traffic PM_{10}=-0.0001*(Traffic Volume)+104
NO_2	Traffic NO_2 =0.0001*(Traffic Volume) + 10.3
SO_2	Traffic SO_2 = -0.003*(Traffic Volume) + 54.1
CO	Traffic CO = 0.033*(Traffic Volume) + 610.4

Table -4: LR Model for week-end day at Shah alam cross road

Vehicular emission	LR model
$PM_{2.5}$	Traffic $PM_{2.5}$=-0.008*(Traffic Volume) + 104
PM_{10}	Traffic PM_{10} =-0.009*(Traffic Volume)+ 162
NO_2	Traffic NO_2 = 0.0001*(Traffic Volume) +6.5
SO_2	Traffic SO_2 = -0.021*(Traffic Volume) + 185
CO	Traffic CO = 0.13 *(Traffic Volume)- 261.3

From above prediction LR model author was predict vehicular emission corresponding to traffic volume for next week day and week end day at two traffic intersections which is shown in table. Compare observed and predicted emission values at week day at RTO circle shown in table 5 and at week end day shown in table 6. Same for at shah alam cross road for week day shown in table 7 and for week end day shown in table 8.

Table -5: Observed and Predicted emission values at week day at RTO circle

Observed Value					Predicted Value				
$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO	$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO
30	78	7	35	700	28.8	81.5	6.9	34.3	690
20	69	6	26	550	22.8	71.9	6.2	26.8	546
31	80	7	35	700	29.2	82.2	7	34.7	700
30	80	7	33	700	28.3	80.8	6.8	33.7	679
30	80	7	33	700	28.2	80.8	6.8	33.6	679
30	82	7	33	650	27	78.7	6.7	32	647
30	82	7	34	700	28.9	81.9	6.9	34.5	696
33	84	7	35	730	30.2	83.9	7.1	36	725

All values in mg/m^3 except CO in $\mu g/m^3$

Table -6: Observed and Predicted emission values at week-end day at RTO circle

Observed Value					Predicted Value				
$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO	$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO
25	78	6	35	650	27.5	81.6	6.1	32.4	628
21	67	5	25	450	20.7	69.7	5.3	24.8	449
20	67	5	21	450	19.6	67.8	5.1	23.5	420
17	66	4	22	400	17.7	64.5	4.9	21.5	371
18	66	4	22	400	17.5	64.2	4.9	21.2	367
14	58	4	19	300	15	59.8	4.6	18.4	300
22	66	5	25	450	20.1	68.7	5.2	24.1	433
23	74	5	30	550	24.1	75.6	5.7	28.6	538

All values in mg/m^3 except CO in $\mu g/m^3$

Table -7: Observed and Predicted emission values at week day at Shah alam cross road

Observed Value					Predicted Value				
$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO	$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO
36	74	15	66	700	63.9	103.3	11.1	30.9	865
41	86	14	68	600	55	103.4	11	34.2	829
42	87	15	39	500	60.4	103.3	11.1	32.2	851
38	80	16	34	500	63.5	103.3	11.1	31	864
32	78	18	27	400	61.1	103.4	11.1	31.9	854
31	68	16	21	700	60.5	103.4	11	32.2	851
22	63	17	18	999	65.6	103.3	11.1	30.2	873
31	65	25	13	700	65.3	103.3	11.1	30.3	872

All values in mg/m^3 except CO in $\mu g/m^3$

Table -8: Observed and Predicted emission values at week-end day at Shah alam cross road

Observed Value					Predicted Value				
$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO	$PM_{2.5}$	PM_{10}	NO_2	SO_2	CO
43	73	13	48	800	54.9	106.9	7.1	55.2	562
53	77	14	62	500	68.2	121.9	6.9	90.3	340
40	82	15	39	300	68.3	122	6.9	90.4	339
31	80	16	46	500	71.4	125.4	6.9	98.5	288
21	78	14	26	400	73.1	127.4	6.8	103	259
15	79	14	17	800	75	129.4	6.8	107	229
24	64	14	12	900	70.8	124.7	6.9	96.9	298
17	62	17	8	600	60.9	113.7	7	71.2	461

All values in mg/m^3 except CO in $\mu g/m^3$

Correlation chart was built from observed and predicted values for two intersections. Chart 1 to 5 was correlation between observed and predicted emission values for week day at RTO-Circle rotary intersection also show correlation coefficient in chart also Chart 6 to 10 for week end day at RTO-Circle rotary intersection. Chart 10 to 15 was correlation between observed and predicted emission values for week day at Shah Alam cross road intersection also show correlation coefficient in chart also Chart 16 to 20 for week end day at Shah Alam cross road intersection.

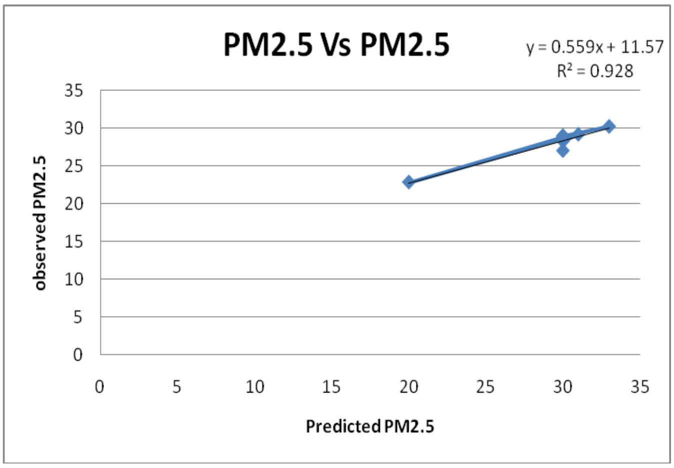

Chart -1: Correlation between Observed and predicted $PM_{2.5}$

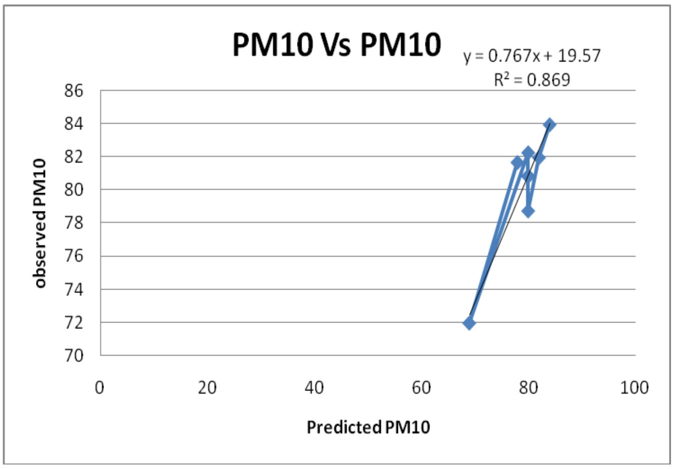

Chart -2: Correlation between Observed and predicted PM_{10}

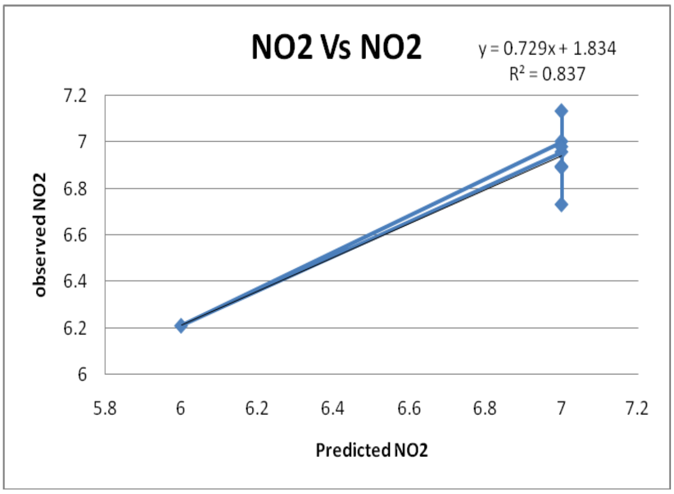

Chart -3: Correlation between Observed and predicted NO_2

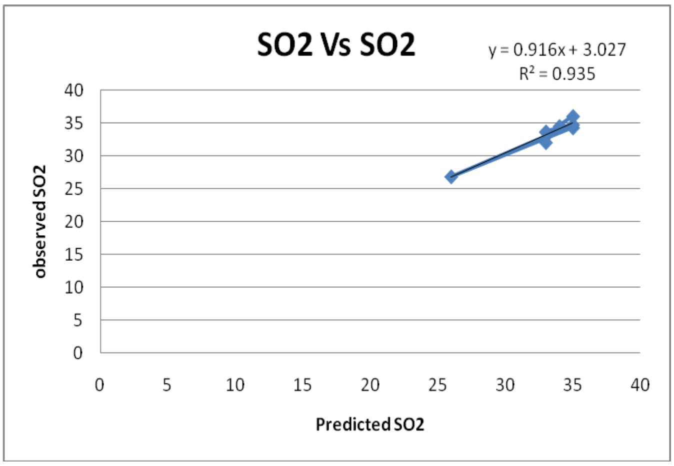

Chart -4: Correlation between Observed and predicted SO_2

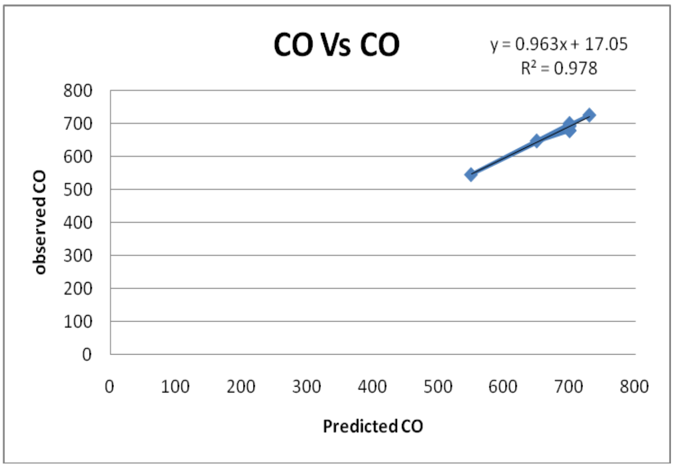

Chart -5: Correlation between Observed and predicted CO

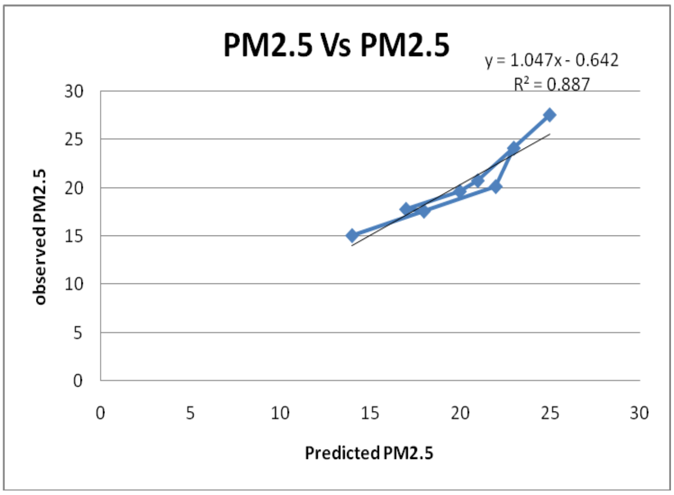

Chart -6: Correlation between Observed and predicted $PM_{2.5}$

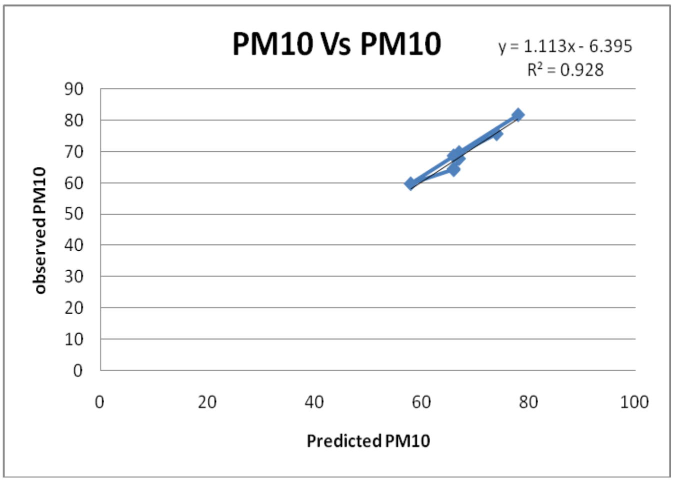

Chart -7: Correlation between Observed and predicted PM_{10}

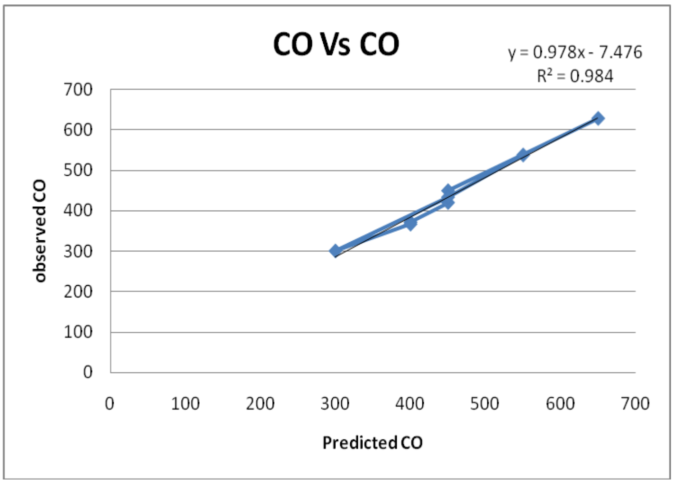

Chart -10: Correlation between Observed and predicted CO

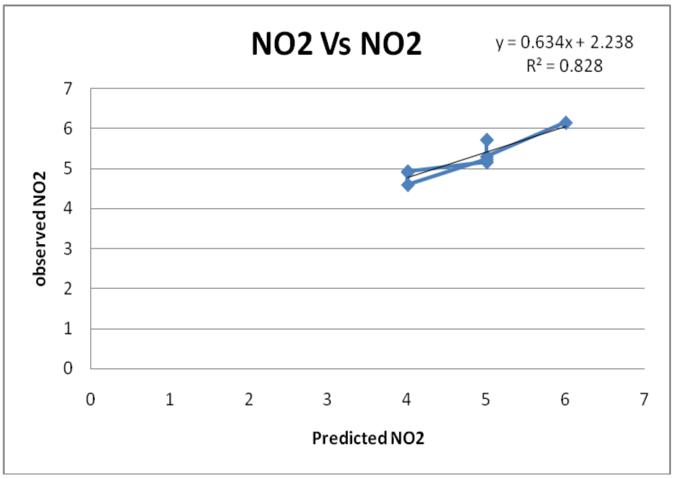

Chart -8: Correlation between Observed and predicted NO_2

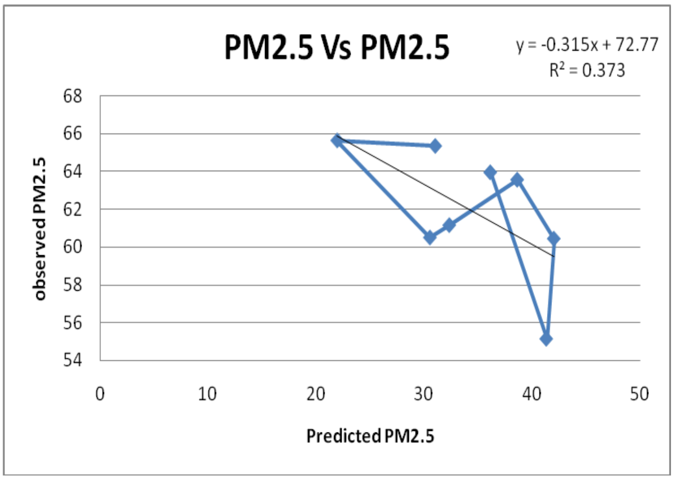

Chart -11: Correlation between Observed and predicted $PM_{2.5}$

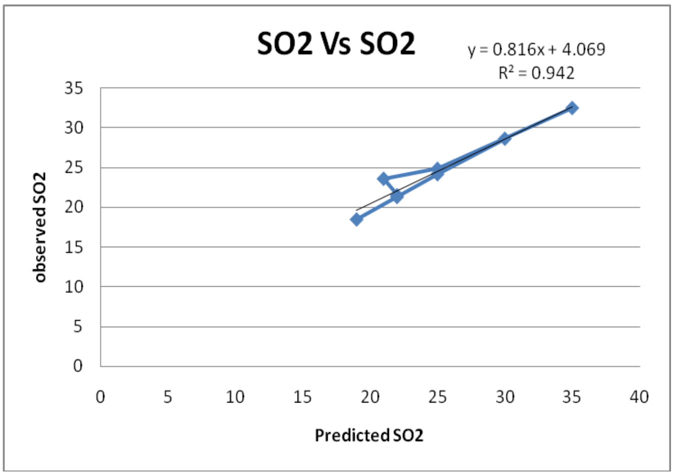

Chart -9: Correlation between Observed and predicted SO_2

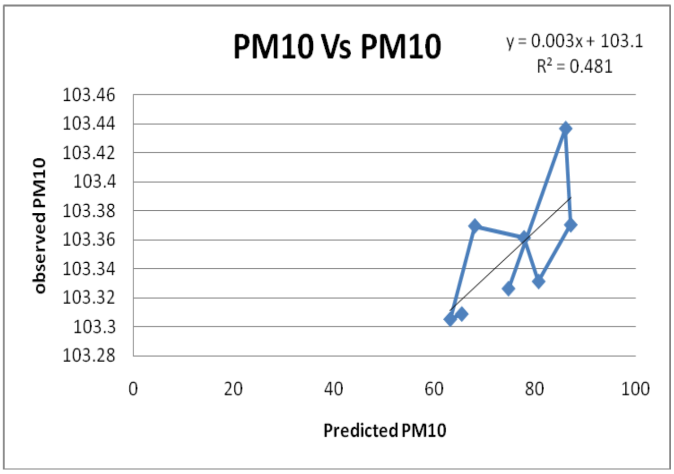

Chart -12: Correlation between Observed and predicted PM_{10}

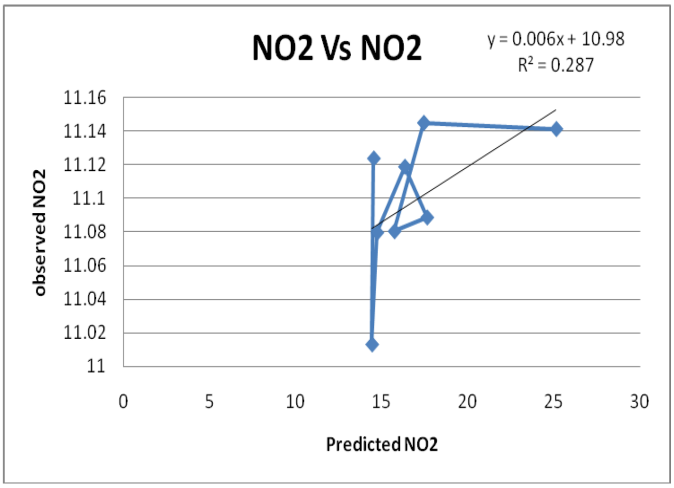

Chart -13: Correlation between Observed and predicted NO_2

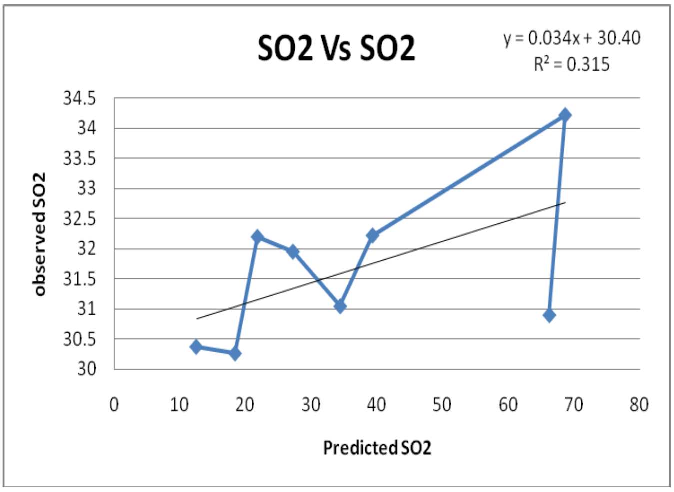

Chart -14: Correlation between Observed and predicted SO_2

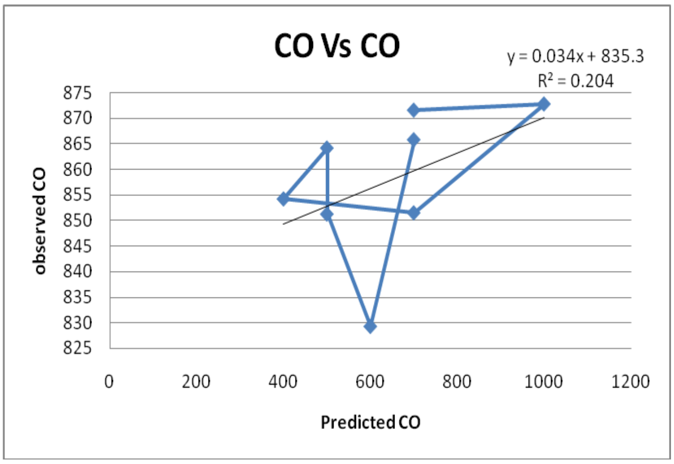

Chart -15: Correlation between Observed and predicted CO

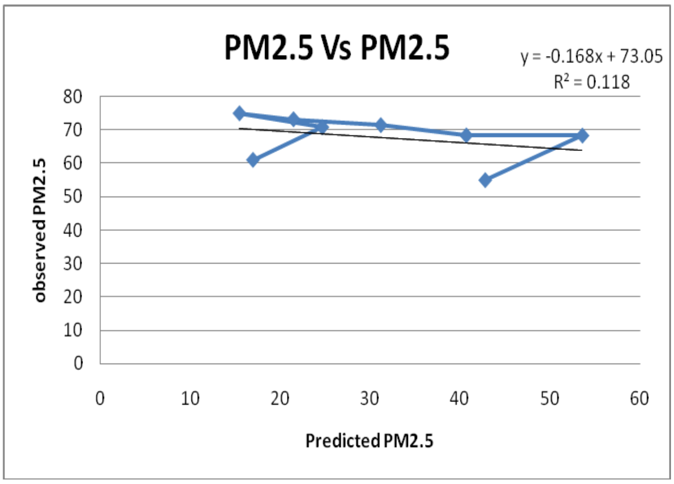

Chart -16: Correlation between Observed and predicted $PM_{2.5}$

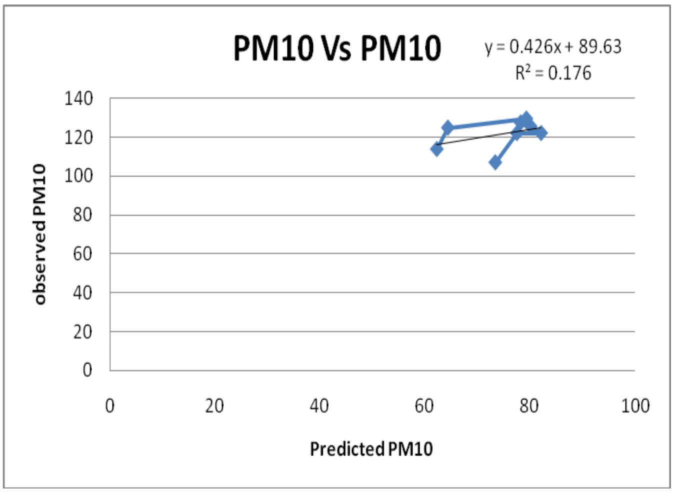

Chart -17: Correlation between Observed and predicted PM_{10}

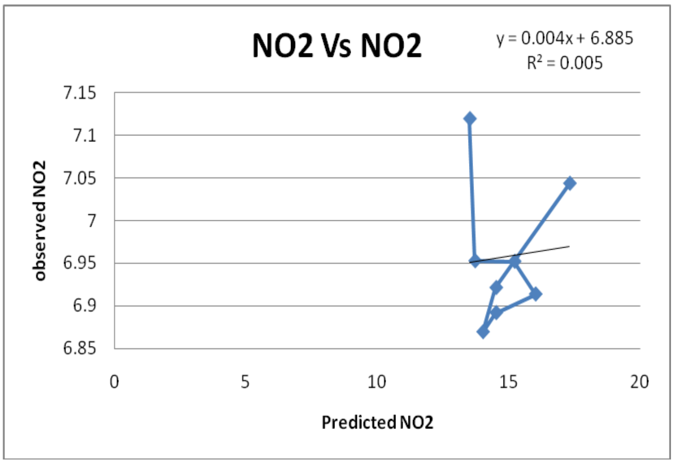

Chart -18: Correlation between Observed and predicted NO_2

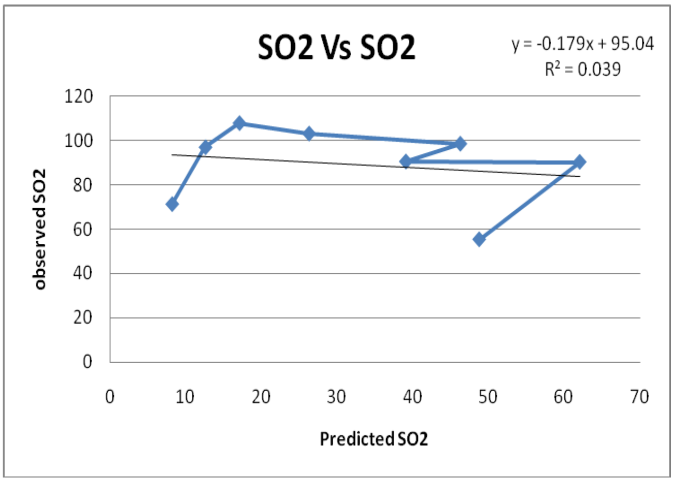

Chart -19: Correlation between Observed and predicted SO_2

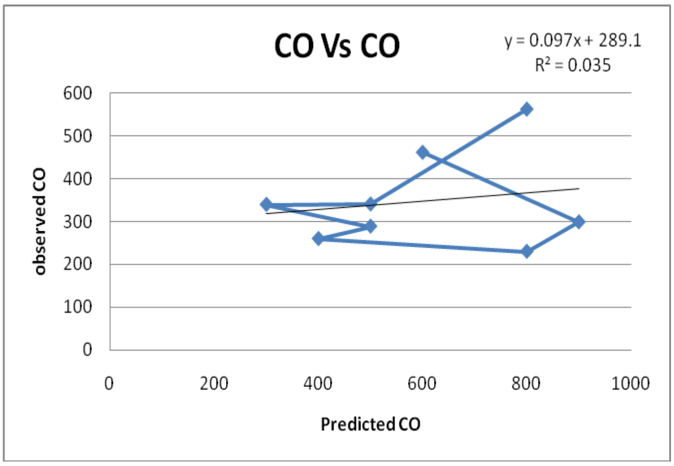

Chart -20: Correlation between Observed and predicted CO

4. CONCLUSIONS

Very high correlations were identified between observed and predicted $PM_{2.5}$, SO_2 and CO concentrations at RTO circle for week day. Also very high correlations were identified between PM_{10}, SO_2 and CO concentration at RTO circle for week end day because of correlation coefficient was greater than 0.9. High correlations were identified between observed and predicted NO_2 concentration for both day i.e. week day and week end day because correlation coefficient was 0.837 and 0.828 respectively. Correlation of $PM_{2.5}$ for week day was higher than week end day also correlation of PM_{10} for week day was weaker than week end day for RTO Circle rotary traffic intersection. Very poor correlations were identified between all observed and predicted vehicular emissions at Shah Alam cross road intersection because of correlation coefficient was less than 0.5.This due to large sample size and the vehicular emission measurement station being too far from the intersection. It can be said that the LR prediction model for Shah Alam cross road intersection failed to make a prediction because the correlation coefficient is too small.

5. FUTURE SCOPE

These regression models have been developed from two Traffic intersection of Ahmadabad city. These developed models can be applied in the other cities and checked for its usefulness. Vehicular Pollutants depends on various factors like vehicular factors (fuel consumption, age, geometry, fuel type), whether condition, wind speed, wind direction, installation of measuring instrument, season and road condition also affect the concentration of vehicular emission. In the present study, Author was considering only traffic volume. Above mention factors should be studied and a new model should be developed taking into account maximum possible variables.

REFERENCES

[1] Omer Saud Azeez , Biswajeet Pradhan, Helmi Z. M. Shafri, "Vehicular CO Emission Prediction Using Support Vector Regression Model and GIS" Sustainability, vol. 10, Sept. 2018, pp. 1-18, DOI: 10.3390/su10103434

[2] Byeong-Kyu Lee, Haengah Kim Lee, O-Kun Lee, "Analysis of the correlation between particulate matter concentrations and traffic volume in the metropolitan city of Ulsan, Korea," IEEE, vol. 6, Oct. 2006, pp. 351-353, 1-4244-0427-4

[3] Massimiliano Gastaldi, Claudio Meneguzzer, Rosa Arboretti Giancristofaro, Gregorio Gecchele, Luca Della Lucia, Maria Vittoria Prati, "On-road measurement of CO2 vehicle emissions under alternative forms of intersection control," Science,vol. 27, Dec. 2017, pp. 476-483, doi:10.1016/j.trpro.2017.12.048

[4] C S R K Prasad, M V L Satish, "Influence of highway traffic on intensity of CO in ambient air," Science, Published under National conference on "Urban air pollution issues and management" organised by SVNIT-Surat, 2003.

[5] https://aqicn.org/city/india/ahmedabad/maninagar/

[6] https://www.iqair.com/india/gujarat/ahmedabad/navrangpura-safar

[7] https://www.google.com/intl/en_in/earth/