INTERRELATIONS AMONG NO_2, SO_2 AND PM_{10} CONCENTRATIONS AND THEIR PREDICTIONS IN SHIMLA

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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CERTIFICATE

This is to certify that the work which is being presented in the project title "**INTERRELATIONS AMONG NO_2 AND PM_{10} CONCENTRATIONS AND THEIR PREDICTIONS IN SHIMLA**" in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out By Satyarth during a period from August 2014 to May 2015 under the supervision of **Dr. Rajiv Ganguly,** Assistant Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

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ABSTRACT

In this project we have first of all studied the concentrations of NO_2 and PM_{10} and then predicted their future level of concentrations in the ambient air of Kolkata. The data collected from West Bengal Pollution Control Board website have been used to construct linear, second degree, and third degree polynomial equations using MATLAB software. Since a curve in a small interval can be approximated by a line segment in that small interval, we have observed that better result can be achieved if we replace the curves piece wise in small intervals by line segments during January-April, May-August and September-December months for linear equations.. Finally, we have predicted the value of each parameter in terms of only one dependent variable.

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CHAPTER 1
INTRODUCTION

Metropolitan city like Kolkata has been suffering from various types of health hazards problems for long time due to air pollution. Risk assessments for the toxic pollutants are widely used in different countries as a regulatory decision making processes to combat air pollution. In the mega cities of India such as Mumbai, Delhi and Kolkata, PM10 has exceeded the regulatory limits. It has been found from available data that the presence of particulate matter (PM10) is highest in the atmosphere of Kolkata. Among the pollutants listed in NAAQS one of the most notorious pollutants is PM10.It is well known that PM10 is responsible for respiratory hazards in human health. Such particulates can also obstruct lung function without reacting chemically, by depositing in human lungs and interfering with normal functioning. Moreover, it takes part in formation of sulphurous smog. One of the main sources of existence of PM10 in air is vehicular pollution. Various typical anthropogenic activities like intense transportation, Industrial and commercial activities are prevailing in urban areas, particularly in the metropolitan cities. It is also known that increased level of Sulphur-dioxide (SO2) and Nitrogen-dioxide (NO2) lead to the formation of different types of secondary pollutants in environment. Studies reveal that the occurrence is mainly due to expanding industries and growing number of vehicles within the state. The West Bengal Pollution Control Board (WBPCB) had initiated air quality monitoring of Kolkata through a limited number of stations in 1992 and subsequently expanded its monitoring network to systematic pattern from December 1998. At present the air quality of Kolkata is monitored through 16 fixed monitoring stations.

CHAPTER 2
OBJECTIVE

Our main objective is to develop and fit the provided monitored concentration data of pollutants in Kolkata suitably by first, second and third degree equation by using MATLAB software. We have used MATLAB software on the available data to suitably fit first degree, second degree, and third degree curves for each parameter. It has been found that the best predictions for some of the parameters are obtained sometimes for first degree, second degree, and sometimes for third degree equations —but no unique curve is obtained to make best predictions for all the three parameters. Since a curve in a small interval can be approximated by a line segment in that small interval, we have considered the curves piece meal wise from January to April, May to August and September to December for all the parameters in case of first degree. For second and third degree we have not considered the curves piece meal wise from January to April, May to August and September to December. Then we have approximated the curves obtained in the above time periods by suitable line segments and found predictions are quite encouraging.

CHAPTER 3

SIGNIFICANCE

The significance of this project is to predict the concentrations of NO2 and PM10 using MATLAB. Thus we will be predicting the concentrations of NO2 and PM10 emitted from industrial plants, from the vehicles. This is significant as in we can take certain measure to downwind the concentrations. Various activities like intense transportation, industrial and commercial activities are prevailing in urban areas, particularly in metropolitan cities. These pollutants when present in increased levels lead to the formation of secondary pollutants in environment. So predicting the concentrations will allow us to take necessary steps to decrease the concentrations.

CHAPTER 4

LITERATURE REVIEW

Many researchers have studied the effects of NO_2 and PM_{10} on environment. Air quality in urban areas is a cause of concern because of increased industrial activities that contribute to large quantities of emissions. **Harold Wilson Tumwitike Mapoma,**

Chifundo Tenthani*, Madalitso Tsakama and Ishmael Bobby Mphangwe Kosamu

have presented a statistical study on Air quality assessment of carbon monoxide, nitrogen dioxide and sulfur dioxide levels in Blantyre, Malawai . Factor analysis (FA) showed that air temperature had significant contribution to variations in mean values of CO, SO2 and NO2 for the entire study period. The study shows a need for constant urban air quality monitoring in Blantyre and all urban areas in Malawi.

Manju Mohan, Anurag Kandya and Manish Yadav, have presented a statistical study on working through the historical data in a general way and finding guides to future behaviour. In the present study, forecasting of the criteria pollutants has been done using simple statistical techniques and attempt has been made for an inter-comparison of these techniques with various advanced statistical and deterministic techniques.

The inter-comparison analysis leads us to the conclusion that there is no single modelling approach which generates optimum results. Considering the uncertainty and unavailability of most of the inputs of deterministic and advance statistical techniques, the methods adopted here are proposed to have great potential for air pollution forecasting.

4.1 NO2 AS A POLLUTANT

Nature and Sources of the Pollutant: Nitrogen dioxide belongs to a family of highly reactive gases called nitrogen oxides (NO_x). These gases form when fuel is burned at high temperatures, and come principally from motor vehicle exhaust and stationary sources such as electric utilities and industrial boilers. A suffocating, brownish gas, nitrogen dioxide is a strong oxidizing agent that reacts in the air to form corrosive nitric acid, as well as toxic organic nitrates. It also plays a major role in the atmospheric reactions that produce ground-level ozone (or smog).

Health and Environmental Effects: Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infections such as influenza. The effects of short-term exposure are still unclear, but continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children. Nitrogen oxides contribute to ozone formation and can have adverse effects on both terrestrial and aquatic ecosystems. Eutrophication occurs when a body of water suffers an increase in nutrients that leads to a reduction in the amount of oxygen in the water, producing an environment that is destructive to fish and other animal life.

4.2 PM_{10} AS A POLLUTANT

Nature and Sources of the Pollutant: Particulate matter is the term for solid or liquid particles found in the air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can be detected only with an electron microscope. Because particles originate from a variety of mobile and stationary sources (diesel trucks, woodstoves, power plants, etc.), their chemical and physical compositions vary widely. Particulate matter can be directly emitted or can be formed in the atmosphere when gaseous pollutants such as SO2 and NOx react to form fine particles.

Health and Environmental Effects: In 1987, EPA replaced the earlier Total Suspended Particulate (TSP) air quality standard with a PM-10 standard. The new standard focuses on smaller particles that are likely responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract. The PM-10 standard includes particles with a diameter of 10 micrometers or less.

CHAPTER 5

WHY USING MATLAB

To evaluate large amounts of data that are acquired automatically by means of computers and other technical appliances. In other software, it is way too laborious to manually preprocess every single data set with a spreadsheet software and export it to a statistics software package. Thus, automating this process by means of a MATLAB program will be profitable. The application of programmed data evaluation routines is a more efficient way if the evaluation procedure has to be changed over and over again to 'fine-tune' it. Re-calculating the whole data set with the changed procedure is then done in a snap. MATLAB allows for the programming of user-friendly interfaces for data evaluation programs that are repeatedly used. Thus, complicated data evaluation procedures can also be performed by collaborators who are less skilled with the computer.

CHAPTER 6

PROCESS OF MATLAB

6.1 How to Plot a Curve

To plot a curve in x-y following steps are followed

x=[x1 x2 x3 x4….]

Y=[y1 y2 y3 y4….]

Plot (x,y)

After plotting….

Write x label ("abc")

Write y label ("xyz")

6.2 How to Find Best Curve Fit

X=[x1 x2 x3 x4…]

Y=[y1 y2 y3 y4…]

p=polyfit(X,Y,n)

where n=degree of the equation

p will be a row matrix of n+1 columns containing the coefficient of polynomial equation in order of decreasing powers of x.

p1=polyval(p, x1)

p2=polyval(p, x2)

p3=polyval(p, x3)

p4=polyval(p, x4)

pX will give the value of the polynomial at X .

6.3 MATLAB Code for Modeling

6.3.1 First Degree Equation

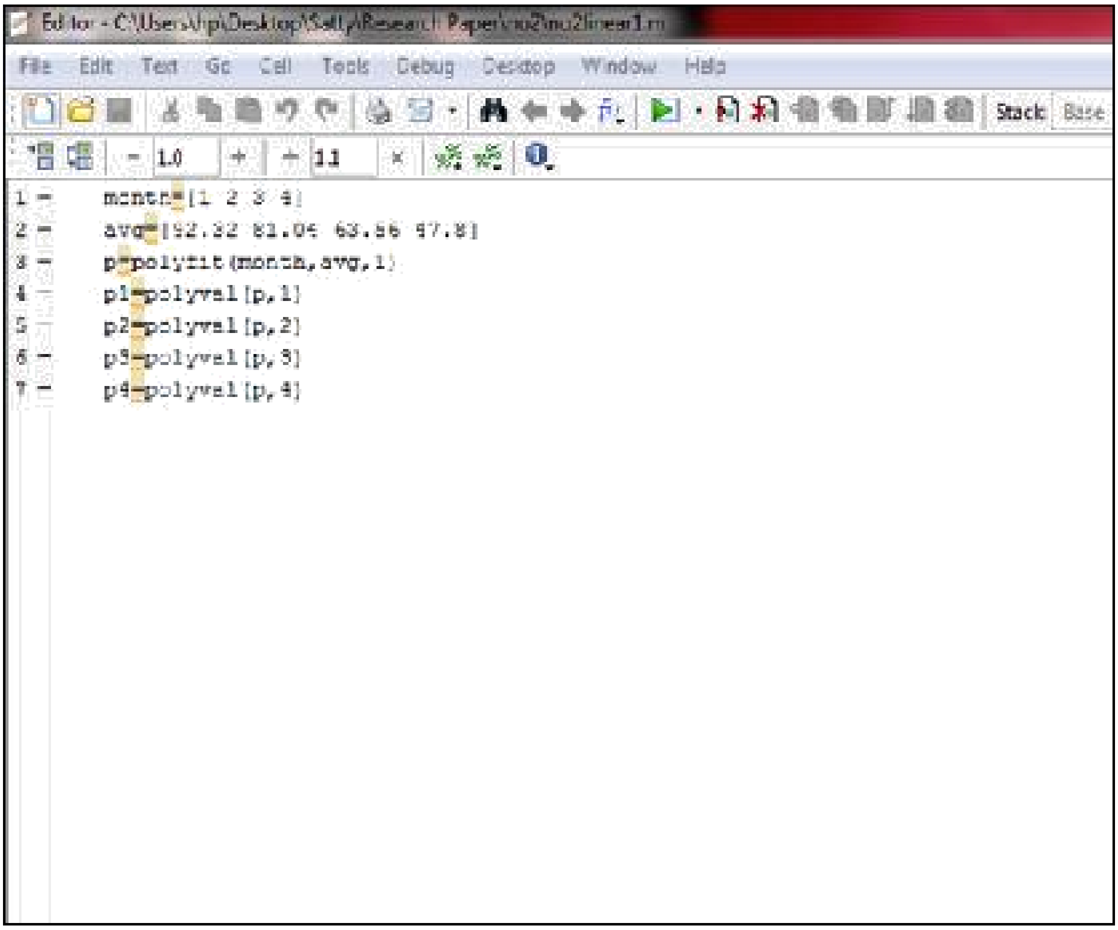
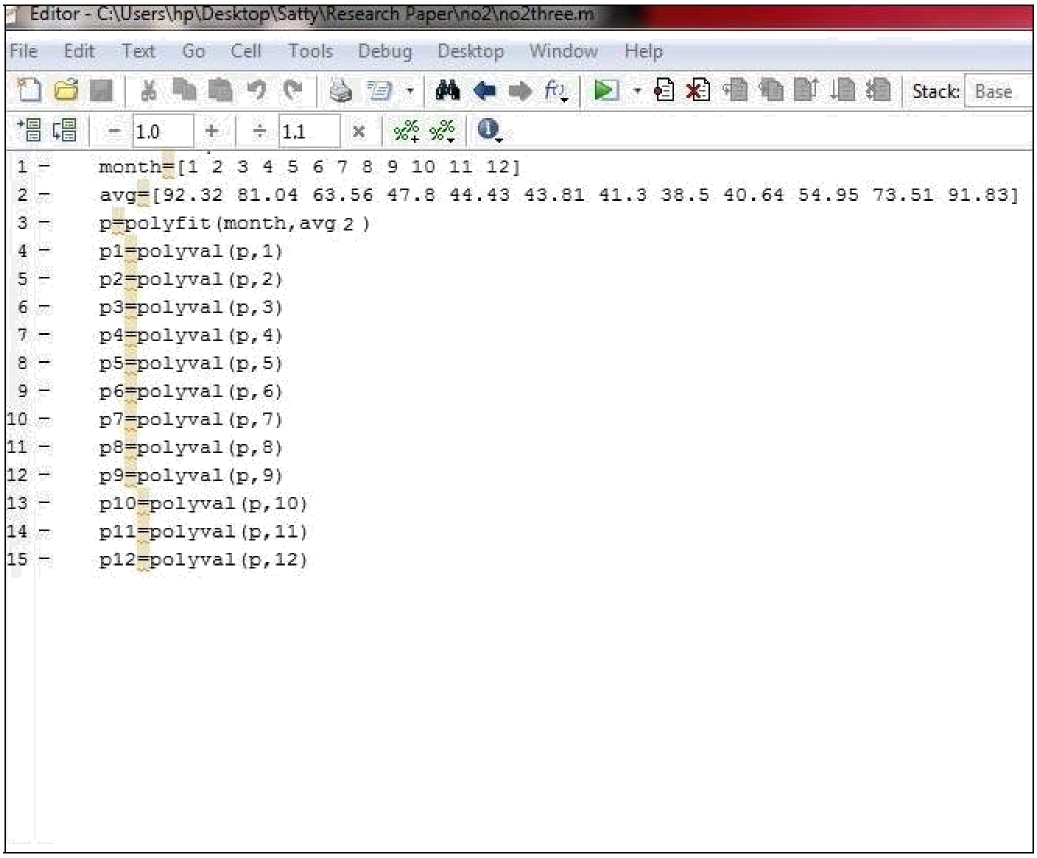


Fig. 6.3.1. MATLAB Code for first degree equation

6.3.2 Second Degree Equation



<u>Fig. 6.3.2 MATLAB Code for second degree equation</u>

6.3.3 Third Degree Equation

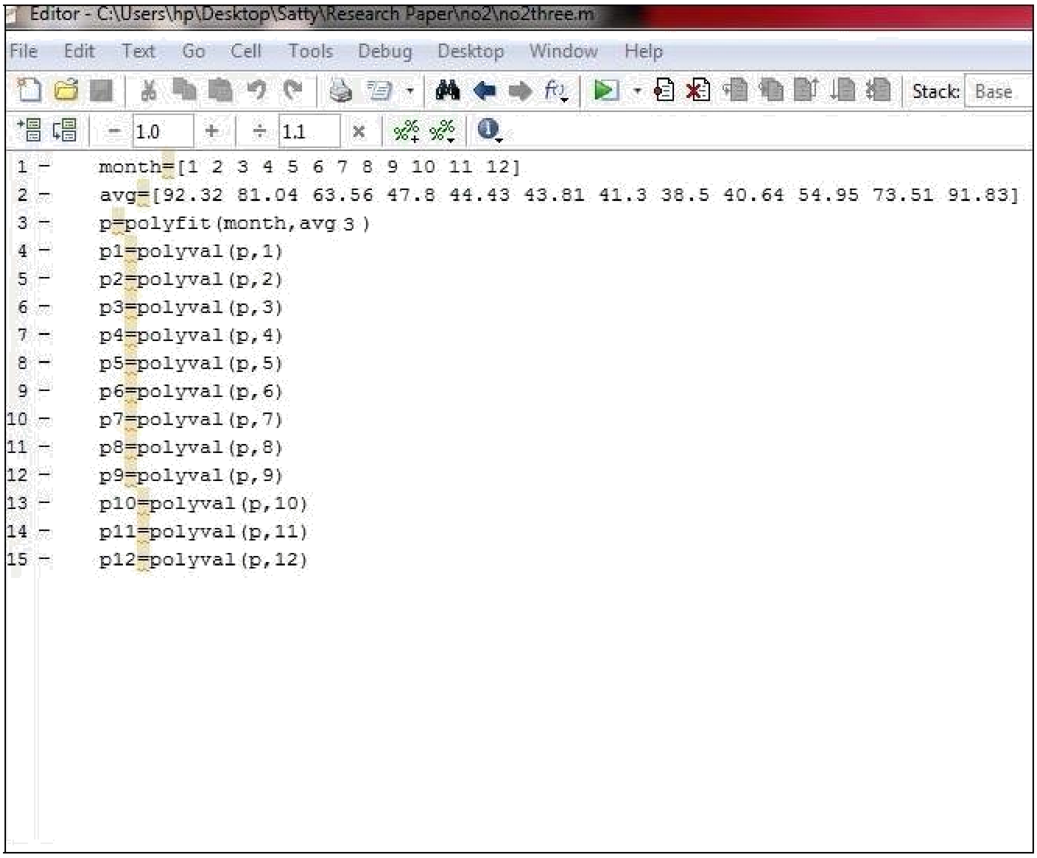


Fig. 6.3.3. MATLAB Code for third degree equation

CHAPTER 7

DATA

MONTH	2003	2004	2005	2006	2007	2008	2009	2010	AVG
January	82.24	74.5	93.9	96	95.1	91.9	98.9	106.0	92.3
February	71.85	73.3	91.9	74.2	76.4	81.1	87.1	92.5	81.04
March	58.46	51.9	63.7	59.0	65.6	69.7	69.9	70.2	63.56
April	46.4	44.3	39.4	43.7	43.9	62.7	51.8	50.2	47.8
May	42.3	46.6	37.6	41.9	48.4	52.42	43.6	42.6	44.43
June	40.80	51.1	36.3	45.9	42.7	44.10	45.8	43.8	43.81
July	36.6	40.9	36.7	44.4	43.8	47.49	41.1	39.4	41.3
August	36.4	30.1	40.9	42,4	39.9	44.8	35.1	38.4	38.5
September	42.9	31.8	37.9	44.9	43.7	43.8	42.8	37.3	40.64
October	46.7	47.2	48.9	62.2	56.6	65.5	62.9	49.6	54.95
November	73.4	77.2	77.9	72.2	62.5	87.8	71.4	66.7	73.51
December	82.9	100.3	101.2	84.9	84.8	94.5	105.9	80.1	91.83

Table 7.1. The average month wise data for NO2 (Source: Daily Ambient Air quality Information in terms of (µg/m³).

MONTH	2003	2004	2005	2006	2007	2008	2009	2010	Average
January	204	196	211	202	223	174	195	178	**198**
February	186	186	203	154	118	140	163	167	**165**
March	68	137	150	126	91	81	107	93	**107**
April	60	94	81	62	45	54	56	46	**62**
May	57	71	64	51	46	45	40	36	**51**
June	47	64	59	46	31	39	38	34	**45**
July	41	56	51	38	32	36	34	28	**40**
August	45	51	50	37	34	40	37	34	**38**
September	47	51	50	37	34	40	37	34	**41**
October	55	62	52	86	67	81	83	63	**69**
November	132	131	122	128	110	125	115	130	**124**
December	218	230	209	207	191	176	174	176	**198**

Table 7.2. The average month wise data for PM10 (Source: Daily Ambient Air quality Information (WBPCB) in terms of (µg/m³).

CHAPTER 8

RESULTS

8.1 Prediction of NO_2 using first degree equation

MONTH	AVERAGE	PREDICTION	OBSERVED(2011)	% ERROR
1	92.3	**93.8**	**94.67**	**0.92**
2	81.04	**78.7**	**81.42**	**3.34**
3	63.56	**63.6**	**60.68**	**-4.81**
4	47.8	**48.5**	**43.93**	**-10.4**
5	44.43	**45.05**	**40.98**	**-9.93**
6	43.81	**43.02**	**36.73**	**-17.13**
7	41.3	**40.99**	**31.74**	**-29.14**
8	38.5	**38.96**	**32.18**	**-21.07**
9	40.64	**39.41**	**37.8**	**-4.26**
10	54.95	**56.62**	**58.25**	**2.8**
11	73.51	**73.83**	**59.11**	**-24.9**
12	91.83	**91.04**	**127.4**	**28.54**

Table 8.1. Prediction of NO_2 using first degree equation

JAN-APR

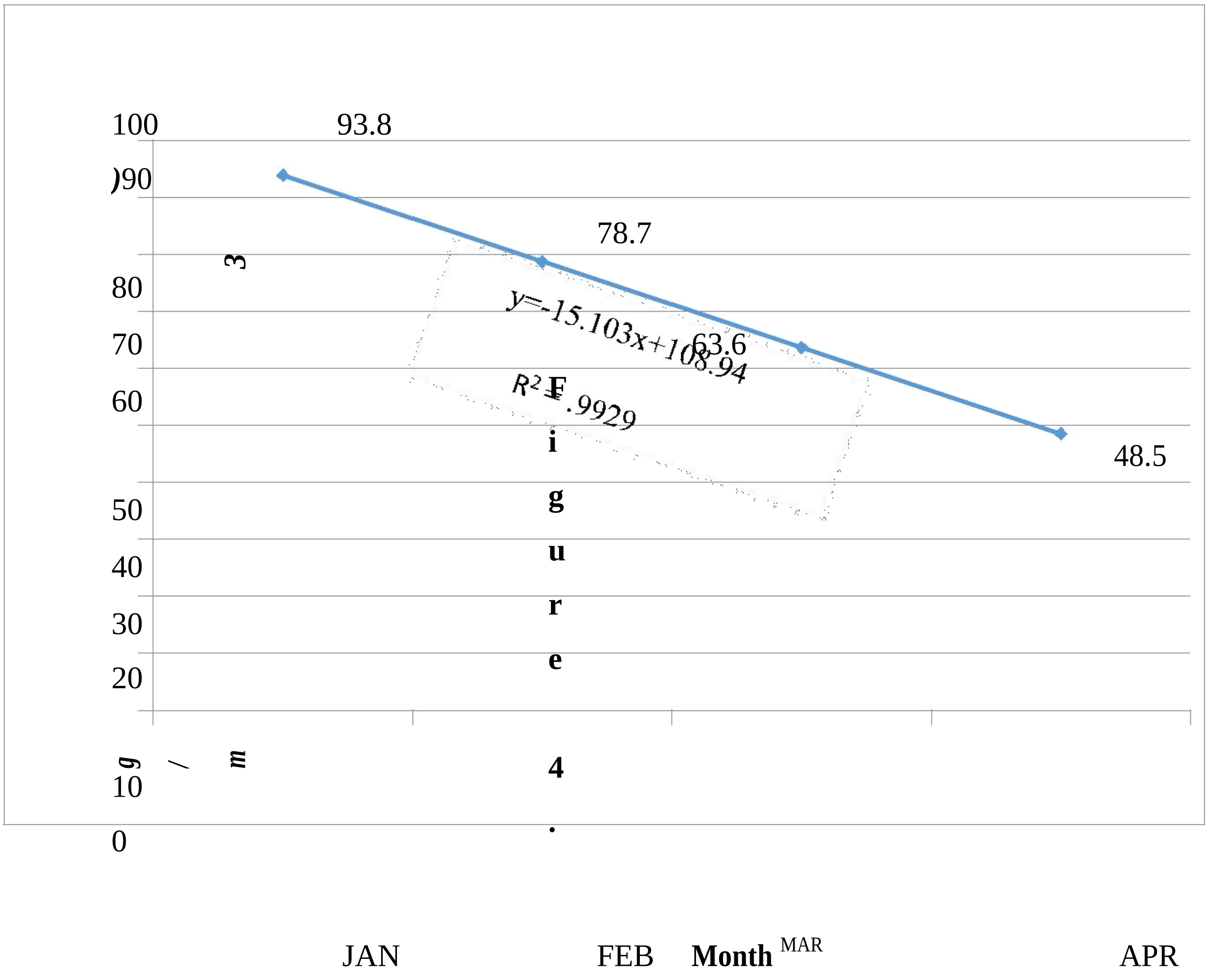
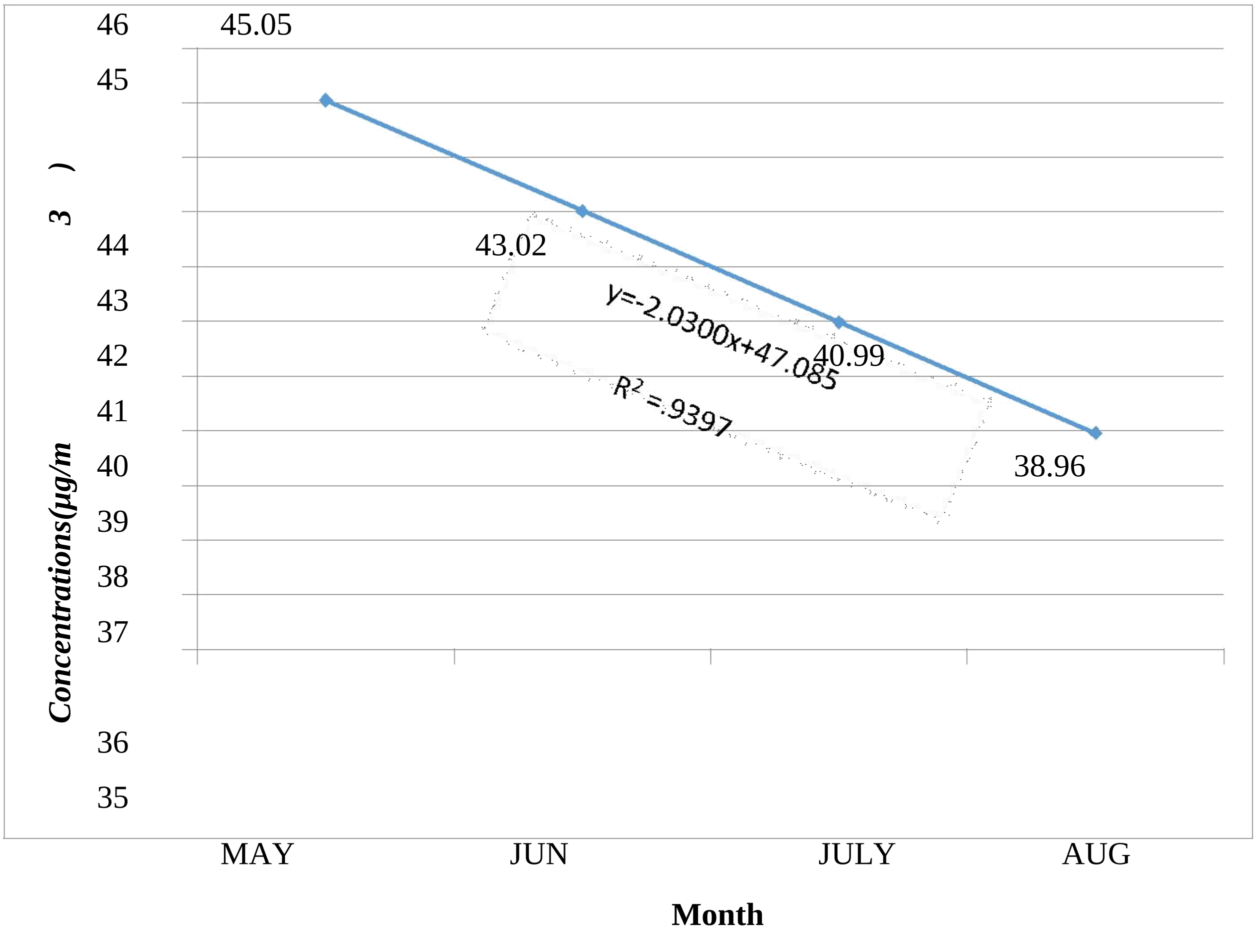


Fig 8.1.1 1st degree curve

MAY-AUG



<u>Fig 8.1.2 1st degree curve</u>

SEP-DEC

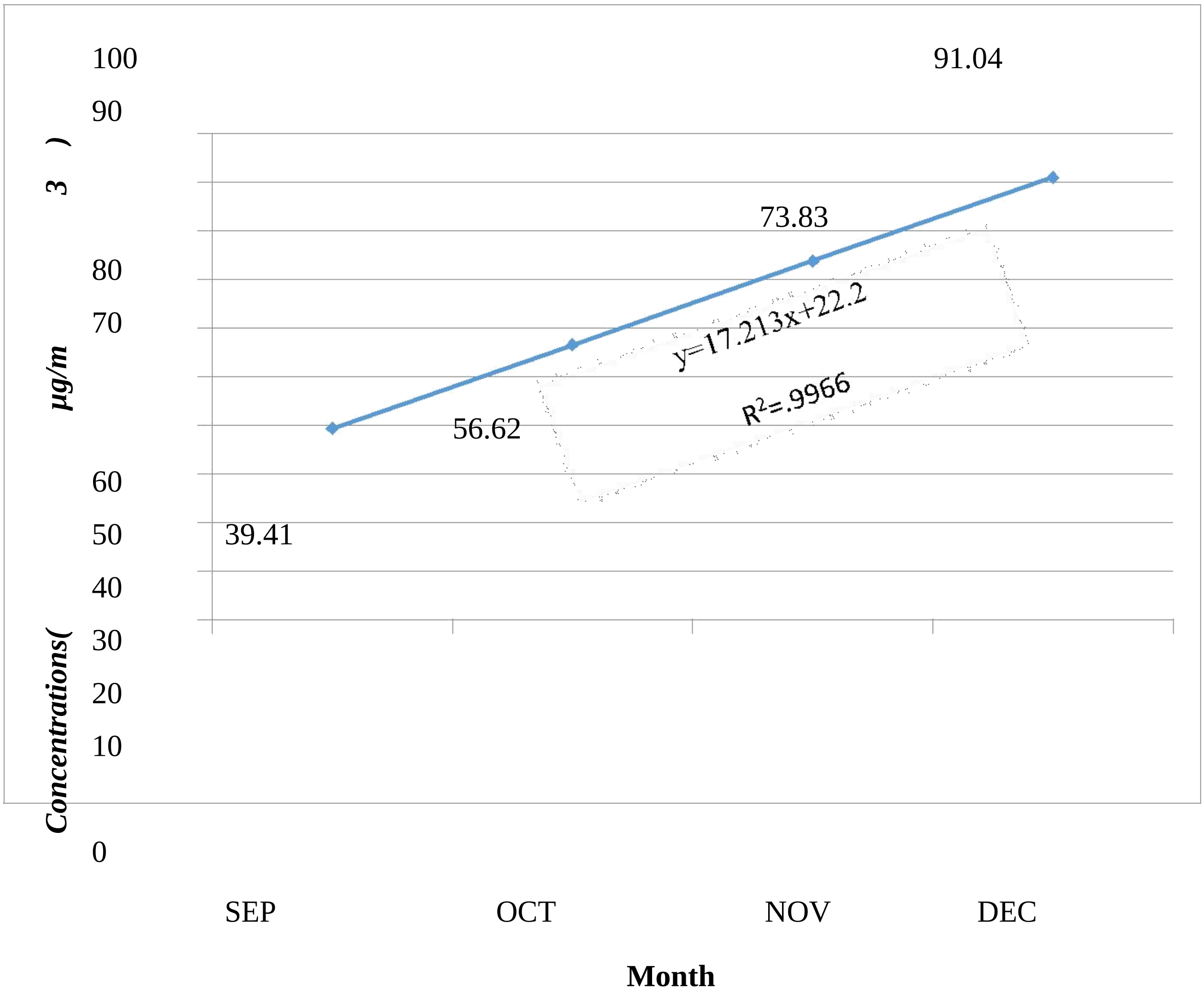


Fig 8.1.3 1st degree curve

8.2 Prediction of NO_2 using second degree equation

MONTH	AVERAGE	PREDICTION	OBSERVED(2011)	% ERROR
1	92.3	**96.17**	**94.67**	**-1.59**
2	81.04	**77.48**	**81.42**	**4.84**
3	63.56	**62.39**	**60.68**	**-2.81**
4	47.8	**50.90**	**43.93**	**-15.87**
5	44.43	**43.3**	**40.98**	**-4.99**
6	43.81	**38.76**	**36.72**	**-5.55**
7	41.3	**38.09**	**31.73**	**-20.06**
8	38.5	**41.04**	**32.17**	**-27.57**
9	40.64	**47.59**	**37.77**	**-26**
10	54.95	**57.75**	**59.66**	**3.2**
11	73.51	**71.52**	**59.1**	**21.1**
12	91.83	**88.89**	**127.4**	**30.23**

Table 8.2 Prediction of NO_2 using second degree equation

8.3 Prediction of NO_2 using third degree equation

MONTH	AVERAGE	PREDICTION	OBSERVED(2011)	% ERROR
1	92.3	**92.99**	**94.6**	**1.7**
2	81.04	**77.77**	**81.42**	**4.49**
3	63.56	**64.41**	**60.68**	**-6.15**
4	47.8	**53.32**	**43.93**	**-21.36**
5	44.43	**44.86**	**40.98**	**-9.48**
6	43.81	**39.44**	**36.72**	**-7.41**
7	41.3	**37.44**	**31.73**	**-17.98**
8	38.5	**39.23**	**32.17**	**-21.95**
9	40.64	**45.21**	**37.77**	**-19.71**
10	54.95	**55.77**	**59.66**	**6.52**
11	73.51	**71.29**	**59.1**	**-20.62**
12	91.83	**92.15**	**127.40**	**27.67**

Table 8.3 Prediction of NO_2 using third degree equation

8.4 Prediction of PM_{10} using first degree equations

MONTH	AVERAGE	PREDICTION	OBSERVED(2011)	% ERROR
1	**198**	**203**	**207**	**2.16**
2	**165**	**156**	**174**	**10.32**
3	**107**	**110**	**100**	**-9.56**
4	**62**	**63**	**67**	**5.85**
5	**51**	**50**	**46**	**-8.91**
6	**45**	**46**	**40**	**-14.10**
7	**40**	**41**	**34**	**-21.12**
8	**38**	**37**	**32**	**-14.75**
9	**41**	**29**	**42**	**30.43**
10	**69**	**82**	**153**	**23.66**
11	**124**	**134**	**162**	**17.20**
12	**198**	**187**	**210**	**11.14**

Table 8.4. Prediction of PM_{10} using first degree equation

JAN-APR

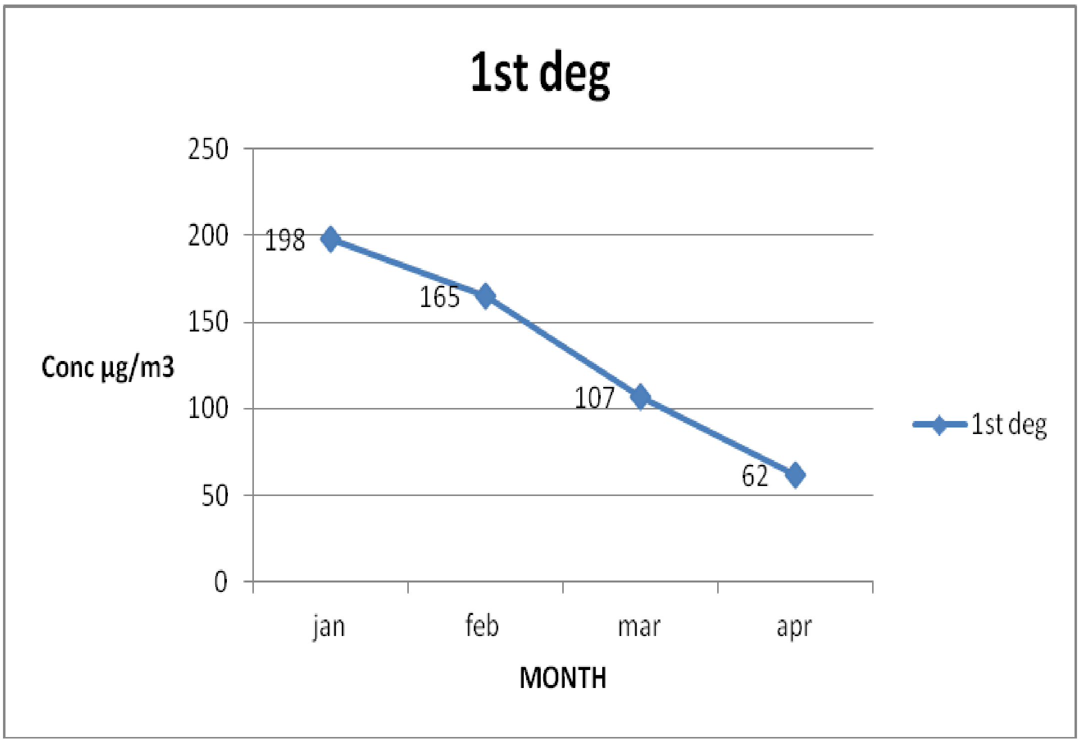


Fig. 8.4.1 1st degree curve

MAY-AUG

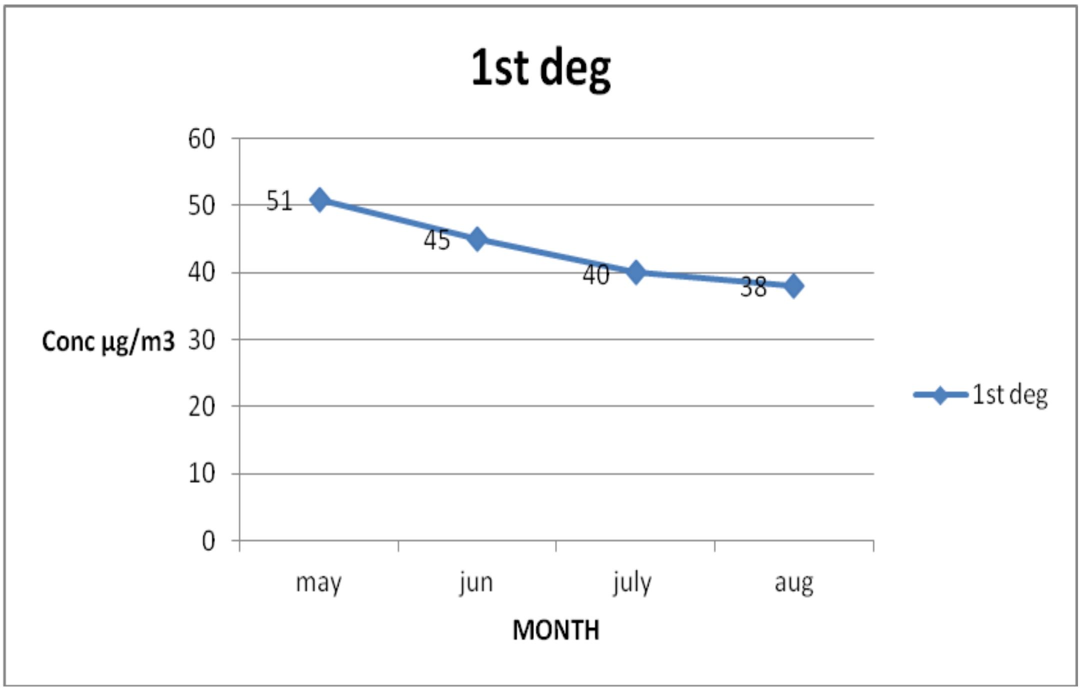


Fig 8.4.2 1st degree curve

SEP-DEC

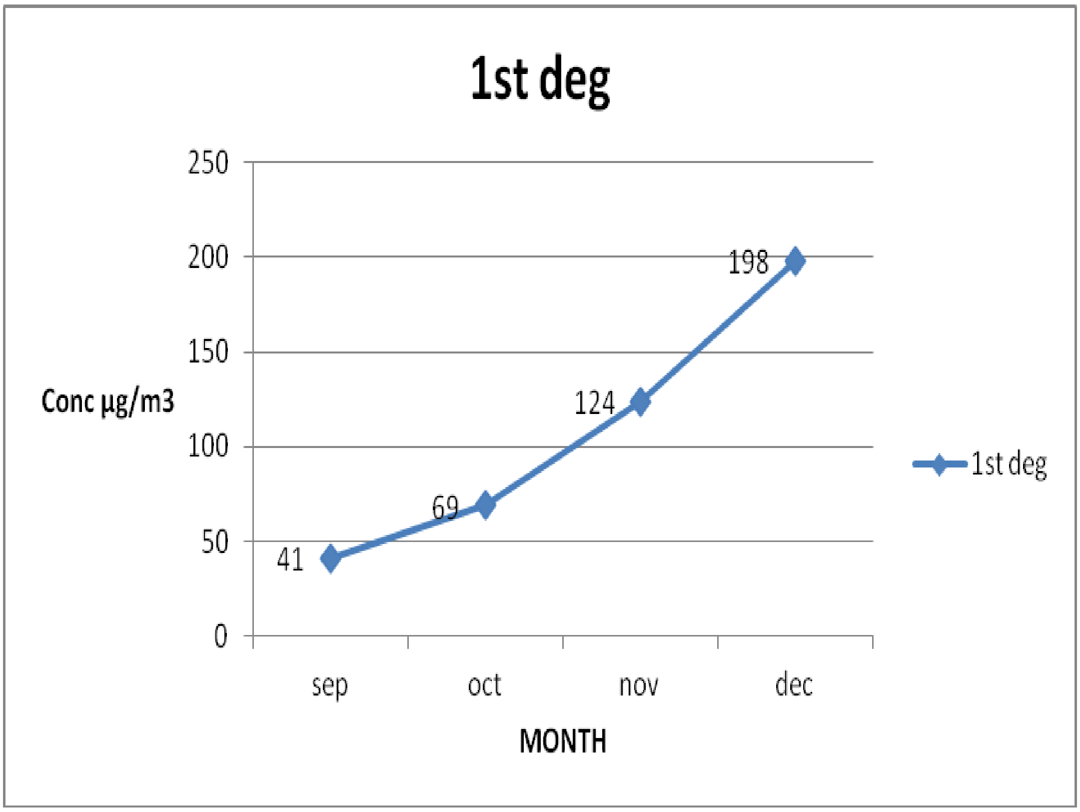


Fig. 8.4.3 1st degree curve

8.5 Prediction of PM_{10} using second degree equation

MONTH	AVERAGE	PREDICTION	OBSERVED(2011)	% ERROR
1	**198**	**210**	**207**	**-1.48**
2	**165**	**153**	**174**	**12.24**
3	**107**	**106**	**100**	**-6.25**
4	**62**	**71**	**67**	**-5.57**
5	**51**	**46**	**46**	**-0.29**
6	**45**	**32**	**40**	**18.83**
7	**40**	**30**	**34**	**12.57**
8	**38**	**38**	**32**	**-18.47**
9	**41**	**57**	**42**	**-35.76**
10	**69**	**87**	**153**	**43.1**
11	**124**	**128**	**162**	**20.98**
12	**198**	**180**	**210**	**14.33**

Table 8.5 Prediction of PM_{10} using second degree equation

8.6 Prediction of PM_{10} using third degree equation

MONTH	AVERAGE	PREDICTION	OBSERVED(2011)	% ERROR
1	**198**	**199**	**207**	**3.87**
2	**165**	**154**	**174**	**11.67**
3	**107**	**113**	**100**	**-13.3**
4	**62**	**79**	**67**	**-18.09**
5	**51**	**53**	**46**	**-14.17**
6	**45**	**35**	**40**	**12.94**
7	**40**	**27**	**34**	**19.45**
8	**38**	**32**	**32**	**1.42**
9	**41**	**49**	**42**	**-15.83**
10	**69**	**80**	**153**	**47.69**
11	**124**	**127**	**162**	**21.58**
12	**198**	**191**	**210**	**9.03**

Table 8.6 Prediction of PM_{10} using third degree equation

CHAPTER 9

SHIMLA DATA

9.1 NO_x (Station 1)

.

Month	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Avg
Jan	5.33	4.97	6.2	6.5	5.2	6.5	6.9	6.3	9.4	6.36
Feb	4.17	14.42	5.21	8	6.5	8.5	9.8	7.2	8.5	8.03
Mar	3.6	10.4	6	6.5	6.2	8.5	7.4	9.4	9.2	7.46
Apr	15.34	5.68	11.27	6.5	4.7	8.7	8.9	7.3	9.1	8.61
May	16.49	5.03	11.12	7.2	5.1	7.5	8.8	8.2	10.1	8.83
June	15.39	4.06	9.94	7.5	6	7.2	9.9	10.4	6.2	8.51
July	9.8	5.9	5.77	6.2	6.4	5.3	10.3	8.6	12	7.80
Aug	8.47	6.43	6.12	6.8	8.7	5.5	11.2	8.3	9.1	7.84
Sep	10.29	7.1	7.54	5.4	9.6	6.4	8.1	9.5	8.9	8.09
Oct	9.82	6.69	12.51	6.9	7.3	6.6	9.2	9.7	10.6	8.82
Nov	8.2	11.36	6.36	12.1	6.8	8.5	10.1	8.2	8.4	8.89
Dec	5.76	6.82	4.57	8.9	6.4	8.8	8.3	7.5	10.7	7.52

Table 9. 1. The average month wise data for NO_x(Source: Daily Ambient Air quality Information in terms of (µg/m³)

9.2 NO_x (Station 2)

Month	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Avg
Jan	7.93	5.65	16	14.4	9.5	14.9	17.1	14.8	12.4	12.52
Feb	6.96	14.28	8.9	11	10.7	15.1	18.8	14.1	12.2	12.44
Mar	5.41	15.57	8.7	9.1	7.9	14.4	15.3	15.1	12.6	11.56
Apr	29.19	7.57	20.14	8.5	8.9	8.7	17.1	14.4	16	14.5
May	24.2	7.05	21.34	9.5	8.7	14.1	18.8	18.9	19.6	15.78
June	23.09	4.15	60.36	8.9	11.7	11.2	15.3	16.7	8.8	17.8
July	21.11	7.26	8.79	10.8	12.5	8.6	18.2	16.2	10.6	12.67
Aug	15.5	9.35	10.93	9.5	8.7	11.4	16.2	15.7	11.1	12.04
Sep	17.91	10.63	14.64	10.6	9.6	11.2	16.5	17.4	12.8	13.47
Oct	13.36	9.49	24.66	13.2	12.4	13.1	16.8	17.5	11.3	14.64
Nov	12.04	6.01	16.62	18.5	9	14	19.2	16.7	12.8	13.87
Dec	9.09	10.49	14.82	11.7	6.4	18	18.7	17.9	12.5	13.28

Table 9.2. The average month wise data for NO_x(Source: Daily Ambient Air quality Information in terms of ($\mu g/m^3$).

9.3 SO_2(Station 2)

Month	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Avg
Jan	2.62	1.98	5.3	3.9	2.9	2.6	3.8	2	2	3.01
Feb	2.28	4.44	4	2.6	3.6	3.9	3	2	2	3.09
Mar	1.92	8.34	4	2.8	3.1	4.1	3.4	2	2	3.51
Apr	7.09	2.74	8.69	3.3	5	3.9	4.2	2	2	4.32
May	7.31	2.5	11.43	3.3	3	3.7	3.7	2	2	4.32
Jun	6.87	1.71	14.03	2.8	2.9	2.6	3	2	2	4.21
July	6.73	2.37	4.98	4.2	3.3	2.5	2.6	2	2	3.4
Aug	4.93	2.49	6.63	3.3	2.8	2.4	3.5	2	2	3.33
Sep	4.86	3.22	7.5	4.5	2.9	2.7	3.5	2	2	3.68
Oct	3.89	2.91	10.92	5.7	2.8	3	3.7	2	2	4.10
Nov	3.74	2.09	5.3	4.3	3.6	3.1	4.5	2	2	3.4
Dec	3.02	3.36	3.12	3	2.5	4.6	3.6	2	2	3.02

Table 9.3. The average month wise data for SO_2 (Source: Daily Ambient Air quality Information in terms of (μg/m³).

9.4 <u>SO_2 (Station 1)</u>

Month	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Avg
Jan	2.25	1.62	2.13	3.4	2.5	2.6	2.8	2	2	2.36
Feb	2.1	3.93	2.4	3.2	2.5	2.3	2.5	2	2	2.54
Mar	1.43	5.39	3	3	2.9	2.1	2.6	2	2	2.71
Apr	4.53	1.83	6.03	2.9	2.7	3.3	2.5	2	2	3.08
May	4.46	1.95	5.57	2.7	3.1	2.8	2.3	2	2	2.98
June	4.27	1.46	4.38	2.7	3.1	2.2	3.3	2	2	2.82
July	3.71	1.85	2.46	3.7	2.6	2.1	2.5	2	2	2.54
Aug	2.68	1.87	3.05	3.4	2.8	2.5	2.9	2	2	2.57
Sep	3.33	2.2	4.05	4.2	2.9	2.5	2.8	2	2	2.88
Oct	3.89	2.18	7.11	4.2	2.4	2.5	2.6	2	2	3.2
Nov	2.78	3.31	2.52	4	2.2	2.7	2.9	2	2	2.71
Dec	1.8	2.19	2.09	2.4	2.5	2.7	2.3	2	2	2.22

<u>Table 9.4. The average month wise data for SO_2. (Source: Daily Ambient Air quality Information in terms of (µg/m³).</u>

9.5 **RSPM (STATION 1)**

Month	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Avg
Jan	40.5	34	51.4	41	45	36	41.6	41.35
Feb	28.8	52	56	50	55	52	40.3	47.72
Mar	41	61	83	67	59	71	44.6	60.94
Apr	58.96	62	62	78	80	73	55.2	67.02
May	67.84	67	73	79	82	65	71.9	72.24
June	67.69	60	45	90	82	66	86.1	70.97
July	33.19	31	40	49	41	40	50.1	40.61
Aug	25.01	28	57	45	33	31	31.5	35.78
Sep	27.24	32	51.5	39	28	30	24.1	33.12
Oct	29.83	43	47	48	55	45	38.2	43.71
Nov	28.65	53	36.7	51	53	47	43.8	46.16
Dec	34.4	49	41.8	83	55	33	41.3	48.21

Table 9.5. The average month wise data for RSPM (Source: Daily Ambient Air quality Information in terms of ($\mu g/m^3$).

9.6 **RSPM (Station 2)**

Month	06-07	07-08	08-09	09-10	10-11	11-12	12-13	Avg
Jan	67.5	58.75	53	57	52	66	57	58.75
Feb	59	89	60.3	60	54	70	45.4	62.52
Mar	53	68	87.3	68	63	99	48	69.47
Apr	59.91	67	62	68	81	68	61.5	66.77
May	89.77	70	73	145	79	43	81.7	83.06
Jun	77.6	65	65	92	78	76	122.2	82.25
July	48.1	47	60	56	52	51	68.9	54.71
Aug	38.31	41	57	52	57	37	33	45.04
Sep	42.66	44	51.5	50	34	43	30.9	42.29
Oct	50.29	38	62	59	52	59	40.3	51.52
Nov	79.26	58.27	46.6	56	56	57	54.8	58.27
Dec	73.03	55.70	51.3	67	46	49	47.9	55.70

Table 9.6. The average month wise data for RSPM (Source: Daily Ambient Air quality Information in terms of (µg/m³).

CHAPTER 10

RESULTS

10.1 Prediction of NO2 using (Station 1)

MONTH	AVERAGE	PREDICTIONS(Linear)	PREDICTIONS(2nd degree)	PREDICTIONS(3rd degree)
1	6.36	6.69	6.98	6.71
2	8.03	7.31	7.41	7.43
3	7.46	7.92	7.76	7.94
4	8.61	8.54	8.05	8.26
5	8.83	8.8	8.2	8.43
6	8.51	8.43	8.41	8.47
7	7.80	8.06	8.49	8.43
8	7.84	7.69	8.5	8.34
9	8.09	8.56	8.45	8.24
10	8.82	8.39	8.3	8.14
11	8.89	8.21	8.12	8.1
12	7.52	8.09	7.8	8.13

Table 10.1 Prediction of NO_2 station 1

JAN-APR

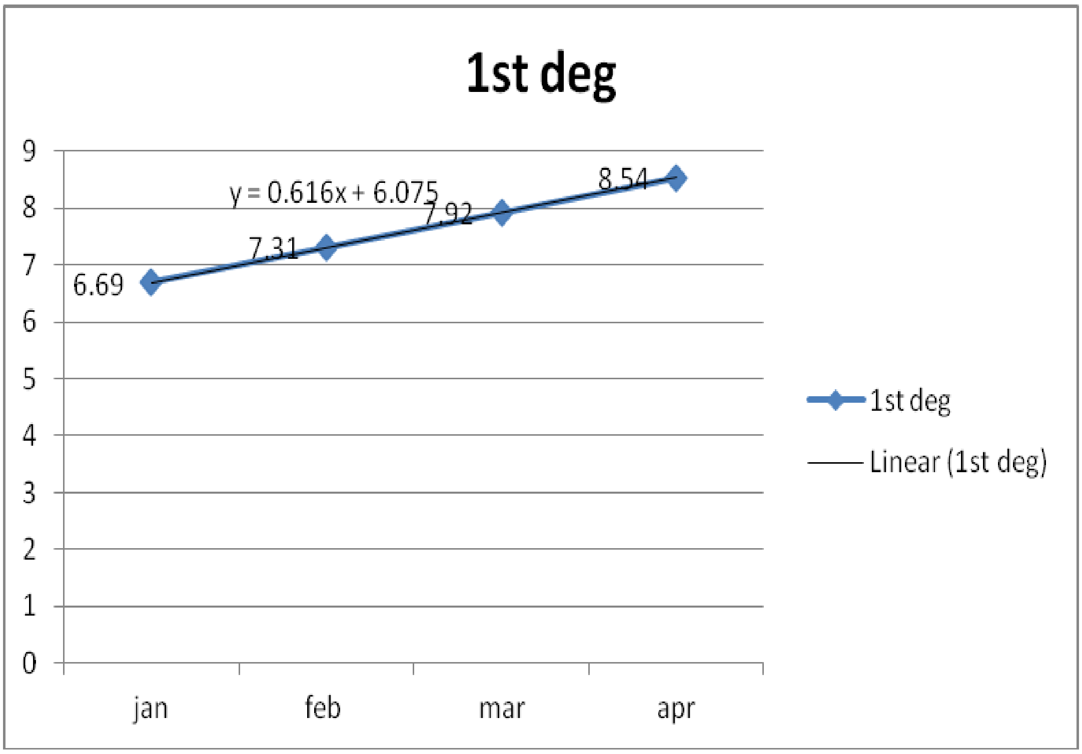


Fig. 10.1.1 1ST degree curve

MAY-AUG

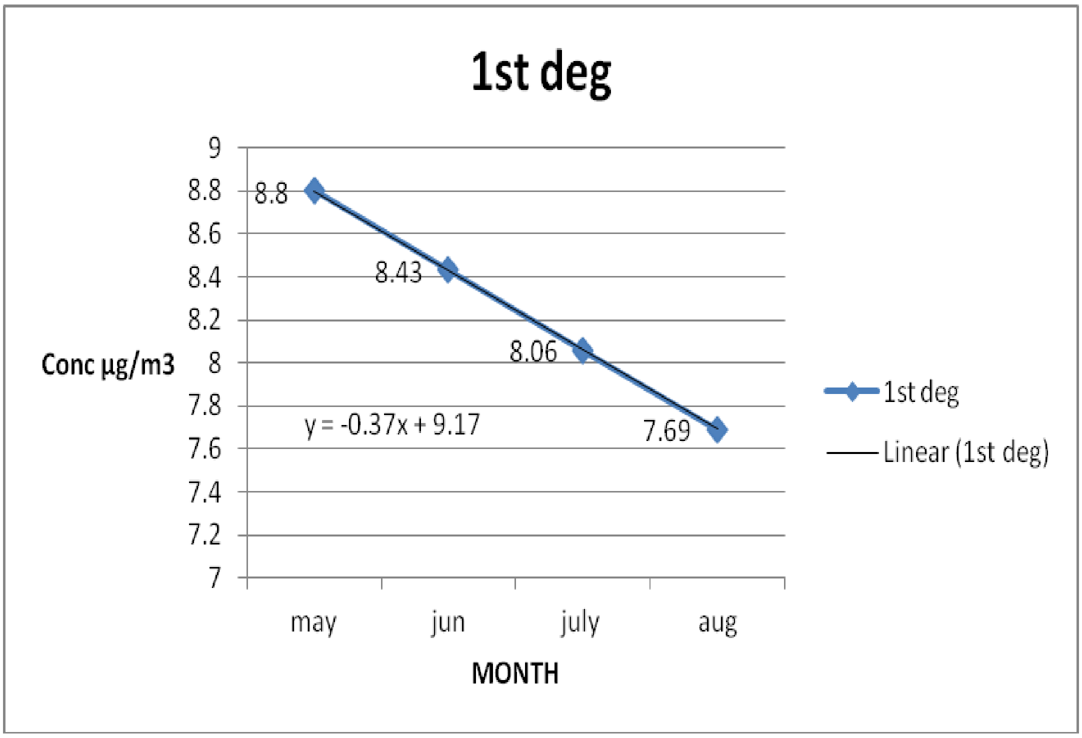


Fig. 10.1.2 1st degree curve

SEP-DEC

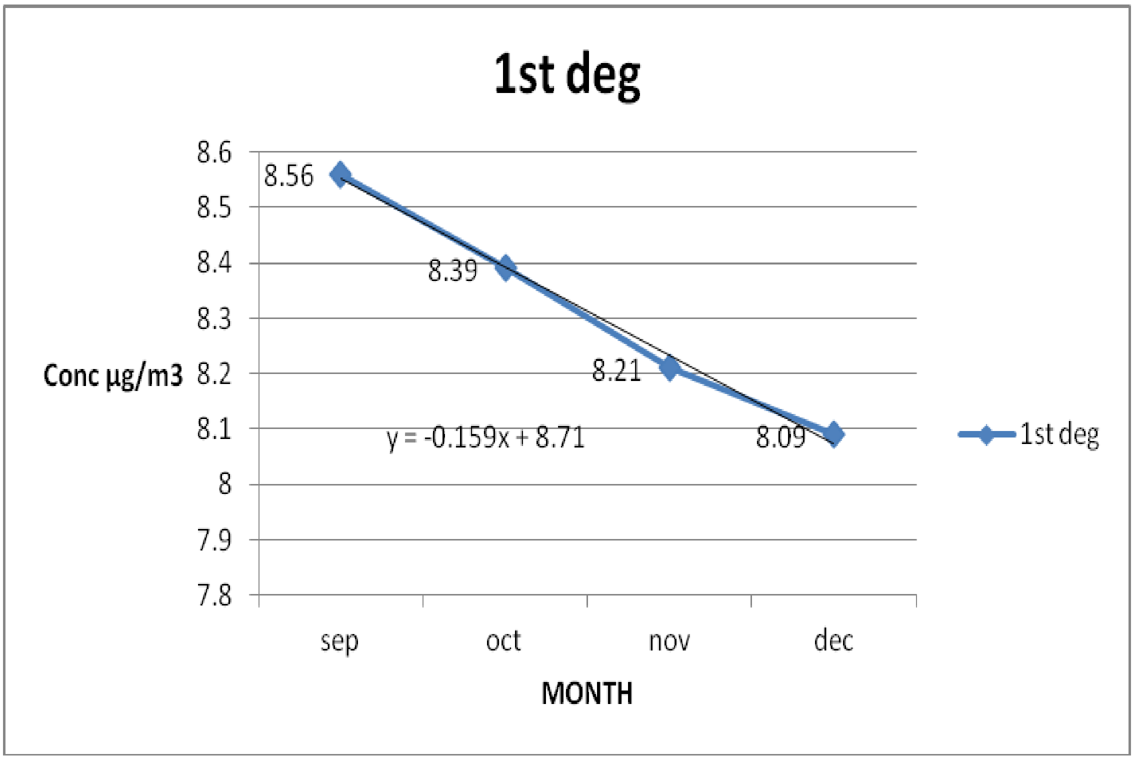


Fig. 10.1.3 1st degree curve

10.2 Prediction of NO_2 (Station 2)

MONTH	AVDERAGE	PREDICTION	PREDICTION (2ND DEGREE)	PREDICTION (3RD DEGREE)
1	12.52	59.72	65.49	53.84
2	12.44889	62.82	66.19	67.25
3	11.56444	65.92	66.43	73.84
4	14.5	69.02	66.2	75.02
5	15.79889	87.5	65.52	72.22
6	17.8	73.34	64.37	66.84
7	12.67333	59.18	62.75	60.28
8	12.04222	45.02	60.68	53.97
9	13.47556	44.89	58.14	49.32
10	14.64556	49.59	55.13	47.72
11	13.87444	54.29	51.67	50.61
12	13.28889	58.99	47.74	59.38

Table 10.2 Prediction of NO_2 over station 2

JAN-APR

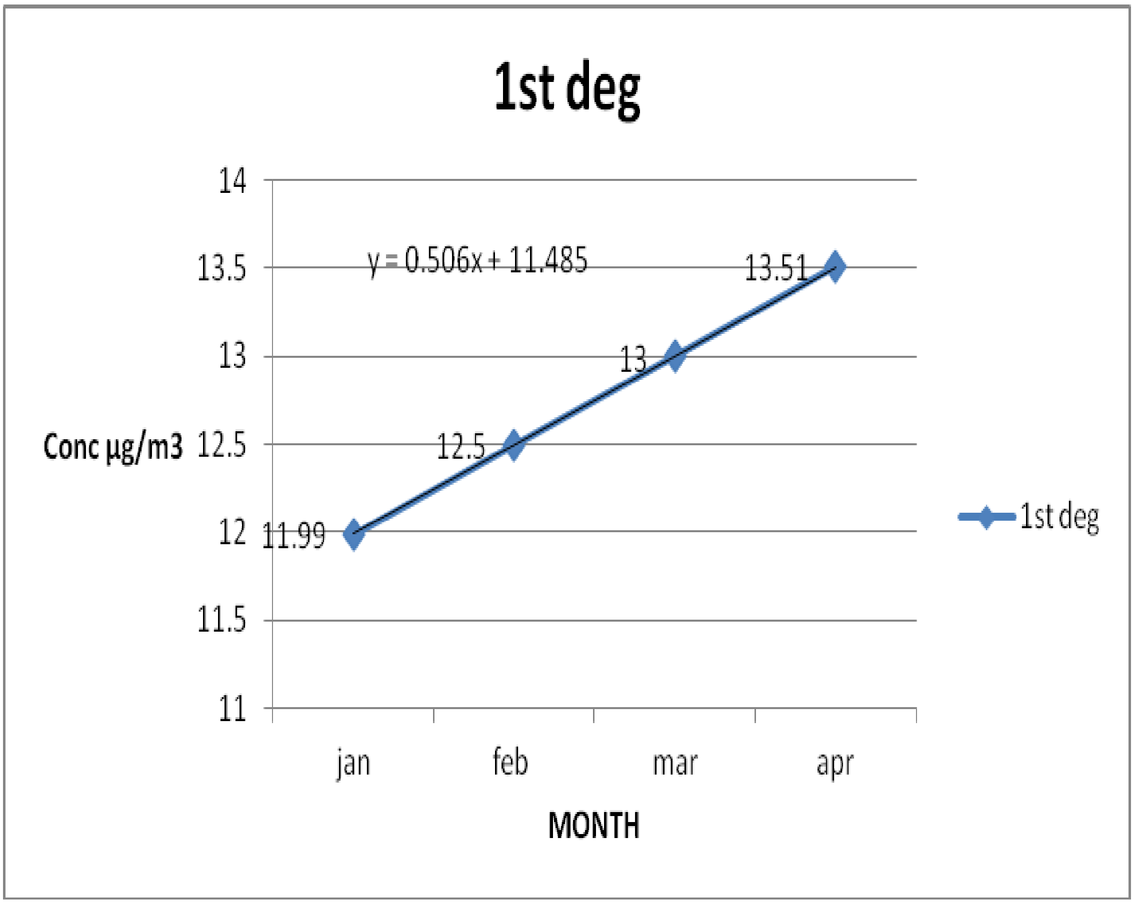


Fig 10.2.1 1st degree curve

MAY-JUN

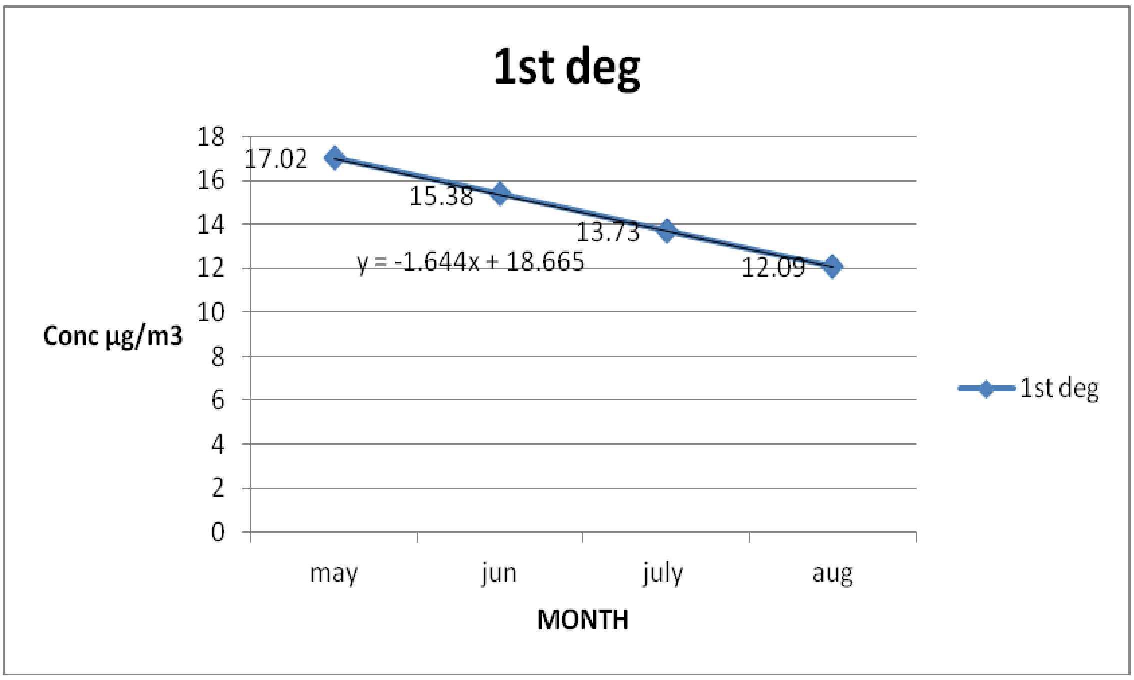


Fig 10.2.2 1st degree curve

SEP- DEC

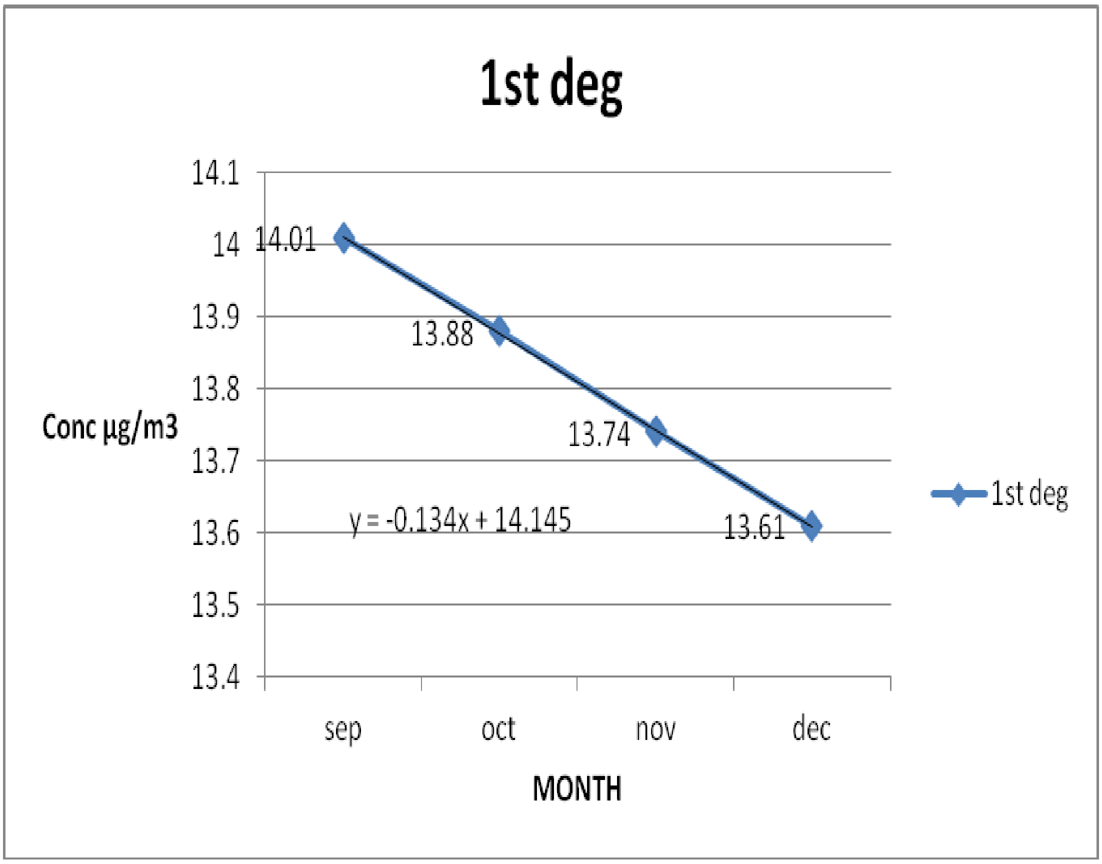


Fig 10.2.3 1st degree curve

10.3 Prediction of SO_2 (Station 1)

MONTH	AVERAGE	PREDICTION	PREDICTION (2^{ND} DEGREE)	PREDICTION (3^{RD} DEGREE)
1	2.366667	2.323	2.42	2.425
2	2.547778	2.556	2.57	2.576
3	2.713333	2.789	2.7	2.698
4	3.087778	3.02	2.79	2.792
5	2.986667	2.954	2.85	2.85
6	2.823333	2.803	2.89	2.89
7	2.546667	2.652	2.89	2.89
8	2.577778	2.501	2.86	2.87
9	2.886667	3.123	2.81	2.81
10	3.208889	2.876	2.72	2.72
11	2.712222	2.629	2.6	2.6
12	2.22	2.382	2.45	2.45

Table 10.3 Prediction of SO_2 over station 1

10.4 Prediction of SO_2 (Station 2)

MONTH	AVERAGE	PREDICTION	PREDICTION (2^{ND} DEGREE)	PREDICTION (3^{RD} DEGREE)
1	3.011111	2.83	3.053	2.876
2	3.091111	3.265	3.359	3.375
3	3.517778	3.7	3.605	3.717
4	4.324444	4.13	3.789	3.922
5	4.326667	4.382	3.911	4.013
6	4.212222	4	3.973	4.01
7	3.408889	3.626	3.973	3.936
8	3.338889	3.24	3.912	3.81
9	3.686667	3.952	3.7899	3.65
10	4.102222	3.684	3.606	3.49
11	3.403333	3.416	3.3613	3.34
12	3.022222	3.148	3.055	3.231

Table 10.4 Prediction of SO_2 station 2

10.5 **Prediction of RSPM (Station 1)**

MONTH	AVERAGE	PREDICTION	PREDICTION(2ND DEGREE)	PREDICTION (3RD DEGREE)
1	41.35714	40.72	51.49	36.46
2	47.72857	49.74	53.61	54.98
3	60.94286	58.76	55.04	64.61
4	67.02286	67.79	55.8	67.19
5	72.24857	75.86	55.87	64.53
6	70.97	61.88	55.26	58.45
7	40.61286	47.9	53.97	50.78
8	35.78714	33.93	52.01	43.35
9	33.12	35.64	49.36	37.96
10	43.71857	40.41	46.03	36.46
11	46.16429	45.18	42.01	40.65
12	48.21429	49.95	37.32	52.36

Table 10.5 Prediction of RSPM station 1

JAN-APR

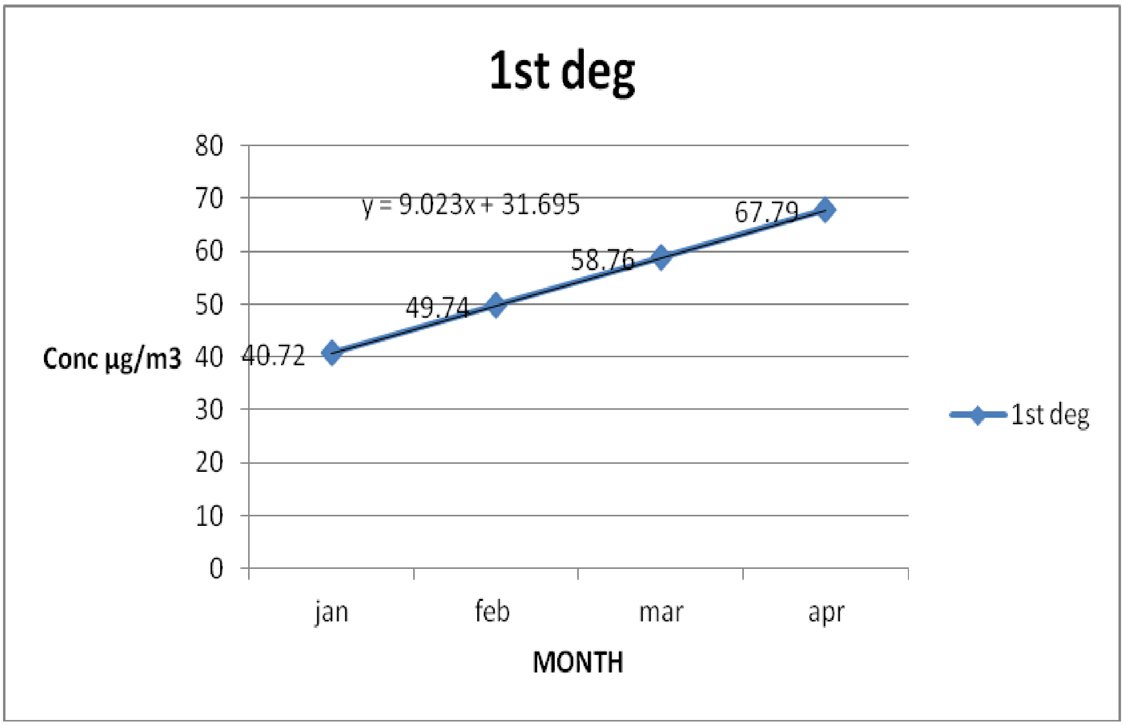


Fig. 10.5.1 Prediction of RSPM station 1

MAY-AUG

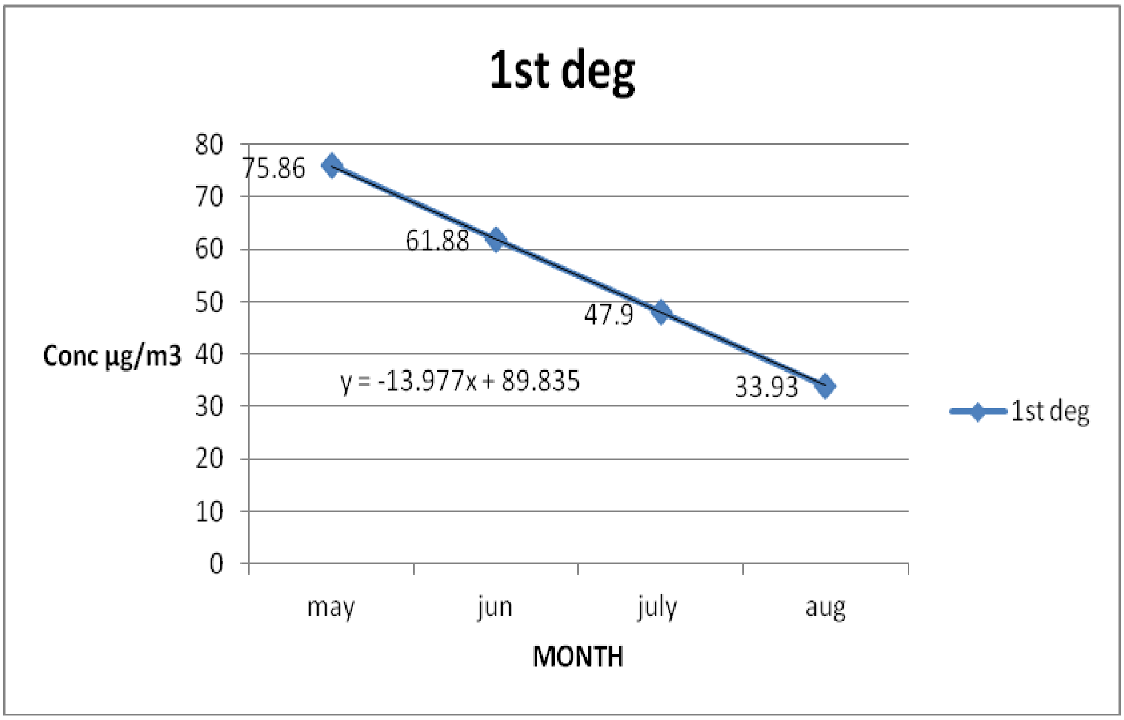


Fig. 10.5.2 Prediction of RSPM station 1

SEP-DEC

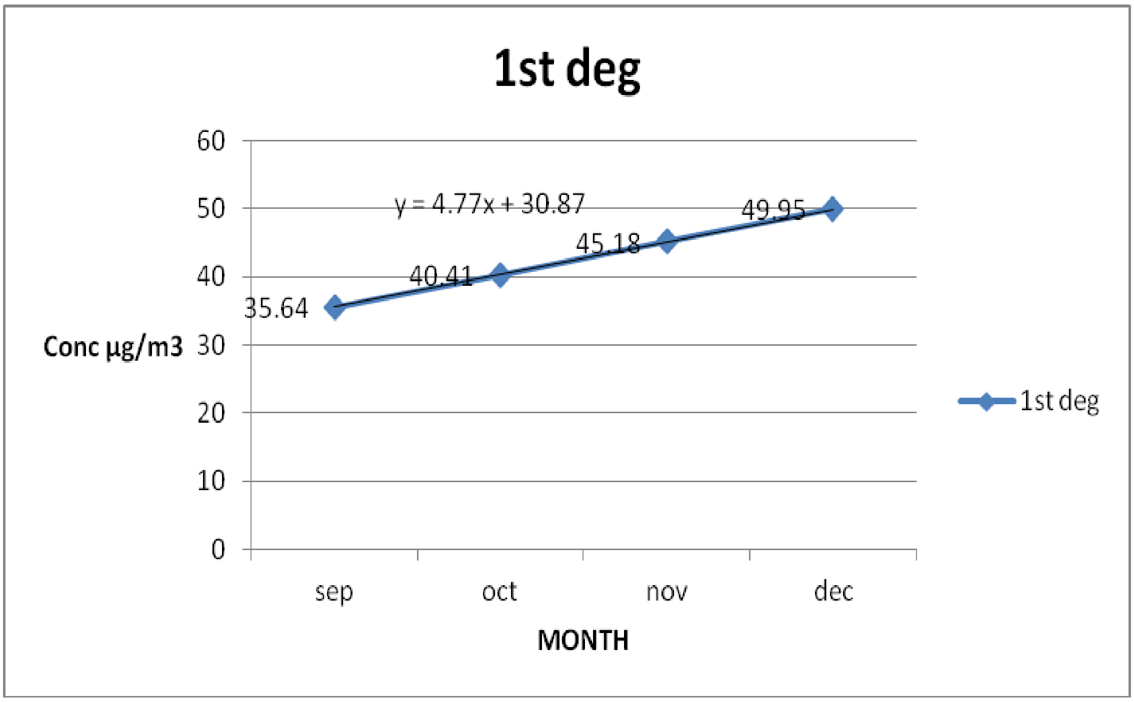


Fig. 10.5.3 Prediction of RSPM station 1

10.6 Prediction of RSPM (Station 2)

MONTH	AVERAGE	PREDICTION	PREDICTION(2ND DEGREE)	PREDICTION(3RD DEGREE)
1	58.75	59.72	65.49	53.84
2	62.52857	62.82	66.19	67.25
3	69.47143	65.92	66.43	73.84
4	66.77286	69.02	66.2	75.02
5	83.06714	87.5	65.52	72.22
6	82.25714	73.34	64.37	66.84
7	54.71429	59.18	62.75	60.28
8	45.04429	45.02	60.68	53.97
9	42.29429	44.89	58.14	49.32
10	51.52714	49.59	55.13	47.72
11	58.27571	54.29	51.67	50.61
12	55.705	58.99	47.74	59.38

Table 10.6 Prediction of RSPM station 2

CHAPTER 11

DISCUSSION

These primary data have been used to get non-linear curve for each case. We then use MATLAB to predict their concentrations by second degree, third degree equation. The results thus obtained are quite good except in a few cases, as in the case of first degree equations. So for obtaining better result in terms of accuracy, we have again divided the entire data into three segments *i.e.* from January-April, May-August and September-December. In each case we get linear equations and the predictions made are quite encouraging.

It has been found that the best predictions for some of the parameters are obtained sometimes for second degree, sometimes for third degree and sometimes for first degree curves but no unique curve is obtained to make best predictions for all the three parameters.

CHAPTER 12

CONCLUSION

As different parameters are involved for dispersion of pollutants in atmosphere, it is not possible to achieve 100% accuracy for prediction in most of the cases due to different climatic parameters, sampling errors etc. Our study involves the prediction of major three types of pollutants and tries to give an idea about their levels which may help many future activities. If we follow the method given in our paper we find that instead of collecting all types of data, we need to measure only two types of parameters depending on the time periods. For example, prediction of PM10 can be made using the value of any one of the parameters NO_2 and SO_2. However, it is interesting to observe that prediction of PM10 is more accurate when only the value of NO_2 is used instead of SO_2. Thus during the process of data collection if sample of NO_2 is only collected, our purpose would be served and, consequently, the cost involved in the field work to collect samples can be significantly reduced. As we know SO_2, NO_2 and PM10 have very negative impact of on our society; their predictions may help us adopt necessary preventive measure time to time to ensure better living conditions.

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