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Effect of Meteorological Conditions on Air Pollution of Surat City[#]

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Abstract: Meteorology is the science of the atmosphere and study of the characteristics of the weather elements and meteorological conditions including certain meteorological parameters like Wind Speed, Wind Direction, Temperature, Atmospheric Stability, Mixing Height etc. Generally, the degree to which air pollutants discharged from various sources, concentrate into a particular area depends on meteorological conditions. So, the knowledge of these meteorological parameters which influence the dispersion process of air pollutants will give certain results like whether the air pollutants will be diluted in to the atmosphere or they just simply tend to concentrate on to the ground. Based on this aspect the present study has been conducted with the objectives like observation of the weather and the meteorological parameters of specific area of the city, to correlate meteorological conditions (wind speed, wind direction and temperature) with present Air Quality of selected area and to determine which parameter mainly affects air pollutants dispersion. So, for fulfilment of the same we have selected two stations, first is the monitoring station (which will serve as source station from where air pollutants are emitted) and the other is the dilution station (this station is selected 6 to 7 kms far towards North from the source station) looking to the wind rose diagram. The air quality parameters and the meteorological parameters which we are going to measure are as follows. Air Quality Parameters: NO_x, SO_2, SPM. Meteorological Parameters: Wind Speed, Wind Direction, Temperature. From the results and graphical representation of the study it is found that as wind speed and temperature are high the dispersion is high, because of which the difference in air pollutants concentration between source station and dilution station is also very high and vice versa. Out of three meteorological parameters Wind Speed is found to affect the dispersion of pollutants the most. All the Air Quality parameters are found to be within limit. If we compare the summer and post monsoon season, the higher air pollution level has been found in summer season.

Keywords: Meteorology, Source station, Dilution station

Introduction

Meteorology is the science of atmosphere and the study of the characteristics of weather elements. Meteorological parameters are having great importance in transportation, dispersion and natural cleansing of the air pollutants in the atmosphere. Thus, meteorological information is very essential in locating the industry and planning the control measures for air pollution. Based on this theory the study has been conducted.

Objectives of the Study

(a) To observe the weather and meteorological parameters of specific area of the city.
(b) To determine the air quality of that area.
(c) To determine how meteorological parameters affect the dispersion of air pollutants of the study area.
(d) To determine which parameter mainly affects Air Pollutants Dispersion.
(e) To determine the worst period of the day from Pollution dispersion point of view.

Methodology of the Study

Study area

The area selected for study is the highly industrialized area of Surat city named Pandesara comprising of more than 100 industries majorly chemical and textile. The stack of each industry is

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located very nearer to each other and the stack height is in the range of 110-132 ft. In every 15 minutes the plume comes out from a particular industry. So, this area is considered as a highly polluted area with very poor air quality. A source station is selected into the industrial area with the intention to get maximum concentration of pollutants at source.

The other station is the dilution station which is 6-7 km North from the source station selected based on the wind rose diagram because the maximum frequency, intensity and speed of it is found towards North. Dilution station was placed at The Detox Corporation (ring road). The station being selected to determine the dilution trend of the air pollutants (i.e up to what extent the air pollutants are diluted) from the source station.

Table 1. Yearly average values of wind speed and direction for wind rose diagram:

Time in hours	Wind Speed km/hr	Wind Direction
11:45	1.67	North-east
12:45	1.02	North-west
13:45	0.64	North
14:45	0.48	North-east
15:45	1.56	South-east
16:45	0.64	East
17:45	1.13	North
18:45	2.10	North-west

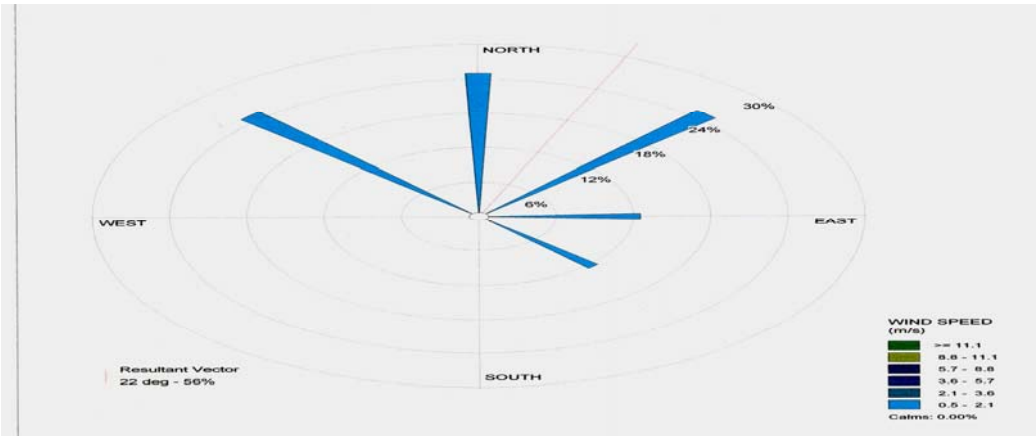


Figure 1. The wind rose diagram of study area

The air quality parameters and the meteorological parameters analysed are mentioned below:

Air Quality Parameters : NO_x, SO_2, SPM

Meteorological Parameters : Wind Speed, Wind Direction, Temperature

Monitoring periods:

For our study, we have chosen two seasons as monitoring periods. The two seasons are summer and the post monsoon. The time and the duration are given into the following table.

- The Air Quality Parameters were measured twice a day for two weeks in Summer season and thrice a day for two weeks in Post Monsoon season for both Source and Dilution stations.
- Similarly, Meteorological parameters were measured for two weeks on hourly basis for 8 hours a day on source station only.

Seasons of the year	Monitoring month	Number of weeks
Summer	May – June ‘08	2
Post monsoon	September-October ‘08	2

Table 2. National Ambient Air Quality Standards (Source: Central Pollution Control Board, India)

Pollutants	Time-weighted average	Concentration in ambient air (µg m^{-3})		
		Industrial Areas	Residential, Rural & other Areas	Sensitive Areas
SulphurDioxide (SO_2)	Annual Average	80	60	15
	24 hours Average	120	80	30
Oxides of Nitrogen (as NO_2)	Annual Average	80	60	15
	24 hours Average	120	80	30
Suspended Particulate Matter (SPM)	Annual Average	360	140	70
	24 hours Average	500	200	100

Results and Discussion.

Result of Post Monsoon Season: (Average values from 1st-7th September'08)

Table 3. Results of meteorological parameters

Time in hours	Wind Speed km/hr	Wind Direction	Temperature ^oC
10:45	3.9	North	29.0
11:45	2.4	North-east	29.5
12:45	0.2	North/north-east	31.2
13:45	1.9	East	31.5
14:45	0.2	North	31.9
15:45	0.9	North-east	32.2
16:45	3.4	North	32.9
17:45	4.5	South	31.0
18:45	4.6	South	30.6

Table 4. Concentration of air pollutants

Time period in hours	Air pollutants	Concentration of air pollutants at source station µg m^{-3}	Concentration of air pollutants at dilution station µg m^{-3}	% Reduction in concentration
10:45-12:45	Con. of NO_X	30.60	15.50	49.34
	Con. of SO_2	18.50	7.96	56.97
	Con. of SPM	240.00	160.00	33.33
13:45-15:45	Con. of NO_X	30.40	12.40	59.21
	Con. of SO_2	13.50	6.90	48.88
	Con. of SPM	245.45	195.00	20.55
16:45-18:45	Con. of NO_X	32.40	11.90	63.27
	Con. of SO_2	20.50	10.50	48.78
	Con. of SPM	255.54	172.00	32.69

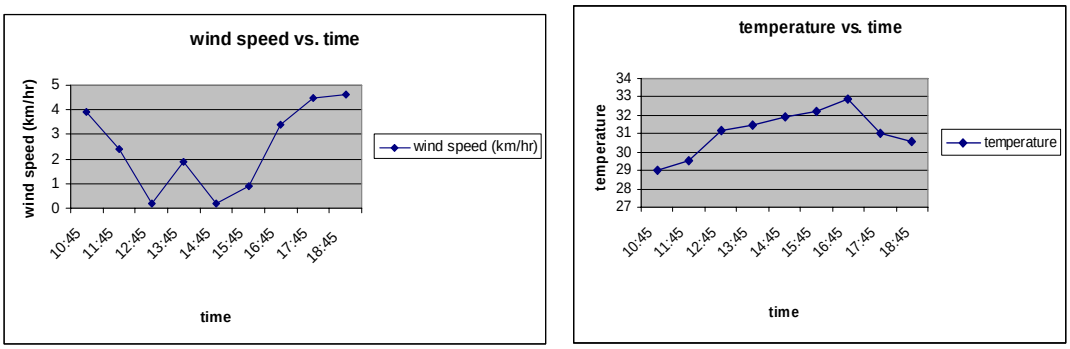


Figure 2. Graphical representation of meteorological parameters *vs.* hours of the day for Day 1(Post Monsoon)

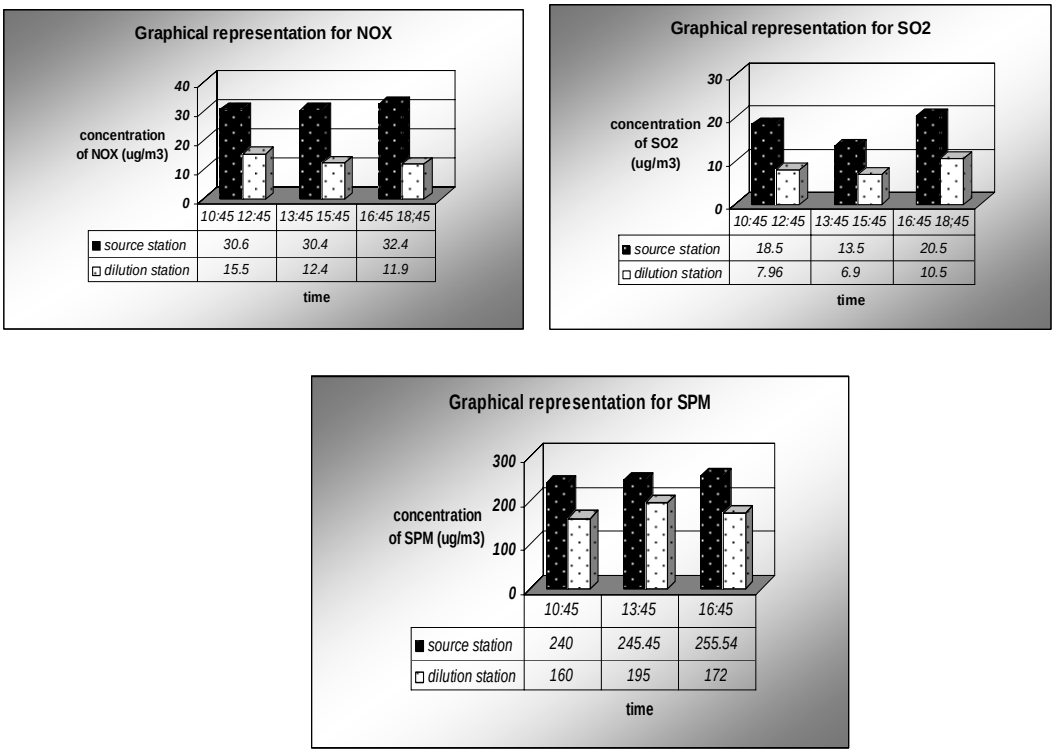


Figure 2.Graphical comparison of air quality parameters with respect to time at source and dilution stations for Day 1 (Post Monsoon)

Week 1

From the results obtained and graph plotted it is observed that during different hours of the day a reasonably good dispersion is obtained for all the three parameters. Its observed that wind speed governs dispersion more as compared to temperature. NOx is seen to have maximum dispersion when the wind speed is maximum and temperature is reasonably high during late hours of the day. Whereas SO2 and SPM have been seen to have more dispersion during early hours of the day when wind speed was reducing though high and temperature was increasing.

Results of Post Monsoon Season: (Average values from 1st-7th October'08)

Table 5. Results of meteorological parameters

Time in hours	Wind Speed km/hr	Wind Direction	Temperature ^{o}C
10:45	2.5	North	29.2
11:45	2.3	North-east	29.3
12:45	2.9	North	30.6

13:45	0.2	North	31.5
14:45	0.4	North	32.2
15:45	2.5	South	33.1
16:45	2.2	North	32.9
17:45	3.0	South	31.3
18:45	3.4	West	31.0

Table 6. Concentration of air pollutants

Time period in hours	Air pollutants	Concentration of air pollutants at source station µg m^{-3}	Concentration of air pollutants at dilution station µg m^{-3}	% Reduction in concentration
10:45-12:45	Con. of NO_X	34.50	20.50	40.28
	Con. of SO_2	14.10	8.34	40.86
	Con. of SPM	275.00	220.00	20.00
13:45-15:45	Con. of NO_X	28.90	13.30	53.97
	Con. of SO_2	20.30	9.70	52.21
	Con. of SPM	368.00	200.00	45.65
16:45-18:45	Con. of NO_X	33.45	10.30	69.20
	Con. of SO_2	15.50	6.70	56.77
	Con. of SPM	268.00	210.00	21.64

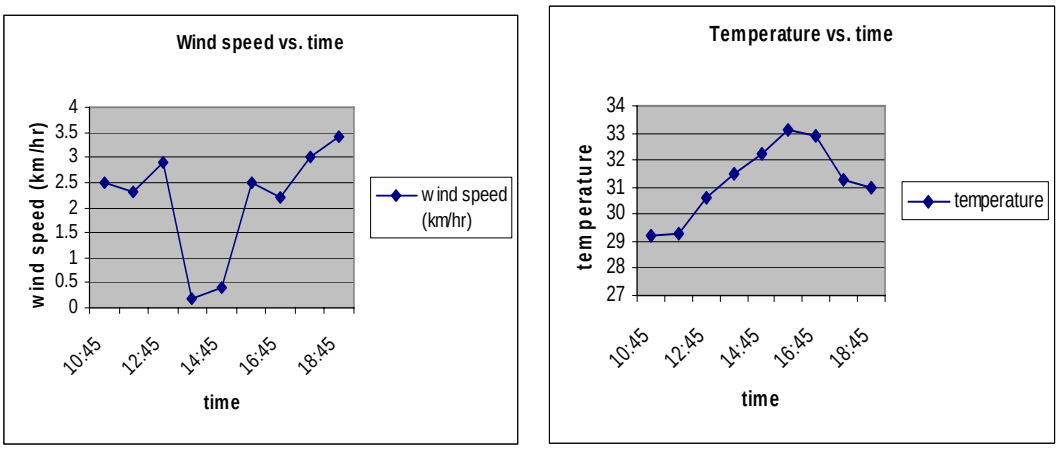


Figure 3. Graphical representation of meteorological parameters vs hours of the day for Day 2(Post Monsoon).

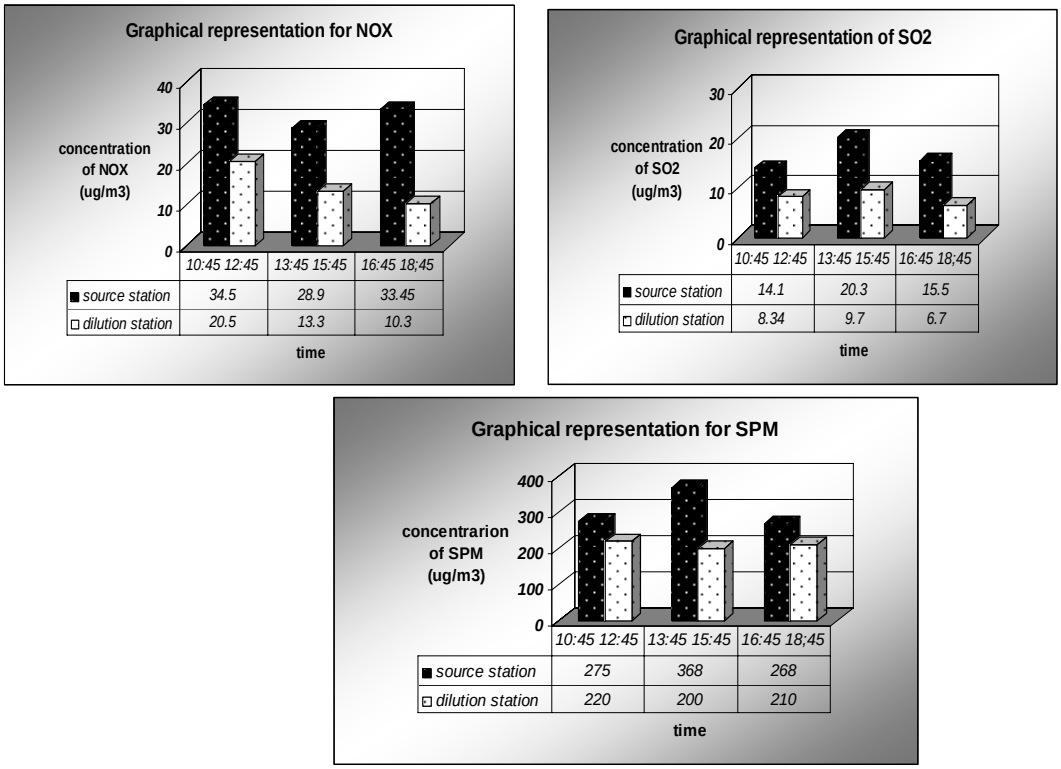


Figure 4.Graphical comparison of air quality parameters with respect to time at source and dilution stations for Day 2 (Post Monsoon)

Week 2

The results obtained indicate that at maximum temperature conditions SPM shows maximum dispersion whereas at maximum wind speed conditions SO2 and NOx are showing maximum dispersion pattern.

Results of summer season: (Average values from 1st-7th May'08)

Table 7. Results of meteorological parameters

Time in hours	Wind Speed km/hr	Wind Direction	Temperature ^{o}C
11:45	3.9	North	30.4
12:45	7.5	North-east	31.2
13:45	9.5	South	31.7
14:45	7.4	North	32.4
15:45	4.9	North	31.9
16:45	9.2	North-east	31.3
17:45	9.9	East	30.3
18:45	10.5	South	32.0

Table 8. Concentration of air pollutants

Time period in hours	Air pollutants	Concentration of air pollutants at source station µg m^{-3}	Concentration of air pollutants at dilution station µg m^{-3}	% Reduction in concentration
11:45-14:45	Con. of NO_X	87.50	79.50	9.14
	Con. of SO_2	27.50	22.50	18.18
	Con. of SPM	375.00	360.00	4.00

15:45-18:45	Con. of NO_X	92.50	82.50	10.81
	Con. of SO_2	30.65	20.70	32.46
	Con. of SPM	390.00	340.00	12.82

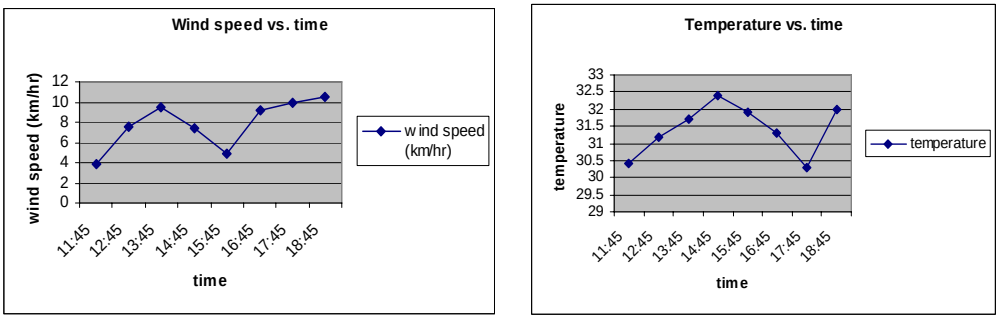


Figure 5. Graphical representation of meteorological parameters vs hours of the day for 1 (Summer Season).

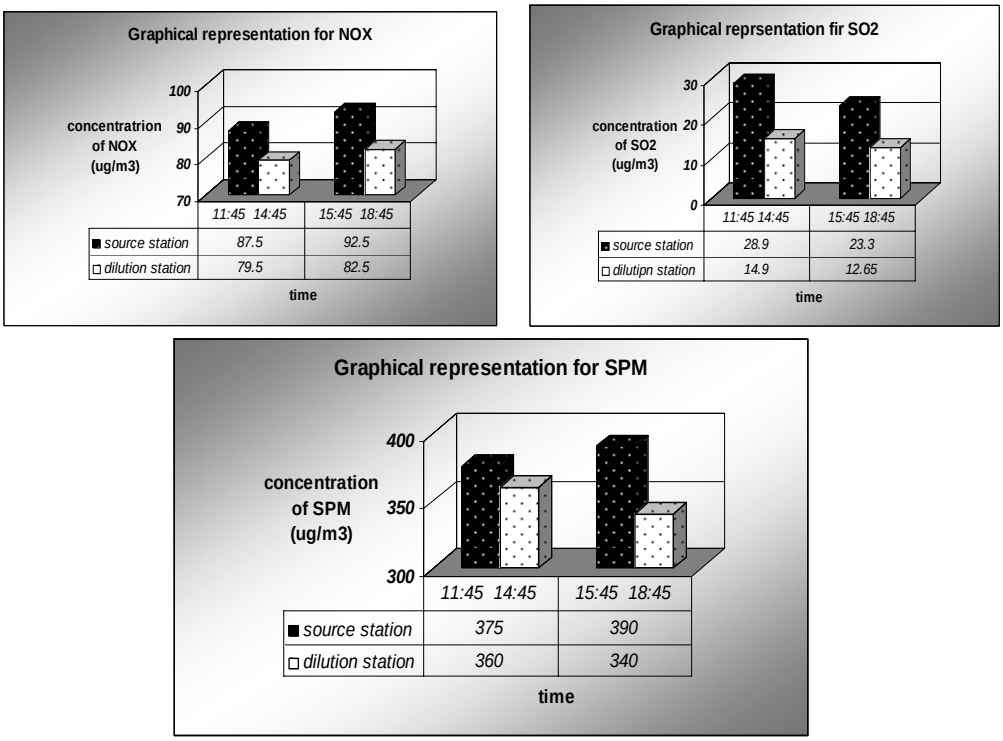


Figure 6.Graphical comparison of air quality parameters with respect to time at source and dilution stations for Day 1 (Summer Season)

Week: 1

Very ideal conditions are obtained in this case where at high wind speed and temperature maximum dispersion is obtained for all three parameters and vice versa.

Results of Summer Season: (Average values from 1st-7th June'08)

Table 9. Results of meteorological parameters

Time in hours	Wind Speed km/hr	Wind Direction	Temperature ^oC
11:45	9.7	North	29.5
12:45	9.6	South	31.3
13:45	7.5	North-east	31.5

14:45	9.4	South	31.9
15:45	3.4	North	32.0
16:45	3.9	North-east	32.2
17:45	4.2	East	31.7
18:45	5.2	North	30.4

Concentration of air pollutants

Time period in hours	Air pollutants	Concentration of air pollutants at source station µg m^{-3}	Concentration of air pollutants at dilution station µg m^{-3}	% Reduction in concentration
11:45-14:45	Con. of NO_X	87.50	40.50	53.71
	Con. of SO_2	28.90	14.90	48.45
	Con. of SPM	410.00	425.00	--
15:45-18:45	Con. of NO_X	98.00	96.50	1.53
	Con. of SO_2	22.30	12.65	43.27
	Con. of SPM	392.50	395.00	--

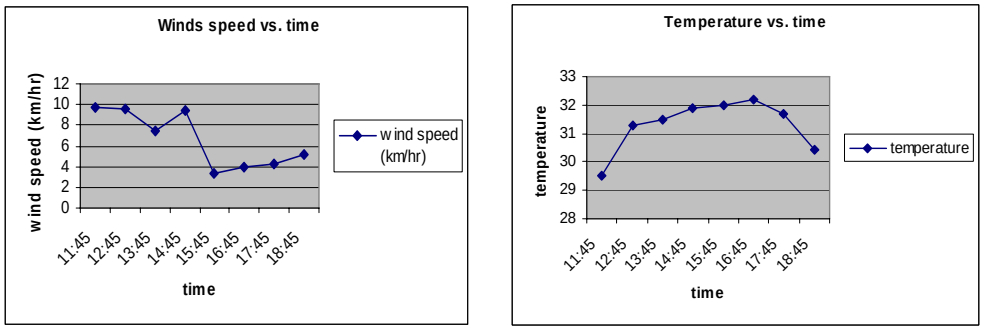
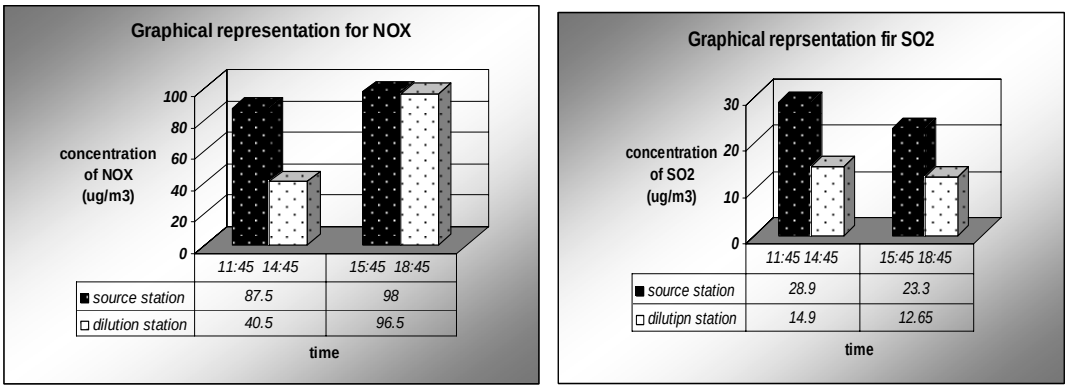


Figure 7. Graphical representation of meteorological parameters vs hours of the day for Day 2 (Summer Season).



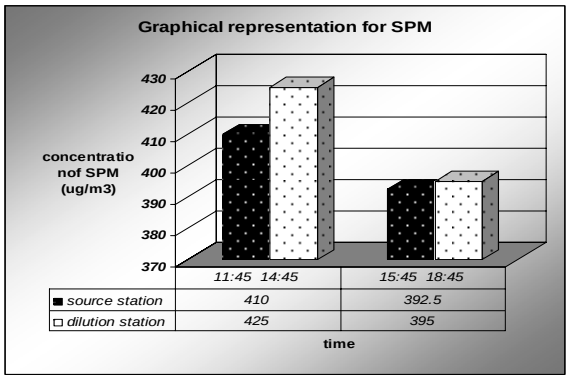


Figure 8.Graphical comparison of air quality parameters with respect to time at source and dilution stations for Day 2 (Summer Season)

Week: 2

Here from the graph it is observed that during late hours of the day very less dispersion is observed for NOx which may be because of heavy vehicular traffic conditions observed those days which itself would add to the emission to NOx at dilution station. SPM is observed to have increased instead of reducing which was observed due to fly over construction at dilution site leading to release of SPM. SOx is seen to have good dispersion at maximum wind speed and temperature.

Conclusion

1. From the experimental data and graphical data it has been concluded that, high pollution has occurred during the summer season and number of areas affected are also more because even at dilution station the air pollutants concentration is high affecting the exposed areas.
2. While during post monsoon season the air quality is comparatively good than summer season both at source station and dilution station.
3. When wind speed is high the dispersion of air pollutants is also high and when wind speed is less the dispersion of air pollutants is also less. From the results obtained we got high difference in air pollutant concentration between the source station and the dilution station based on wind speed and temperature.
4. The source station being at an elevation of 10 meters and dilution station at elevation of 8 meters, the results indicate tentatively no ground mixing.
5. All the Air Quality parameters are found to be within limit most of the times.
6. During the summer season, the NO_X concentration at dilution station is found to be increased because the dilution station selected is located in the very busiest route of the city that is at ring road. So, this seems to be the reason for increase in its concentration.
7. SPM concentration is also found to have increased which may be because of fly over construction at the dilution station site.
8. Compare to NO_X and SO_2, the SPM is less dispersed.
9. In both the seasons, the worst time for air pollutant dispersion process has been found out during the afternoon i.e. minimum dispersion is obtained during afternoon period of the day.
10. And meteorological conditions should be given priority (should be considered) during the development of industrial sites.
11. From the study Wind Speed is considered to be the parameter majorly affecting the dispersion of pollutants as compared to temperature.

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