

COMPARATIVE STUDY OF AIR QUALITY OF CEMENT AFFECTED AND NON-CEMENT AFFECTED AREAS OF THE SAME GEOGRAPHICAL AREA OF KASHMIR (J&K)

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Abstract: The rapid population growth along with high rate of urbanization and an increase in industrialisation has resulted in an increase in the levels of various air pollutants. Although, a considerable amount of work has been done to measure the various characteristics of air pollutants in industrialized areas, there is dearth of knowledge on air quality in general. It is in this context that the present study was undertaken to measure the ambient air quality with respect to suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), nitrogen dioxide (NO₂) and sulphur dioxide (SO₂) at a cement industrialised areas of Kashmir valley. The ambient air quality at three different station namely Khrew town, Khonmoh and Chatterhama was monitored with a sampling frequency of 1 hour from March to December in 2011. The results indicated that average values of SPM, NRSPM and RSPM levels exceeded the hourly limits so the values of NO₂ and SO₂ which also exceeds the limits as set by NAAQS at site I and II while as at site III it was within permissible limits. Further high concentration of pollutants was observed in the winter months and least in summer. The highest average concentration of particulate pollutants was recorded at Khonmoh site, while least values were observed at Chatterhama (control) site while as the highest mean concentration of gaseous pollutants was estimated at Khrew site and lowest at Chatterhama site. It can be concluded that cement industry is one of the biggest source of air pollutants and responsible for the high concentration of pollutants in the area.

[Syed Sana Mehraj, Gowher Ahmad Bhat. **COMPARATIVE STUDY OF AIR QUALITY OF CEMENT AFFECTED AND NON-CEMENT AFFECTED AREAS OF THE SAME GEOGRAPHICAL AREA OF KASHMIR (J&K)**. *World Rural Observ* 2012;4(4):1-9]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). <http://www.sciencepub.net/rural>. 1

Keywords: Ambient; SPM; PM₁₀; industrialisation

Introduction

The modernization and industrialization of developing countries has led to the increased use of fossil fuels and their derivatives. As such, developing countries are confronted with the great challenge of controlling the atmospheric pollution, especially in the rapidly growing urban centers. Air pollution is an important problem in industrial areas which may have an adverse effect on the health of the population. Air pollution is due to the discharge of toxic fumes, gases, smoke and dusts into the atmosphere (Park and Park, 1985).

Concern about air pollution in urban regions is receiving increasingly importance worldwide, especially pollution by gaseous and particulate trace metals (Azad and Kitada, 1998; Salam et al., 2003; Begum et al., 2004; and Cachier et al., 2005). A great deal of attention has focused on particulate matter (PM) pollution, due to their severe health effects, especially fine particles. Several epidemiological studies have indicated a strong association between elevated concentrations of inhalable particles (PM₁₀ and PM_{2.5}) and increased mortality and morbidity (Perez and Reyes, 2002; Lin and Lee, 2004; Namdeo

and Bell, 2005). Particulate matter pollution in the atmosphere primarily consists of micron and sub-micron particles from anthropogenic and natural sources. The characterization of fine particles has become an important priority of regulators, and researchers due to their potential impact on health, climate, global warming, and long-range transport (Dockery et al., 1993; IPCC, 2001).

India, one of the leading developing countries has undergone rapid industrialization in the few decades of near past. India today is one of the first ten industrialized countries of the world (Sharma, 2004). The industry releases huge amounts of cement dust into the atmosphere which settle on the surrounding areas forming a hard crust and causes various adverse impacts.

Cement manufacture has caused environmental impacts at all stages of the process in the area. These include emissions of airborne pollution in the form of dust, gases, noise and vibration when operating machinery and during blasting in quarries, and damage to countryside from quarrying. Equipment to reduce dust emissions during quarrying and manufacture of cement should

have been widely used, and equipment to trap and separate exhaust gases should have come into increased use.

Three criteria air pollutants are released to the air during cement manufacturing: particulate matter (PM), nitrogen oxides (NO_x) and sulfur dioxide (SO₂).

Materials and Methods

Ambient air quality was monitored from March to December during 2011 at three sites in Kashmir valley for priority parameters (Total suspended particulate matter (TSPM), Respirable suspended particulate matter (PM₁₀), Non-Respirable suspended particulate matter (NRSPM), Nitrogen dioxide and Sulphur dioxide). In selection of sampling points, the priority was given to populated areas. The three sampling stations, namely, Khrew (Site I), Khonmoh (Site II) and Chatterhama (Site III) were selected for the study (Fig 1). The description of the sampling sites is shown in Table 1.

Air quality parameters, TSP, PM₁₀, NRSPM, SO₂ and NO₂ were monitored by using High Volume Respirable Dust Sampler (Envirotech Instrument APM 460NL). The sampling instrument was set up 3 meters above ground and hourly values for all pollutants were measured at each site. The particulate matter (PM₁₀) collected on fiber-glass filter was determined by weighing the filter before and after exposure to ambient air. Non-Respirable particles (NRSPM) were determined by dust cup vial method. Total suspended particulate matter (TSPM) was determined from the sum of PM₁₀ and particles larger than PM₁₀. The mass of PM larger than PM₁₀ was determined from the initial and final weight of the dust Cup Vial. The collected samples (Fiber glass filter) were properly stored and placed in vacuum desiccators and transported to the laboratory for analysis. The samples of nitrogen dioxide (NO₂) and sulphur dioxide (SO₂) were collected in glass impingers using sodium arsenate and sodium tetrachloro-mercurate absorption solutions respectively. NO₂ in the samples was determined using Jacob and Hochheiser (1958) modified method, while SO₂ was determined using the modified West and Gaeke (1956) method. Samples were kept in a refrigerator until analysis to minimize volatilization.

Results

The observed values of particulate matter (SPM, PM₁₀ and RSPM), NO_x, and SO₂ noted according to the sampling sites of study sites is presented in Figure 2. The ambient air concentration of SPM RSPM, and PM₁₀ were observed more than the stipulate standard values at all three sites (Table 2). SPM concentration ranged from 928.57 to

1595.24 μg/m³, 1006.22 to 1539.11 μg/m³ and 151 to 193 μg/m³ at site I, II and III respectively (Figure 2). The highest concentration of SPM was observed at site I in the month of December and lowest at the III site in the month of April. Further it was observed that average concentrations of SPM ranged from a maximum of 1244.47 μg/m³ to a minimum of 168.4 μg/m³ at site II and III respectively (Table 2). The highest average value of SPM at site II is due to presence of numerous other industries at site II than at site I.

It is observed from figure 2 that the concentration of PM₁₀ was recorded as 562 to 880.5 μg/m³, 578.22 to 811 μg/m³, and 73 to 99 μg/m³ at site I, II and III, respectively. Highest concentration of PM₁₀ was recorded during December at site I and site II whereas at site III, the highest concentration was recorded during October. Further, average concentration of PM₁₀ ranged between 87.8 μg/m³ at site III to 668.21 μg/m³ at site II (Table 2). However, higher levels of SPM and PM₁₀ in the month of October may be due to the prevalence of anti-cyclonic conditions, which is characterized by calm or light winds and restricted mixing depth due to a stable or inversion atmosphere lapse rate, resulting in little dispersion or dilution of pollutants which in turn, helps in the build-up of SPM and PM₁₀ concentration (Reddy and Ruj, 2002).

According to the present study, NO_x and SO₂ concentrations at all three sites were exceeding the maximum allowed limit of National Ambient Air Quality Standards (NAAQS). The concentration (μg/m³) of Nitrogen oxides measured was in general recorded as higher at the cement polluted sites as compared to the control Site. The highest concentration of 141.44 μg/m³ of Nitrogen oxides (NO_x) was estimated for the Site I during the month of December. Among the two cement dust receiving sites, site I was found to contain a minimum of 99.11 μg/m³ of nitrogen oxides during the observations. At the control Site (III) during the month of March a significantly low concentration of 21.44 μg/m³ was estimated. The average ±SD concentration of NO_x estimated showed the following trend 15.71 μg/m³ at Site I; 13.79 μg/m³ at Site II; 4.19 μg/m³ at Site III.

The concentration (μg/m³) of sulphur dioxide estimated appeared to follow absolutely the same trend as nitrogen oxides i.e., more at polluted sites than at control. The highest concentration of SO₂ (129.34 μg/m³) was estimated at Site I during the observations. The average ±SD SO₂ (μg/m³) observed at the sites showed the following trend: 9.34 μg/m³ at Site I; 10.14 μg/m³ at Site II; 4.29 μg/m³ at Site III; during the study period. In general the concentration was found to be higher towards the sites in the

direction of the factory and lower towards the control site which was away from the factory.

Discussion

The fact that air pollution is hazardous to human health is well known. WHO estimates that, worldwide, at least two million people every year die prematurely due to health effects caused by a lack of clean air. Air is the basic necessity of human life but the quality of air is deteriorating continuously and it is being constantly polluted from different sources. One of the major sources of air pollution are automobiles and industries, as per estimates vehicular pollution is the primary cause of air pollution in urban areas (60%), followed by industries (20-30%) in India (Sivasamy and Srinivasan, 1997). Number of industries in India is increasing with time so is increase in air pollution. Cement industry is one of the most important industry in India, as India is the second largest cement producer in the world, cement consumption in the country has been growing @ 10% per annum in the last few years and this growth pattern is expected to be maintained, still country has per capita consumption about 150 as compared to world average of about 400 which is a huge gap, so cement production of country is expected to increase at an alarming rate.

The discharge of cement factories generally consist of Particulate matter, Sulphur dioxide and Nitrogen oxides producing continuous visible clouds which ultimately settle on the surroundings as a result the whole ecosystem around the cement factory is subjected to extraordinary stress and abuse. Huge clouds of cement dust have been in generation in the area right from the establishment of these factories. This dust has been falling in the area around the cement factory to a considerable distance.

Almost all the manufacturing units of a cement factory e.g., raw mill, kiln, coal mill, cement mill are point sources of pollution emission. In addition some other activities associated with post-manufacturing stages like open air handling, loading and unloading etc. result in leakage of dust into the environment, which are called fugitive sources of emissions. Emissions of Carbon dioxide take place during cement manufacturing due to decarbonisation of Calcium carbonate and Magnesium carbonate and burning of fossil fuels. Oxidation of Sulphur in fuel generates SO_x (Sulphur dioxides) and combination of Oxygen and Nitrogen at high temperature in the burning zone generates Nitrogen oxides. The cement manufacturing processes thus result in release/emission of following pollutants:

Particulate matter (Respirable and non respirable), Nitrogen oxides, Sulphur oxides, Carbon monoxide, Volatile organic compounds (VOC) and

Green House Gases (GHG). Other substances include: Acidic compounds, Heavy metals – Cadmium, Lead, Mercury and Nickel. It is due to emission of such and other lethal pollutants that the cement industry finds place in the red category industry i.e. the most polluting industry (Ministry of Environment and Forest, Government of India and Central Pollution Control Board).

SPM

During the present investigation of various components of air samplings carried out during, March 2011 and December 2011 at various study sites the concentrations of all the components, remained fairly higher than the prescribed standards for residential areas (Table 5.4). The average site wise estimations of SPM pollution indicated highest average of $1244.47 \mu\text{g}/\text{m}^3$ at Site II (the site in Khonmoh) and $1208.78 \mu\text{g}/\text{m}^3$ site I which is followed by significantly lowest of $168.4 \mu\text{g}/\text{m}^3$ at (control) site III with maximum SPM in the month of December ($1595 \mu\text{g}/\text{m}^3$) at site I and minimum at site III ($150 \mu\text{g}/\text{m}^3$) in the month of August.

RSPM

During the analysis it was recorded that the highest average level of RSPM was found at site II ($668.21 \mu\text{g}/\text{m}^3$) followed by site I ($664.98 \mu\text{g}/\text{m}^3$) which was followed by $87.8 \mu\text{g}/\text{m}^3$ at the control site (site III). When monthly values were compared the result indicates that the highest value of RSPM of $880 \mu\text{g}/\text{m}^3$ occurred at site I in the month of December followed by site II ($811 \mu\text{g}/\text{m}^3$) in the same month. Fairly lowest values of $73 \mu\text{g}/\text{m}^3$ RSPM were estimated for the control site (Site III).

NRSPM

The results indicated that the average NRSPM values decreased from site II to site III with highest value of $576.25 \mu\text{g}/\text{m}^3$ at site II, $543.85 \mu\text{g}/\text{m}^3$ at site I and $80.6 \mu\text{g}/\text{m}^3$ at site III. Monthly maximum and minimum values of NRSPM for site I were $833 \mu\text{g}/\text{m}^3$ for the month of July and $309 \mu\text{g}/\text{m}^3$ for the month of May, similarly at site II and Site III (control site) the maximum and minimum values of NRSPM were $838 \mu\text{g}/\text{m}^3$ and $393 \mu\text{g}/\text{m}^3$ for the month of June and May and $97 \mu\text{g}/\text{m}^3$ and $71 \mu\text{g}/\text{m}^3$ for the month of July and March respectively.

GASEOUS POLLUTANTS

Nitrogen oxide (NO_x) is emitted from the combustion of fossil fuels and also from the oxidation of NO. The highest average value of $117.09 \mu\text{g}/\text{m}^3$ was found at site I followed by site II ($113.96 \mu\text{g}/\text{m}^3$) and $19.46 \mu\text{g}/\text{m}^3$ at site III. The S.D value of NO_2 was 15.71 at site I, 13.79 at site II and 4.19 at site III.

Monthly maximum and minimum values of NO_2 for site I were $141.44\mu\text{g}/\text{m}^3$ for the month of December and $97.56\mu\text{g}/\text{m}^3$ for the month of March, similarly at site II and III the maximum and minimum values of NO_2 were $139.24\mu\text{g}/\text{m}^3$ and $99.46\mu\text{g}/\text{m}^3$ for the month of December and June and $26\mu\text{g}/\text{m}^3$ and $13\mu\text{g}/\text{m}^3$ for the month of March and May respectively. Therefore highest value for NO_2 was found in winter, similar observations were made by Anglauf et al. (1986).

Sulphur dioxide values also varies from site to site, the average value of $115.82\mu\text{g}/\text{m}^3$ was found at site I, $115.32\mu\text{g}/\text{m}^3$ at site II and $28.13\mu\text{g}/\text{m}^3$ at site III. Monthly maximum and minimum values of SO_2 for site I were $129.34\mu\text{g}/\text{m}^3$ for the month of December and $101.1\mu\text{g}/\text{m}^3$ for the month of March, similarly at site II and III the maximum and minimum values of SO_2 were $128.64\mu\text{g}/\text{m}^3$ and $102.22\mu\text{g}/\text{m}^3$ for the month of December and July and $33.44\mu\text{g}/\text{m}^3$ and $21.44\mu\text{g}/\text{m}^3$ for the month of

October and March respectively. Prevalence of relatively higher levels of SO_2 during winter months can be attributed to the burning of more coal (fuel) for the manufacturing of cement in the kilns of factory and also by the burning of more coal by the employees residing in nearby quarters in cold weather conditions. Lower levels of SO_2 values during summer can be attributed to the prevalence of high wind currents to which dispersion of the pollutants takes place, resulting in lower SO_2 levels. Similar observations were made by Reddy and Ruj (2003) while working on the ambient air quality status in an industrial area.

The month wise variations in the estimations of SO_2 , NO_2 , SPM, RSPM, NRSPM are in general attributable to variations in wind speed and wind direction and appeared to be well related to the variations in meteorological data of wind direction and wind speed.

FIGURE 1: SATELLITE IMAGE OF STUDY SITES



Table 1: Study sites with description

S.No.	Site	Description
1	Site I	The site was located at a distance of 2.5 kms from the cement factory (JK cements Ltd.) in south-eastern direction, representing an area inhabited by the human population, possessing a ground cover of dwarf herbs and grasses with some scattered shrubs. Khrew is about 20 kms away from the center of main Srinagar city. Apparently cement pollution has adversely affected the area. The site lies in the co-ordinates of 34° 01' 14.00'' N 075° 00' 05.0'' E and at an altitude of 1632 m above mean sea level.
2	Site II	The site was located at a distance of about 2kms from the cement factory (Saifco and Khyber cements limited) in southern direction, representing an area inhabited by the human population, possessed a ground cover of dwarf herbs and grasses with some scattered shrubs. Khonmoh is about 18 kms away from the main Srinagar city. Cement pollution in this area is apparent. The geographical co-ordinate of the site were 34°04'30'' N 74°58' 10'' E. It lies at an altitude of 1649m above mean sea level.
3	Site III	This was situated at Chatterhama (Burzuhama) and represented the control site. This site was about 18 to 20 kms away from the main Srinagar towards the northern side at geographical co-ordinates of 34° 09'58''N 074° 53' 39.1''E and lies at an altitude of 1639m above mean sea level. The area remained under paddy cultivation with scattered horticultural orchards and was apparently not in receipt of any cement dust from the factory or any other kind of pollution.

Table 2: Monthly, mean and S.D values of RSPM, NRSPM and SPM values ($\mu\text{g}/\text{m}^3$) at different sites.

S. No	MONTH	RSPM ($\mu\text{g}/\text{m}^3$)			NRSPM ($\mu\text{g}/\text{m}^3$)			SPM ($\mu\text{g}/\text{m}^3$) (RSPM + NRSPM)		
		Site I	Site II	Site III	Site I	Site II	Site III	Site I	Site II	Site III
1	March	595.24	596.24	97	476.19	486.19	71	1071	1082.43	168
2	April	562.5	578.22	73	416.67	428	78	979.17	1006.22	151
3	May	619.05	629.01	91	309.52	393	77	928.57	1022.01	168
4	June	619.05	619.81	89	476.19	838	93	1095.24	1457.81	182
5	July	666.67	687.66	96	833.33	495	97	1500	1182.66	193
6	August	777.78	781.12	78	555.56	612	72	1333.34	1393.12	150
7	September	595.24	597.11	91	476.19	496	73	1071.43	1093.11	164
8	October	583.33	593.02	99	625	691	91	1208.33	1284.02	190
9	November	750	789	83	555.56	595.22	79	1305.56	1384.22	162
10	December	880.95	811	81	714.29	728.11	75	1595.24	1539.11	156
	MEAN	664.98	668.21	87.8	543.85	576.25	80.6	1208.78	1244.47	168.4
	SD	104.19	91.87	8.715	150.74	142.63	9.47	221.36	192.86	15.32

Figure 2(a): Monthly values of RSPM ($\mu\text{g}/\text{m}^3$) at different sites

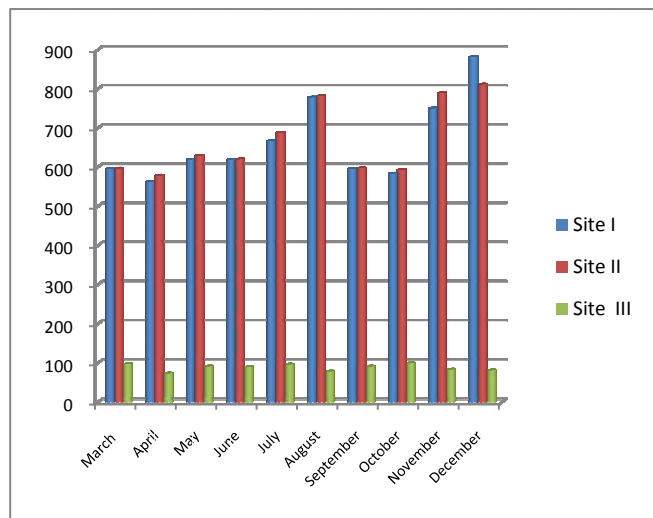


Figure 2 (b): Monthly values of NRSPM ($\mu\text{g}/\text{m}^3$) at different sites

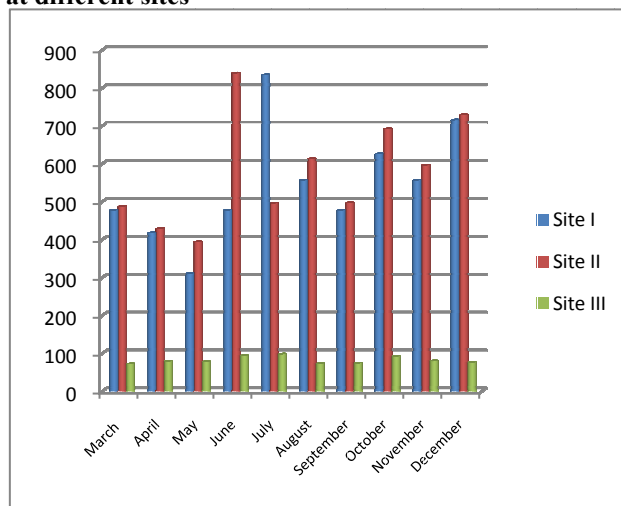


Figure3(c): Monthly values of SPM ($\mu\text{g}/\text{m}^3$) at different sites

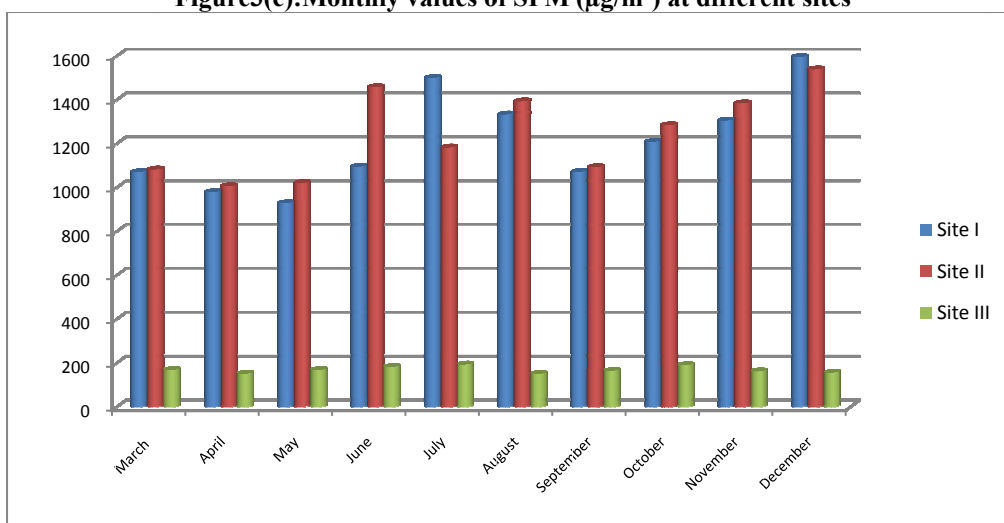


Table 3: Monthly, mean and S.D values of SO_2 $\mu\text{g}/\text{m}^3$ at different sites

S. No	MONTH	Site I	Site II	Site III
1	March	101.1	104.34	21.44
2	April	103.12	116.64	23.6
3	May	117.88	119.43	26.9
4	June	121.4	122.34	28.2
5	July	118.2	102.22	22.64
6	August	114.16	107.33	31.12
7	September	111.11	103.44	30.64
8	October	128.25	121.43	33.44
9	November	113.64	127.42	31.23
10	December	129.34	128.64	32.12
	MEAN	115.82	115.32	28.13
	SD	9.34	10.14	4.29

Figure 4: Monthly values of SO₂ (µg/m³) at different sites

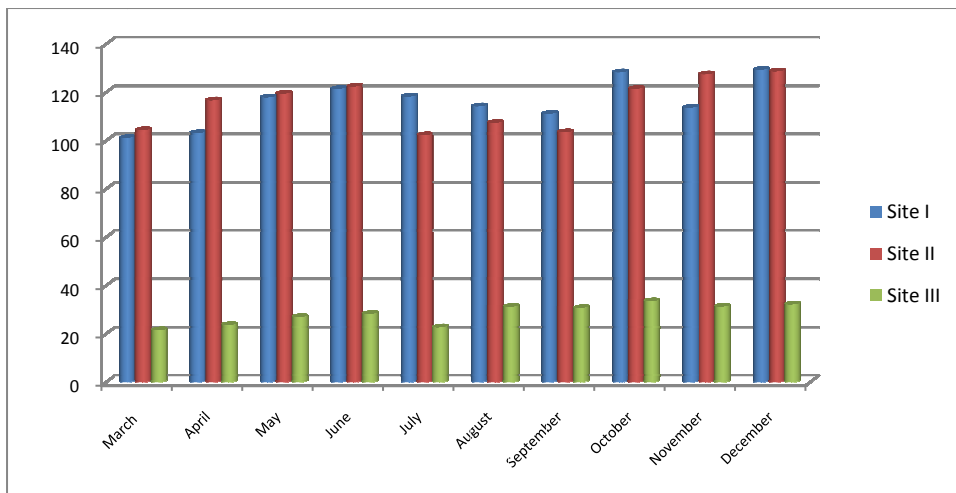
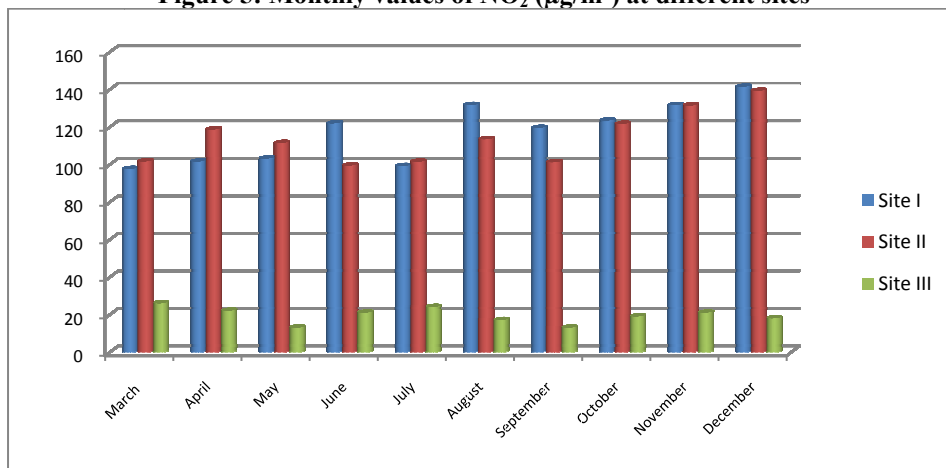


Table 4: Monthly, mean and S.D values of NO₂ µg/m³ at different sites

S. No	MONTH	Site I	Site II	Site III
1	March	97.56	101.64	26
2	April	101.61	118.64	22
3	May	103.16	111.46	13
4	June	121.95	99.46	21
5	July	99.11	101.46	24
6	August	131.64	113.46	17
7	September	119.45	101.18	13.65
8	October	123.43	121.64	19
9	November	131.62	131.43	21
10	December	141.44	139.24	18
	MEAN	117.09	113.96	19.46
	SD	15.71	13.79	4.19

Figure 5: Monthly values of NO₂ (µg/m³) at different sites



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7/17/2012