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# Seasonal concentration of SPM, $SO_2$ and $NO_x$ in the Ambient Air at various sampling sites of JK White cement plant Gotan, (Rajasthan)

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**Abstract**

Ambient air quality is known to be influenced by emission from the source, Meteorological conditions and topography of the area. The Cement industry in its various processes emits Suspended Particulate Matter (SPM) and Oxides of Nitrogen besides Carbon Dioxide, which is produced during calcinations process. This study was undertaken to assess the quality status and seasonal variations of ambient air of pollutants. During rainy season show that the SPM concentration of different sites ranged from 351.65 to 939.5.80 µg/$m^3$. There was a higher concentration of SPM in the ambient air of Gotan Market near Railway station (1327.4 µg/$m^3$) for winter season. Respectively during the summer season the ambient SPM concentrations varied between 385.76 to 1015.30 µg/$m^3$.

Key-Words: Ambient air quality, SPM, Air pollution, Cement factory

## Introduction

Air pollution has been described as an additional stress on plants since they often respond to atmospheric contamination in the same way as they respond to drought and other environment stress. The role of air pollutants causing injury to plants either by direct toxic effect or modifying the host physiology rendering it more susceptible to infection[1,2]. Air pollution has become a major threat to the survival of plants in the industrial areas. Rapid industrialization and addition of the toxic substances to the environment are responsible for altering the ecosystem[3,4,5]. Air pollution has been described as an additional stress on plants since they often respond to atmospheric contamination in the same way as they respond to drought and other environment stress. In severe case of pollution, the injury symptoms were expressed as foliar necrosis or completely disappearance of the plant[6].

Environmental contamination due to dust particle coming from Cement Industries has drawn much attention of the environmental scientists today as they create serious pollution problems and serious pose threat to the ecosystem.

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Air Pollutants means any solid, liquid or gaseous substance present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment[7]. Air pollution is basically the presence of air pollutants in the atmosphere. The air has a relative constant composition of gases and is utilized by most of the living organisms in respiration to liberate chemical energy for their survival. This composition determines its quality and is being changed in the recent past due to emission of large amount of unnatural materials in the atmosphere by Industries and automobiles. This changed quality has become a great threat to survival of life, properties, materials and ecosystem as a whole. In order to arrest the deterioration in air quality, It is necessary to assess the present and anticipated air pollution through continuous air quality monitoring programs[8,9,10].

Air pollution is a problem faced by both developing and developed countries and India is one of them. Rapid industrialization for economic development to meet the specific requirements of the ever-increasing population is proving to be extremely dangerous for human life, ecosystems and cultural assets. Air pollutants do not respect any national boundaries. The complex interplay of natural forces, industrial emissions and transportation is not easily quantifiable. Given such a scenario, it requires a congregation of fertile scientific minds to enumerate evaluate and analyze the data to discern the trends. Several aspects of air pollution need to be addressed, including sources, monitoring, impact assessment, technological remedies, and effect on plant and human health[11, 12].

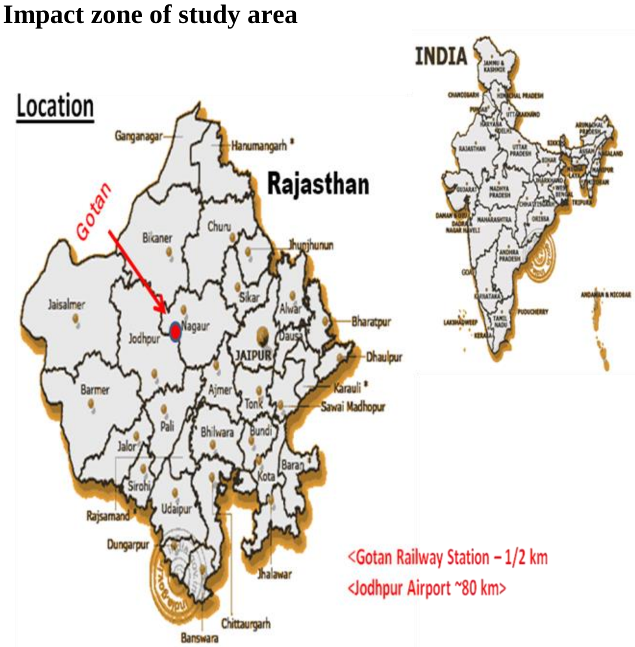
The Cement Industry presents one of the most energy-intensive sectors within the Indian economy and is therefore of particular interest in the context of both local and global environmental discussions. Increases in productivity through the adoption of more efficient and cleaner technologies in the manufacturing sector will be effective in the merging economic, environmental, and social development objectives. Ambitious modernization and expansion programs are currently underway in the Indian Cement Industry which has made significant strides in technological up-gradation and assimilation of latest technology. At present, 91% of the total capacity in the Industry is based on the modern and environment-friendly dry process technology, 7% is based on the old wet process technology and the remaining 2% is of semi-dry technology. The induction of advanced technology has helped the Industry to conserve energy and fuel and to save materials substantially[13,14].

The preparation of Cement involves mining; crushing, and grinding of raw materials (Principally Limestone and clay), calcining the materials in a rotary Kiln, cooling the resulting clinker, mixing the clinker with Gypsum, and Milling, storing and bagging the finished Cement. This process generates a variety of wastes, including dust, which is captured and recycled into the process. The dust pollution is of localized importance near roads, quarries, Cement works, and other industrial areas[15]. Apart from screening out sunlight, dust on leaves blocks stomata and lowers their conductance to $CO_2$, simultaneously interfering with Photosystem II. Polluting gases such as $SO_2$ and $NO_x$ enter leaves through stomata following the same diffusion pathway as $CO_2$. $NO_x$ dissolves in cells and gives rise to Nitrite ions ($NO_2^-$, which are toxic at high concentrations) and Nitrate ions ($NO_3^-$) that enter into Nitrogen metabolism as if they had been absorbed through the roots. In some cases, exposure to pollutant gases, particularly $SO_2$, causes stomatal closure, which protects the leaf against further entry of the pollutant but also curtails photosynthesis. In the cells, $SO_2$ dissolves to give Bisulphite and Sulphite ions. Sulphite is toxic, but at low concentrations it is metabolized by chloroplasts to sulphate, which is not toxic. At sufficiently low concentrations, Bisulphite and Sulphite are effectively detoxified by plants, and $SO_2$ air pollution then provides a Sulphur source for the plant[16].

The generation of fine particulates is inherent in the process, but most are recovered and recycled. Approximately 10-20% of the Kiln feed can be suspended in the Kiln exhaust gases, captured, and returned to the feed, other sources of dust emissions include the clinker cooler, crushers, grinders, and material handling equipment[18].

Gotan, is the location of JK White Cement Rajasthan which is situated 84 kilometres east of Jodhpur by rail, 110 kilometre by road and 541 kilometre west of Delhi connected by broad gauge railway line. It comes under Merta tehsil of Nagaur district of Rajasthan. The village is 500 years old and it had miles and miles of grazing land in the village. The village got its name from "go+than" meaning the place for cows. Jodhpur is the nearest airport. Gotan is one of the villages in Merta Mandal in Nagaur District in Rajasthan State. The history of this study region is attached with the history of Merta, which has been a part of East Marwar state. After independence in 1947, Jodhpur State was merged with other States of greater Rajasthan of which Nagaur became a district. Merta Tehsil is a part of Nagaur district. So Gotan falling within the study region is part of Merta Tehsil.

**Impact zone of study area**




**Sampling sites**

Air sampling for the ambient air concentration of SPM, $SO_2$ and $NO_X$ was done at following sites located in the area of JK White Cement factory area, Gotan.

**Near 132 KV sub Station**

This sampling site is in the vicinity of the Cement plant situated at Cement plant. Dense cultivated plantation and colonization around the site has effectively put a barrier to the dust and kept this place partially safe from hazards.

**Near EDP (Admin Block)**

Sampling point lies in the plant area and the sampling area is a heavily crowded area which allows hundred of trucks and other heavy vehicles in to the plant area. Heavy transportation has further added to the problem of dust deposition and related effects.

**Project Office (TPP)**

It is adjoining to the Thermal Power Plant situated about 150 metre away from the Cement plant. It is the major source of air pollution due to fly ash generation, coal burning and other heavy vehicles used for transportation of materials as well as due to the main road being connected from the area.

**Near Kaveri House**

The area is about 250 meters away from the plant site. It is situated near the colony area, which has silent sound because of lowest transportation and the direction of wind poses a serious threat to the site.

**Old Gotan Village**

It is situated about 2.0 km away from the plant area. Direction WSW The location is completely based on the large number of lime and Kiln (Chuna Bhatta) industries within the town and is connected with the Nagaur - Jodhpur Highway road.

**Gotan Railway station**

The distance is near about 1.5 km away from the plant. The area is heavily crowded area which allows a large number of trucks and other heavy vehicles into the plant area with lime and Kiln (Chuna Bhatta) with in the area which are connected with the Highway road of (Nagaur - Jodhpur). Heavy transportation further adds to the problem of dust deposition and related effects.

**Matwon ki Dhani**

It is nearly about 3.0 km away from the site. Wind direction East, North, East (ENE) the transportation and the direction of wind poses a serious threat to the site.

**Kaswon ki Dhani**

It is situated about 3.5 km away from the plant area. Wind direction SSW There is large number of lime Kilns with in the town.

## Material and Methods

These studies of ambient air quality monitoring are based in and around the periphery of Gotan industrial area. In this section name and model of instruments and methods adopted for monitoring and analysis are given for the following parameters i.e. SPM, $SO_2$, NOx, and meteorological data. Samples were collected from the sites and brought to the laboratory for analysis of different parameters with the use of sophisticated equipment, available in laboratory. Methods for SPM, $SO_2$ and NOx are adopted from the monitoring and testing manual of Envirotech Pvt. Ltd. Delhi.

**SPM**

All micro-organisms responsible for causing the large number of pathogen-caused respiratory, eye and skin disease, various allergens, fibrous materials, heavy metals, metallic fumes and even many organic carcinogens are present in the air in the form of suspended particulates. It is for this reason that Total Suspended Particulates (TSP) or Suspended Particulate Matter (SPM) in air has been world over considered a criteria Parameter to indicate air quality.

Ambient air quality has been characterized with respect to $SO_2$, NOx, Suspended Particulate Matter (SPM) by field monitoring at eight locations. The monitoring locations which were selected were based on a mathematical air quality model. At each location, 24 hour sampling was undertaken on a fort nightly basis. The data was compiled for maximum, minimum, average and compared with National Ambient Air Quality Standards.

Envirotech make respirable dust Sampler (RDS) model no. APM 460 DXm instrument was used for determination of SPM. In this instrument ambient air laden with suspended particulates enters the system through the inlet pipe. As the air passes through the cyclone, coarse, non Respirable dust is separated from the air stream by centrifugal forces acting on the solid particles. These separated particulates fall through the cyclone's conical hopper and is collected in the sampling bottle fitted at its bottom. The fine dust forming the Respirable fraction of the Total Suspended Particulates (TSP) passes through the cyclone and is carried by the air stream to the filter paper (Size: 20.3 X 25.4 cm) clamped between the top cover and filter adapter assembly. The Repairable Dust (RSP) is retained by the filter and carrier air exhausted from the system through the blower. Samples were collected from the sites and brought to the laboratory for analysis.

Samples were collected and have been arranged clock wise as follows. Air at a flow rate of 0.5 Litre per minute (LPM) through Tetra Chloromercurate and Sodium Hydroxide absorbing solution respectively the SPM flow rate of 1 to 1.3 m3/minute. Analysis was carried out as per IS- 5182.

**$SO_2$**

West-Geak Method: sampling of the $SO_2$ was done for 8/24 hrs. in which 20 ml. absorbent reagent at an air flow rate of 0.2 to 0.5 litre per minute was taken. At the end of sampling the flow rate was noted and the pump switched off. A 10 ml sample in a Volumetric flask (25ml) was taken from impinger and 1 ml. each of P-Rosaniline and Formaldehyde was and shaken well. The flask was allowed to stand for 30 minutes for development of red-violet colour. A reagent blank was prepared by treating 10 ml of unexposed absorbent solution with the same procedure, measured transmittance of 560 nm with the reagent blank as reference. A µ litre of $SO_2$ was obtained and was found to present in each sample of absorbent reagent taken for analysis from the calibration curve.

**NOx**

The nitrites ion reacts with Sulphanilamide Phosphoric Acid solution to form a Diazonium salt which couples with NEDA to form a deep coloured Azo dye. Absorbent obtained due to this is measured in Spectrophotometer against a blank. Envirotech make Respirable Dust Sampler model no. APM 460 DXM and Aimil make Spectrophotometer model no. Spectrochem MK II instruments were used for determination of $NO_2$.

Modified Jacob-Hochheiser method: sampling was same as $SO_2$. Transfer 10 ml of the exposed absorbent into a volumetric flask (25 ml) add 1 ml of $H_2O_2$ (30%), 10 ml of Sulphanilamide solution and 1.4 ml of NEDA with thorough mixing after the addition of each reagent. Similarly 10 ml of unexposed absorbent was taken in another flask as a blank and treated after 10 minutes colour- development. The absorbance of the exposed sample is measured with a Spectrophotometer at 540 nm against the blank reagent. Micro gram of $NO_2$ per ml is read from the calibration curve

$NO_2$ (µ gram/$M^3$) = (µ gram $NO_2$/ml) X A/ VX 0.82

(Where, A = volume of absorbing reagent

V = Volume of air sampled in M3

0.82= Factor for collection efficiency

µ gram $NO_2$/ml=reading from calibration curve)

## Results and Discussion

### Ambient Air Quality Monitoring for the period of 2009 –10

Observations from **Table-1** during rainy season show that the SPM concentration of different sites ranged from 351.65 to 939.5.80 µg/$m^3$. The ambient air at Project Office TPP (912.35 µg/$m^3$) exhibited higher concentration of SPM (939.5 µg/$m^3$), to be followed by near Kaveri House (687.35 µg/$m^3$), Gotan Railway station (815.6 µg/$m^3$), Near 132 KV sub Station (623.54 µg/$m^3$), Near EDP (Admin Block) (588.4 µg/$m^3$), Matwon ki Dhani (488.6 µg/$m^3$), Kaswon ki Dhani (376.84 µg/$m^3$) and Old Gotan Village (591.4 µg/$m^3$).

Similarly the $SO_2$ concentrations were observed in the range of 24.65 – 104.85 µg/$m^3$ during the rainy season. Like the other seasons Project Office TPP again exhibited higher concentration of $SO_2$ (87.4 µg/$m^3$) to be followed by near Kaveri House (43.8 µg/$m^3$), near EDP Admin Block (29.8 µg/$m^3$), Gotan Railway station (44.21 µg/$m^3$), Kaswon ki Dhani (28.5 µg/$m^3$), Near 132 KV sub Station (35.1 µg/$m^3$), Old Gotan Village (33.75 µg/$m^3$), Matwon ki Dhani (36.1 µg/$m^3$) **(Table-1)**.

One of the important gaseous air pollutants produced from anthropogenic sources is Sulphur dioxide ($SO_2$). Much of this $SO_2$ comes from combustion of fossil fuels and industrial processes such as sulphuric acid manufacturing and petroleum refining operation. This gas is non-flammable, colorless and can exist in air either as gas or dissolved in water droplets. For the determination of $SO_2$ the well known West-Geak method is adopted; by both EPA as well as ISI (IS: 5182). In this method when air containing $SO_2$ is bubbled through Potassium Tetrachloromercurate solution (absorbent) taken in the impinger, $SO_2$ forms a stable Di-chloro Sulphite Mercurate (DCSM). This complex is not oxidized by oxygen in the air and it remains dissolved in the absorbent. Once formed, DCSM also resist oxidation by ozone. The absorbent containing DCSM is then treated with Parasoniline and Formaldehyde to form an intense red-violet colour. The intensity of this colour is directly related to the amount of $SO_2$ absorbed and is measured Calorimetrically by Spectrophotometer. The quantity of $SO_2$ is then obtained from a calibration curve prepared earlier. Envirotech make Respirable Dust Sampler model no. APM 460 DXm and Aimil make Spectrophotometer model no. Spectrochem MK II instruments were used for determination of $SO_2$.

Out of the various Oxides of Nitrogen only Nitric Oxide (NO) and Nitrogen Dioxide ($NO_2$) are the most important air pollutants. These gaseous pollutants are formed mostly during high temperature combustion of all kinds of fossil fuels. The relative concentration of NO in the combustion emission in much higher than $NO_2$. This $NO_2$ is very reactive, highly oxidizing and an absorber of sunlight. $NO_2$ is reddish-brown in colour and has a characteristic pungent odour. For determination of $NO_2$, Sodium Arsenate Modification of Jacob-Hochheiser method is adopted. $NO_2$ is absorbed in an alkaline solution (NaOH- Sodium Arsenate solution) where it forms Sodium Nitrite which is quite stable. The solution is then fed with possible $SO_2$ interference by treatment with $H_2O_2$ and acidified.

The NOx concentration of ambient air shows data varied between 37.80 to 116.50 µg/m$^3$ during the rainy season of 2009 to 2010 Gotan town. Project Office TPP again exhibited higher concentration of NOx (104.74 µg/m$^3$) in the ambient air to be followed, by Near Kaveri House (61.7 µg/m$^3$), Near EDP Admin Block (53.7 µg/m$^3$), Gotan Railway station (55.36 µg/m$^3$), Kaswon ki Dhani (44.6 µg/m$^3$). Old Gotan Village (44.5 µg/m$^3$), Matwon ki Dhani (53.1 µg/m$^3$) and Near 132 KV sub Station (46.8 µg/m$^3$) **(Table-1)**.

**Table-2** shows SPM concentrations observed almost the same pattern for winter season. There was a higher concentration of SPM in the ambient air of Gotan Market near Railway station (1327.4 µg/m$^3$), to be followed by Near Kaveri House (939.7 µg/m$^3$), near 132 KV sub Station (974.6 µg/m$^3$), Project Office near TPP( 1215.6 µg/m$^3$), Kaswon ki Dhani (534.7 µg/m$^3$), Matwon ki Dhani (788.60 µg/m$^3$), and Old Gotan Village (779.8 µg/m$^3$),near EDP admin Block (1042.10 µg/m$^3$).

The concentration of $SO_2$ varied between (14.20 to 97.50 µg/m$^3$) during winter season. Maximum concentration was observed at Project Office TPP (93.5 µg/m$^3$) to be followed by near EDP Admin Block (41.8 µg/m$^3$), near Kaveri House (39.7 µg/m$^3$), Old Gotan Village (25.85 µg/m$^3$), Gotan Railway station (57.4 µg/m$^3$), Matwon ki Dhani (29.5 µg/m$^3$), Kaswon ki Dhani (31.8 µg/m$^3$) **(Table-2)**.

The winter concentration of NOx of the studied sites varied between 29.40 to 123.60 µg/m$^3$. Project Office TPP again exhibited higher concentration of NOx (112.70 µg/m$^3$), in the ambient air to be followed by near EDP Admin Block (53.9 µg/m$^3$), near Kaveri House (53.97 µg/m$^3$), near 132 KV sub station (61.78 µg/m$^3$), Old Gotan Village (33.4 µg/m$^3$), Gotan Railway station (68.10 µg/m$^3$), Matwon ki Dhani (43.58 µg/m$^3$) and Kaswon ki Dhani (47.70 µg/m$^3$) **(Table-2)**.

Respectively during the summer season the ambient SPM concentrations varied between 385.76 to 1015.30 µg/m$^3$. Maximum concentration of 1031.8 µg/m$^3$ was observed at Gotan Railway station during this season to be followed by near Kaveri House (766.21 µg/m$^3$), near 132 KV sub station (715.8 µg/m$^3$), near EDP admin Block (662.35 µg/m$^3$), Matwon ki Dhani (635.6 µg/m$^3$), Kaswon ki Dhani (465.8 µg/m$^3$). Old Gotan village (738.8 µg/m$^3$) **(Table-3)**.

$S0_2$ concentrations show in the ambient air at selected sites. During summer season of 2008 to 2009, maximum concentration was noted in the ambient air of Project Office TPP (74.26 µg/m$^3$), to be followed by near EDP Admin Block (36.10 µg/m$^3$), near Kaveri House (47.35 µg/m$^3$), near 132 KV sub Station (39.4 µg/m$^3$), Old Gotan Village (31.9 µg/m$^3$), Matwon ki Dhani (43.38 µg/m$^3$), Kaswon ki Dhani 39.50 µg/m$^3$) **(Table-3)**.

The NOx concentrations of different sites were obtained in the range of 29.6 – 93.87 µg/m$^3$ during summer season of 2009 to 2010. The Project Office TPP also registered comparatively higher concentration of NOx (86.4 µg/m$^3$).The minimum concentration was recorded in the ambient air of Kaswon ki Dhani (44.59 µg/m$^3$). The ambient air of other sites exhibited NOx concentration as near EDP Admin Block (49.7 µg/m$^3$), near Kaveri house (61.8 µg/m$^3$), near 132 KV sub Station (54.2 µg/m$^3$). Old Gotan village (46.7 µg/m$^3$). Gotan Railway station (49.7 µg/m$^3$). Matwon ki dhani (53.4 µg/m$^3$). Kaswon ki dhani (44.59 µg/m$^3$) **(Table-3)**.

Mean annual concentration of SPM, $S0_2$ and $NO_x$ in the ambient air of quality of Gotan town has been computed from the basic data for the year 2009 - 2010. Figure No. 5.8 shows that there was a higher concentration of SPM at Gotan railway station (1058.27 µg/m$^{3)}$, minimum concentration was noted at Kaswon ki Dhani (459.11 µg/m$^3$) and other areas are such as project office TPP (1045.10 µg/m$^3$ ), Kaveri house (797.92 µg/m$^3$ ),EDP admin block (764.28 µg/m$^3$), Matwon ki Dhani (637.6 µg/m$^3$ ) **(Table-4)**.

$SO_2$ concentrations observed in the ambient air at selected sites with maximum concentration of $SO_2$ at project office TPP (85.05 µg/m$^3$), and minimum concentration (33.27µg/m$^3$) at Kaswon ki Dhani other areas are such as Kaveri house (43.62 µg/m$^3$), EDP admin block (35.90 µg/m$^3$ ). And The NOx concentration at project office TPP was (101.28 µg/m$^3$), EDP Admin block (52.43 µg/m$^3$), Kaveri house (59.16 µg/m$^3$), Matwon ki Dhani (50.03 µg/m$^3$), Gotan railway station (57.72 µg/m$^3$), 132 KVA substation (54.26 µg/m$^3$) (Table-4).

Results obtained under present investigation, particularly for SPM concentrations, are in agreement with the findings of other investigators monitoring the air quality around different Cement Plants of the country. Agrawal and Khanam (1989) estimated maximum SPM concentration average (1096.77 µg/m$^3$) during winter season at a distance of five km (SE) from Dala Cement factory at Mirzapur U.P. They have also found increased concentrations of SPM (1129 µg/m$^3$), four hours[19]. Average during 1990-91.The SPM concentration recorded at different sites around the JK White Cement Plant are more or less similar to the concentration reported for other places by various investigators. Ravindra (1991) monitored SPM levels in the range of 223.24 to 744.11 µg/m$^3$. In the Ambient air around the Lime Kilns and recorded average values in the range of 500 to 1000 µg/m$^3$ [20].

The results of SPM concentrations under present study are in agreement with the findings of Gupta (1994) and Upadhyay (1998). They have monitored the air quality around the Lime Kilns of Kymore and Maihar region of Madhya Pradesh. Gupta (1994) recorded the average SPM concentration in the Lime Kilns area of Kymore region as 1003.80 µg/m$^3$. Upadhyay (1998) reported the Ambient SPM concentration in the Lime Kiln area of Maihar as 377.69 to 710.41 µg/m$^3$ for 1996-97[21,22], respectively. Naik and Purohit (1998) have reported maximum SPM concentration as 742.0 µg/m$^3$ for the ambient air of Rourkela Plant[23]. According to Yadav (1996) the dust generation is caused due to the fine powder handled in the each section of the Cement Plant ranging from crushing of raw materials to the packing of Cement. It occurs practically from every stage/ section in Cement manufacturing process[24].

## Conclusion

Industrialization is a must and environmental problems are the concomitant products of it. We cannot simply afford to stop the industrial development but we can certainly afford to curb the pollution. Ambient Air constitutes various size ranges of solid particles commonly recognized as Particulates or Dust, which are continuously deposited on various surfaces. Apart from pollutants emanating from a Cement Plant the dust or SPM is probably the most important parameter which poses a significant environmental degradation potential. Micrometeorological data plays a key role in the analysis of the impact of pollutant emission from a particular source on the ambient air quality. The SPM emitted in the environment may remain in the atmosphere for a considerable time or may get transported and dispersed depending upon the climatologically conditions. The dispersed dust particles are ultimately settled down on to the Aqua and Lithosphere.

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**Table 1: Seasonal concentration of SPM, $SO_2$ and $NO_x$ in the Ambient Air at various sampling sites in the vicinity of JK White cement plant (Oct. 2009 – Sept. 2010). Values in parenthesis are average**

| S. No. | Ambient Air Quality Monitoring Site | Result | Parameters (Rainy Season) Unit- (μg/m³) | | |
|---|---|---|---|---|---|
| | | | SPM | $SO_2$ | NOx |
| 1 | Near 132 KV sub Station | | 609.60 - 635.88 | 26.34 - 41.51 | 43.57 - 54.80 |
| | | Avg. | 623.54 | 35.1 | 46.8 |
| 2 | Near EDP (Admin Block) | | 565.75 - 6105.8 | 23.1 - 37.48 | 36.52 - 58.80 |
| | | Avg. | 588.4 | 29.8 | 53.7 |
| 3 | Project Office (TPP) | | 876.30 - 939.5 | 78.30 - 104.85 | 91.15 -116.50 |
| | | Avg. | 912.35 | 87.4 | 104.74 |
| 4 | Near Kaveri House | | 658.9 – 741.87 | 29.35 - 56.35 | 41.30 - 72.60 |

| | | | | | |
|---|---|---|---|---|---|
| | | Avg. | 687.35 | 43.8 | 61.7 |
| **5** | Old Gotan Village | | 578.10 - 626.9 | 29.2 - 37.25 | 37.6 - 51.50 |
| | | Avg. | 591.4 | 33.75 | 44.5 |
| **6** | Gotan Railway station | | 769.40 - 843.47 | 37.61 - 51.70 | 43.42 - 57.47 |
| | | Avg. | 815.6 | 44.21 | 55.36 |
| **7** | Matwon ki Dhani | | 456.30 - 526..40 | 29.57 – 41.35.65 | 48.75 - 57.90 |
| | | Avg. | 488.6 | 36.1 | 53.1 |
| **8** | Kaswon ki Dhani | | 351.65 - 415.8 | 24.65 - 32.87 | 37.80 - 48.75 |
| | | Avg. | 376.84 | 28.5 | 44.6 |

**Table 2: Seasonal concentration of SPM, $SO_2$ and NOx in the Ambient Air at various sampling sites in the vicinity of JK White cement plant (Oct. 2009 – sept. 2010). Values in parenthesis are average**

| S. No. | Ambient Air Quality Monitoring Site | Result | Parameters (Winter Season) Unit- (µg/m$^3$) | | |
|---|---|---|---|---|---|
| | | | SPM | $SO_2$ | NOx |
| **1** | Near 132 KV sub Station | | 945.40 – 988.50 | 34.56 - 48.80 | 49.27 – 73.80 |
| | | Avg. | 974.6 | 43.2 | 61.78 |
| **2** | Near EDP (Admin Block) | | 978.30 – 1105.95 | 26.40 - 56.90 | 41.32 – 61.95 |
| | | Avg. | 1042.10 | 41.8 | 53.9 |
| **3** | Project Office (TPP) | | 1206.64 - 1247.9 | 81.50 – 97.50 | 105.84 -123.60 |
| | | Avg. | 1215.6 | 93.5 | 112.7 |
| **4** | Near Kaveri House | | 912.0 - 976.9 | 27.5 - 63.40 | 44.60 – 57.90 |

| | | | | | |
|---|---|---|---|---|---|
| | | Avg. | 939.7 | 39.7 | 53.97 |
| **5** | Old Gotan Village | | 715.85 – 916.77 | 14.2 -28.60 | 29.40 – 46.80 |
| | | Avg. | 779.8 | 25.85 | 33.4 |
| **6** | Gotan Railway station | | 1278.17 - 1360.65 | 39.4 - 61.80 | 54.75 – 71.95 |
| | | Avg. | 1327.4 | 57.4 | 68.1 |
| **7** | Matwon ki Dhani | | 676.45 – 845.60 | 24.27 - 37.75 | 37.35 -51.80 |
| | | Avg. | 788.60 | 29.5 | 43.58 |
| **8** | Kaswon ki Dhani | | 511.70 – 541.10 | 27.65 - 36.80 | 40.46 – 53.70 |
| | | Avg. | 534.7 | 31.8 | 47.7 |

**Table 3: Seasonal concentration of SPM, $SO_2$ and NOx in the Ambient Air at various sampling sites in the vicinity of JK White cement plant (Oct. 2009 – Sept. 2010). Values in parenthesis are average**

| S. No. | Ambient Air Quality Monitoring Site | Result | Parameters (Summer Season) | | |
|---|---|---|---|---|---|
| | | | Unit- (μg/m$^3$) | | |
| | | | SPM | $SO_2$ | NOx |
| **1** | Near 132 KV sub Station | | 685.90 - 730.70 | 23.2 - 45.67 | 38.88 - 63.60 |
| | | Avg. | 715.8 | 39.4 | 54.2 |
| **2** | Near EDP (Admin Block) | | 625.35 - 710.50 | 31.35 - 43.25 | 38.80 - 53.90 |
| | | Avg. | 662.35 | 36.10 | 49.7 |
| **3** | Project Office (TPP) | | 966.31 - 1015.30 | 61.10 - 83.25 | 81.80 - 93.87 |
| | | Avg. | 1007.35 | 74.26 | 86.4 |
| **4** | Near Kaveri House | | 7430.50 - 781.8 | 33.56 - 56.80 | 57.2 - 68.70 |
| | | Avg. | 766.71 | 47.35 | 61.8 |

| | | | | | |
|---|---|---|---|---|---|
| **5** | Old Gotan Village | | 715.70 - 743.08 | 26.20 - 36.09 | 36.00 - 51.70 |
| | | Avg. | 723.8 | 31.9 | 46.7 |
| **6** | Gotan Railway station | | 966.10 - 1146.68 | 28.6 - 37.50 | 42.60 - 54.30 |
| | | Avg. | 1031.8 | 32.69 | 49.7 |
| **7** | Matwon ki Dhani | | 570.4 – 675.80 | 38.80 - 47.45 | 48.80 - 57.80 |
| | | Avg. | 635.6 | 43.38 | 53.4 |
| **8** | Kaswon ki Dhani | | 385.76 - 473.6 | 21.85 – 46.60 | 29.60 - 53.85 |
| | | Avg. | 465.8 | 39.50 | 44.59 |

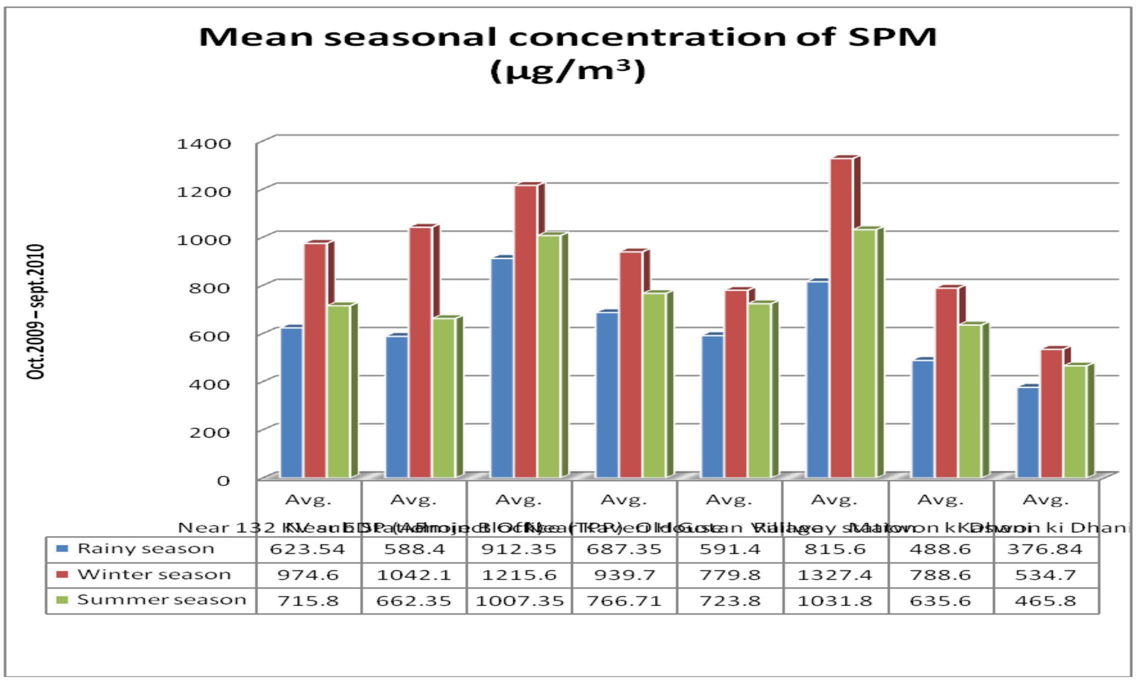



**Fig. 1: Seasonal concentration of SPM (Oct. 2009 – Sept. 2010)**

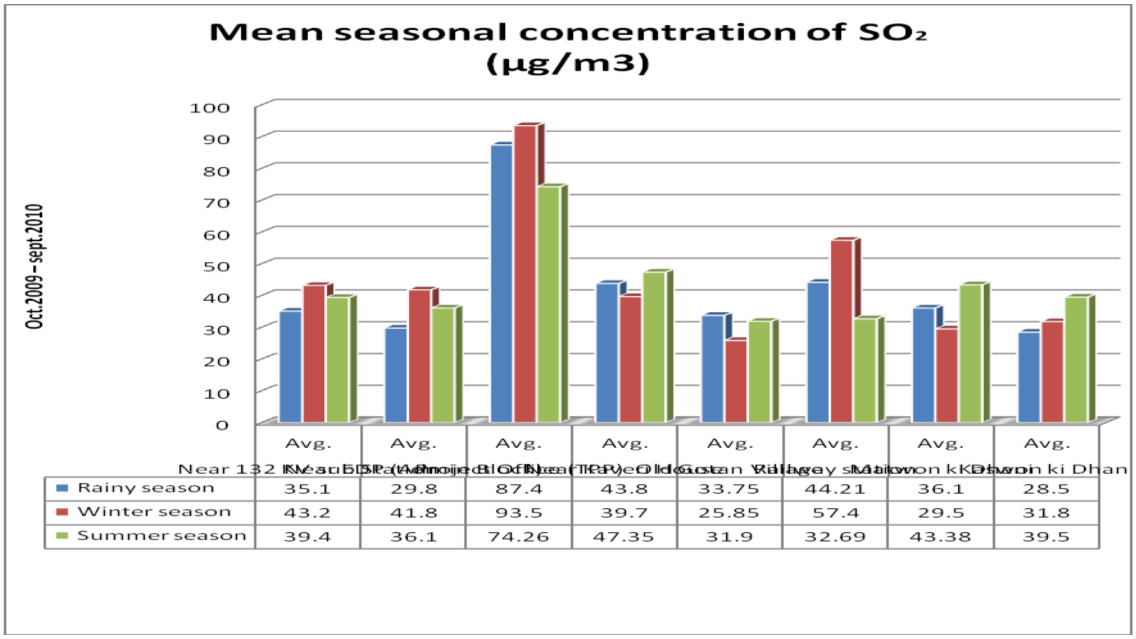



**Fig. 2: Seasonal concentration of $SO_2$ (Oct. 2009 – Sept. 2010)**

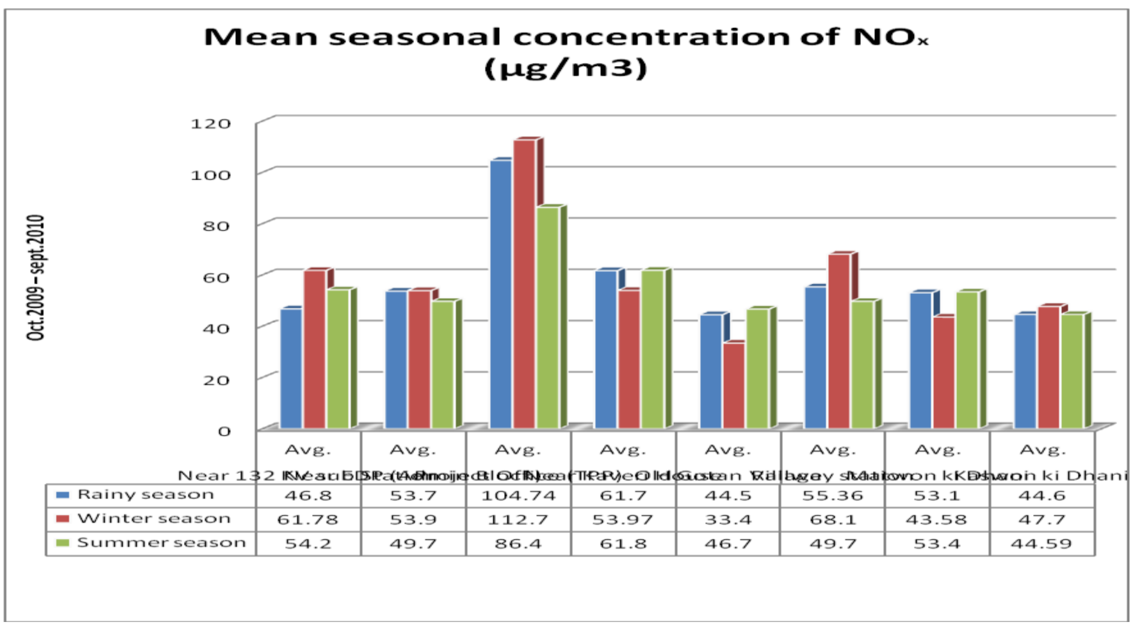
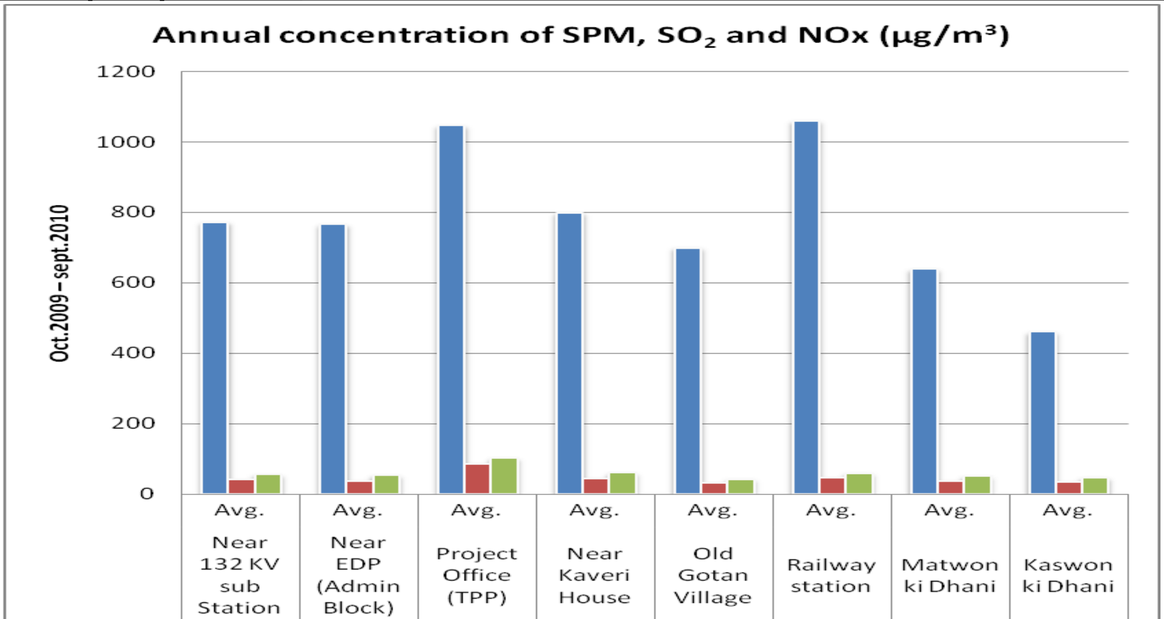



**Fig. 3: Mean seasonal concentration of NOx (Oct. 2009 – Sept. 2010)**




| | Avg. Near 132 KV sub Station | Avg. Near EDP (Admin Block) | Avg. Project Office (TPP) | Avg. Near Kaveri House | Avg. Old Gotan Village | Avg. Railway station | Avg. Matwon ki Dhani | Avg. Kaswon ki Dhani |
|---|---|---|---|---|---|---|---|---|
| SPM | 771.31 | 764.28 | 1045.1 | 797.92 | 698.33 | 1058.27 | 637.6 | 459.11 |
| SO2 | 39.23 | 35.90 | 85.05 | 43.62 | 30.50 | 44.77 | 36.33 | 33.27 |
| Nox | 54.26 | 52.43 | 101.28 | 59.16 | 41.53 | 57.72 | 50.03 | 45.63 |

**Fig. 4: Mean annual ambient air concentration of SPM, $SO_2$ and NOx proximate to JK White cement plant during Oct. 2009 – Sept. 2010)**

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