International Journal for Pharmaceutical Research Scholars (IJPRS)

V-3, I-1, 2014 ISSN No: 2277 - 7873

RESEARCH ARTICLE

Studies on the Air Quality Status through SPM, SO_2 and NO_2 around JK White Cement Plant Gotan, (Rajasthan)

Tiwari S*[1], Arnold R[2], Saxena A[3], Mishra N[4], Tiwari S[5]

[1]*School of Environmental Biology, A.P.S. University, Rewa, M.P., India.*
[2]*Dept. of Botany and Dept. of Zoology,* [3]*Govt. Model Science College, Rewa, M.P., India.*
[4,5]*Study Centre for of Biochemistry, A.P.S. University, Rewa, M.P., India.*

Manuscript No: IJPRS/V3/I1/00046, Received On: 27/01/2014, Accepted On: 01/02/2014

ABSTRACT

Air pollutants generated by the cement manufacturing process consist primarily of alkaline particulates from the raw and finished materials. The direct effects of cement dust pollution are the alkalization of the ecosystem and the changing of the chemical composition of soils. The priority in the cement Industry is to minimise the increase in ambient particulate levels by reducing the mass load emitted from the stacks, from fugitive emissions, and from other sources. Agricultural crops can be injured when exposed to high concentrations of various air pollutants. Injury ranges from visible markings on the foliage, to reduced growth and yield, to premature death of the plant. The development and severity of the injury depends not only on the concentration of the particular pollutant, but also on a number of other factors. The study was aimed to assess the quality status and seasonal variations of ambient air of pollutants in around JK White Cement Plant Gotan, (Rajasthan).

KEYWORDS

Air Pollution, Suspended Particulate Matter, Cement, SO_2, NO_2

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]

***Address for Correspondence:**
Sunil Tiwari
School of Environmental Biology,
A.P.S. University, Rewa, MP, India.
E-Mail Id: seemat452@gmail.com

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. 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]

The JK White Cement factory is located at 26^0 49' N Latitude $73^0$45' E Longitudes at an attitude of about 330 meters above the mean sea level about 1 km South of Northern Railway in Western Rajasthan. 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.

MATERIALS AND METHOD

Methodology of Monitoring

Monitoring of air pollutants is a prerequisite to air quality control. Their impact on the chemical composition of plants is often used as an indicator of and a tool for monitoring environmental pollution (Rao, 1977; Posthumus, 1985; Agrawal and Agrawal, 1989).[19, 20,21]

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.

Suspended Particulate Matter (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 considered in a criteria parameter to indicate air quality.

SPM is calculated as follows

$$\text{SPM } (\mu \text{ gram/m3}) = \frac{(W2 - W1)\ X\ 106}{}$$

Where,

W_1 = Initial weight of filter paper

W_2 = Final weight of filter paper

Vol. of air sampled = Average Flow rate X time in minutes

Sulphur Dioxide SO_2

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 process and petroleum refining operation.

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 impinge 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.

$$\text{SO2 } (\mu \text{ gram/M3}) = \frac{\mu\text{l SO2} \times \text{A X 64 X1000}}{\text{Vs X 24.47}}$$

Where,

Vs= Volume of air sampled (litre)

A= Absorbent reagent taken (ml)

Nitrogen Dioxide (NO_2)

Out of the various oxides of nitrogen 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

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

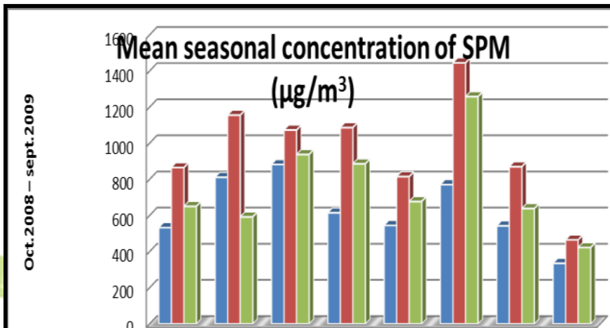
0.82= Factor for collection efficiency

μ gram NO_2/ml=reading from calibration curve

RESULTS AND DISCUSSION

During rainy season, the SPM Concentration of different sites ranged from 346.20 to 910.80 $\mu g/m^3$. The ambient air at Project Office TPP (883.16 $\mu g/m^3$) exhibited higher concentration of SPM (883.16 $\mu g/m^3$), to be followed by near Kaveri House (615.75 $\mu g/m^3$), Gotan railway station (771.6 $\mu g/m^3$), near 132 KV sub Station (533.64 $\mu g/m^3$), near EDP (Admin Block) (812.50 $\mu g/m^3$), Matwon ki Dhani (543.26 $\mu g/m^3$), Kaswon ki Dhani (335.8 $\mu g/m^3$) and Old Gotan Village (545.57 $\mu g/m^3$).

SPM concentrations observed almost the same pattern for winter season. There was higher concentration of SPM in the ambient air of Gotan Market near Railway station (1445.65 $\mu g/m^3$), to be followed by near Kaveri House (1087.64 $\mu g/m^3$), near 132 KV sub Station (865.91 $\mu g/m^3$), Project Office Near TPP.(1073.55 $\mu g/m^3$), Kaswon ki Dhani (465.7 $\mu g/m^3$), Matwon ki Dhani (870.64 $\mu g/m^3$), and Old Gotan Village (815.6 $\mu g/m^3$),near EDP Admin Block (1156.4 $\mu g/m^3$) (Graph-1).



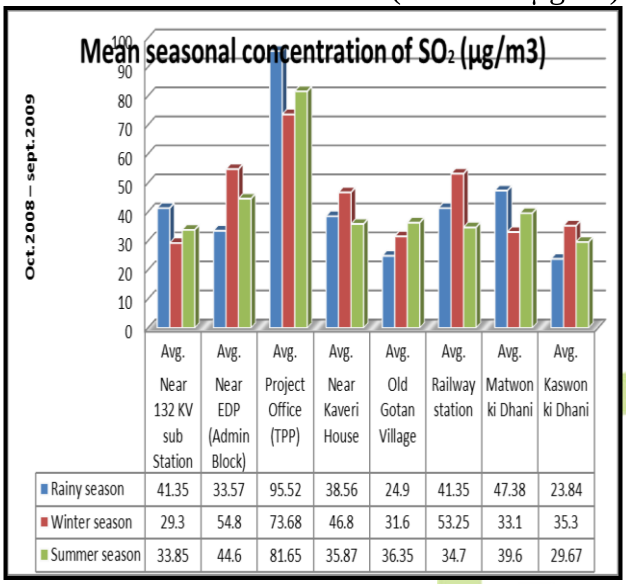
	Avg. Near 132 KV sub Station	Avg. Near EDP (Admin Block)	Avg. Project Office (TPP)	Avg. Near Kaveri House	Avg. Old Gotan Village	Avg. Railway station	Avg. Matwon ki Dhani	Avg. Kaswon ki Dhani
Rainy season	533.64	812.5	883.16	615.75	545.57	771.6	543.26	335.8
Winter season	865.91	1156.4	1073.55	1087.64	815.6	1445.65	870.64	465.7
Summer season	651.6	593.1	938.4	886.95	678.25	1258.34	639.21	423.1

Graph 1: Mean Seasonal concentration of SPM from Oct.2008 to Sept.2009

Similarly the SO_2 concentrations were observed in the range of 16.23 – 112.23 $\mu g/m^3$ during the rainy season of this year. Like the other seasons Project Office TPP again exhibited a higher concentration of SO_2 (95.52 $\mu g/m^3$) to be followed by Near Kaveri House (38.56 $\mu g/m^3$), Near EDP Admin Block (33.57 $\mu g/m^3$), Gotan Railway station (41.35 $\mu g/m^3$), Kaswon ki Dhani (23.84 $\mu g/m^3$), Near 132 KV sub Station (41.35 $\mu g/m^3$), Old Gotan Village (24.90 $\mu g/m^3$), Matwon ki Dhani (47.38 $\mu g/m^3$).

The SO_2 concentration varied between (23.64 to 83.65 $\mu g/m^3$) during winter season. Maximum concentration was observed at Project Office TPP (73.68 $\mu g/m^3$) to be followed by near EDP Admin Block (54.8 $\mu g/m^3$), near Kaveri House (46.8 $\mu g/m^3$), Old Gotan Village (31.6 $\mu g/m^3$), Gotan Railway station (53.25 μg/m^3), Matwon ki Dhani (33.1 μg/m^3), Kaswon ki Dhani (35.3 μg/m^3) (Graph-2).

The NOx concentration of ambient air shows data varied between 19.32 to 130.65 μg/m^3 during the rainy season of 2008 to 2009 Gotan town. Project Office TPP again exhibited higher concentration of NOx (115.60 μg/m^3).



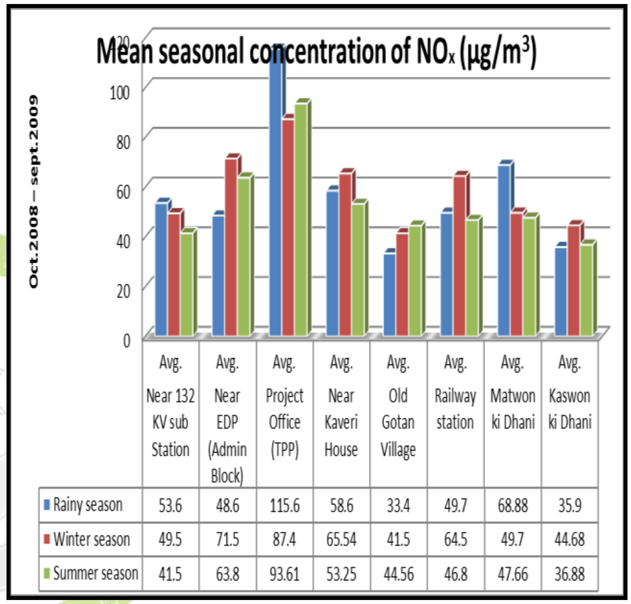
	Avg. Near 132 KV sub Station	Avg. Near EDP (Admin Block)	Avg. Project Office (TPP)	Avg. Near Kaveri House	Avg. Old Gotan Village	Avg. Railway station	Avg. Matwon ki Dhani	Avg. Kaswon ki Dhani
Rainy season	41.35	33.57	95.52	38.56	24.9	41.35	47.38	23.84
Winter season	29.3	54.8	73.68	46.8	31.6	53.25	33.1	35.3
Summer season	33.85	44.6	81.65	35.87	36.35	34.7	39.6	29.67

Graph 2: Seasonal concentration of SO_2 from Oct.2008 to Sept.2009

In the ambient air to be followed by near Kaveri House (58.6 μg/m^3), near EDP Admin Block (48.60 μg/m^3), Gotan Railway station (49.70 μg/m^3), Kaswon ki Dhani (35.90 μg/m^3). Old Gotan Village (33.4 μg/m^3), Matwon ki Dhani (68.88 μg/m^3), near 132 KV sub Station (53.6 μg/m^3).

The winter concentration of NOx of the studied sites varied between 33.62 to 96.31 μg/m^3. Project Office TPP again exhibited higher concentration of NOx (87.4 μg/m^3), in the ambient air to be followed by near EDP Admin Block (71.5 μg/m^3), near Kaveri House (65.54 μg/m^3), Near 132 KV sub Station (49.5 μg/m^3), Old Gotan Village (41.5 μg/m^3) Gotan Railway Station (64.5 μg/m^3), Matwon ki Dhani (49.7 μg/m^3) and Kaswon ki Dhani (44.68 μg/m^3) (Graph-3).

Awasthi *et al.*, 2001 have studied and published a paper on "Environmental assessment studies of lime kilns at Maihar (M.P.)". This indicates that due to lime kilns and ongoing mining, expansion work and also other related activities. The effects of Cement dust pollution have been assessed in Sarla Nagar Maihar Cement Plant, Madhya Pradesh. The results indicated that the increasing trend of deposition on plant leaves surface with increasing distance from the emission source, results indicate that there was considerable loss of total chlorophyll content 18.22% in the leaves growing in the polluted zone[21].



	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
Rainy season	53.6	48.6	115.6	58.6	33.4	49.7	68.88	35.9
Winter season	49.5	71.5	87.4	65.54	41.5	64.5	49.7	44.68
Summer season	41.5	63.8	93.61	53.25	44.56	46.8	47.66	36.88

Graph 3: Seasonal concentration of NOx from Oct. 2008 to Sept.2009

According to Farmer, 1993 Cement Industrial regions are confronted with the problems of alkalization due to high deposition of alkaline Cement dust and their ash in the pollution complex. In addition, the growth of quarrying and open cast mining suggest the dust deposition on vegetation may be increasing.[22]

CONCLUSION

The above study concludes that the ambient air around the JK White Cement Plant consisted higher contents of suspended particulate matter (SPM) than prescribed standard value of 500 μg/m^3 for Industrial area by Central pollution Control, Board, New Delhi. The basic reason of sources of air pollution is there are two units of Cement Plants having a unit of captive power

Table1: Seasonal concentrations of SPM, SO_2 and NOx in the Ambient Air for summer

S. No.	Sampling site	Result	Parameters (Summer Season) Unit- (μg/m³)		
			SPM	**SO_2**	**NOx**
1	Near 132 KV sub Station	Range	646.25 - 675.10	31.34 - 38.65	28.64 - 49.87
		Avg.	651.6	33.85	41.5
2	Near EDP (Admin Block)	Range	585.50 - 608.40	36.34 - 51.26	49.56 - 77.61
		Avg.	593.1	44.6	63.8
3	Project Office (TPP)	Range	918.85 - 940.30	75.70 - 86.21	87.60 – 97.21
		Avg.	938.4	81.65	93.61
4	Near Kaveri House	Range	842.50 - 923.78	29.34 - 48.21	36.61 - 69.65
		Avg.	886.95	35.87	53.25
5	Old Gotan Village	Range	671.70 - 685.60	33.75 - 41.25	39.25 - 47.60
		Avg.	678.25	36.35	44.56
6	Gotan Railway station	Range	1246.71- 1265.70	31.21 - 38.32	38.71 - 51.80
		Avg.	1258.34	34.76	46.8
7	Matwon ki Dhani	Range	625.87-646.20	36.50 - 43.64	42.14-51.40
		Avg.	639.21	39.6	47.66
8	Kaswon ki Dhani	Range	415.65-436.40	21.65 - 34.80	32.64 - 39.30
		Avg.	423.1	29.67	36.88

(Values are shown at various sampling sites in the vicinity of JK White cement plant for Oct. 2008 to Sept. 2009).

Table 2: Seasonal concentration of SPM, SO_2 and NO_x in the Ambient Air in rainy season

S. No.	Sampling site	Result	Parameters (Rainy Season) Unit- (µg/m^3)		
			SPM	**SO_2**	**NOx**
1	Near 132 KV sub Station	Range	526.35 – 553.21	37.54 - 46.45	48.17 - 57.26
		Avg.	533.64	41.35	53.6
2	Near EDP (Admin Block)	Range	806.43 - 825.64	29.21 -43.50	37.2 -56.40
		Avg.	812.5	33.57	48.6
3	Project Office (TPP)	Range	875.34 – 910.80	76.32 - 112.23	88.21 - 130.65
		Avg.	883.16	95.52	115.6
4	Near Kaveri House	Range	632.15 – 665.24	31.55 - 44.35	54.62 - 61.57
		Avg.	615.75	38.56	58.6
5	Old Gotan Village	Range	543.28- 561.30	21.35 - 29.60	31.42 - 37.45
		Avg.	545.57	24.9	33.4
6	Gotan Railway station	Range	768.35 – 788.21	38.56 - 51.45	46.50 – 53.60
		Avg.	771.6	41.35	49.7
7	Matwon ki Dhani	Range	531.61 -553.28	39.32 - 51.50	62.38 - 71.60
		Avg.	543.26	47.38	68.88
8	Kaswon ki Dhani	Range	346.203 - 361.50	16.23 - 31.70	23.51 - 43.56
		Avg.	335.8	23.84	35.9

Table 3: Seasonal concentration of SPM, SO2 and NOx in the Ambient Air

S. No.	**Sampling site**	**Result**	**Parameters (Winter Season) Unit- (µg/m^3)**		
			SPM	**SO_2**	**NOx**
1	Near 132 KV sub Station	Range	845.90-875.60	23.64-39.61	33.62 - 56.32
		Avg.	865.91	29.3	49.5
2	Near EDP (Admin Block)	Range	1145.20 -1175.80	41.23-63.45	67.35-83.21
		Avg.	1156.4	54.8	71.5
3	Project Office (TPP)	Range	1056.65 -1095.64	65.35 - 83.65	83.67-96.31
		Avg.	1073.55	73.68	153.4
4	Near Kaveri House	Range	1031.50 -1115.95	36.24 - 56.21	61.2-76.21
		Avg.	1087.64	46.8	65.54
5	Old Gotan Village	Range	808.27 - 829.40	28.21-36.35	35.2-44.24
		Avg.	815.6	31.6	41.5
6	Gotan Railway station	Range	1430.31-1456.54	51.56-59.45	59.75 - 67.31
		Avg.	1445.65	53.5	64.5
7	Matwon ki Dhani	Range	866.31- 886.20	28.35-36.62	43.35-51.65
		Avg.	870.64	33.1	49.7
8	Kaswon ki Dhani	Range	445.85- 468.90	28.34-38.52	39.21-48.50
		Avg.	465.7	35.3	44.68

Plant capacity 7.5 MW which is coal and lignite based. Another source of air pollution is Lime kiln/ Chuna Bhatta. The area possesses mainly four types of Industries i.e. the Cement Industries, the Lime Industries, the paint Industries and the Mining Industries.

ACKNOWLEDGEMENTS

I acknowledge with thanks, the contributions made by the Department of Envirotech Pvt. Ltd. Delhi for testing and monitoring of samples, Staff and other workers of the JK White Cement Plant, Gotan, Rajasthan, who helped to complete the work and collect the data.

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