International Journal Of
Recent Scientific
Research
ISSN: 0976-3031
Volume: 7(5) May -2016

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THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

Available Online at http://www.recentscientific.com

International Journal of Recent Scientific Research
Vol. 7, Issue, 5, pp. 11102-11106, May, 2016

ISSN: 0976-3031

International Journal of Recent Scientific Research

Research Article

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ARTICLE INFO

Article History:

Received 05th February, 2016
Received in revised form 21st March, 2016
Accepted 06th April, 2016
Published online 28th May, 2016

Keywords:

Emission; Particulate matter;
Cement; pollution

ABSTRACT

Cement production, in any country, plays a major role in the growth of the nation. The air quality was assessed based on new national ambient air quality standard. PM2.5, PM10, SO_2, and NO_2 are the selected parameters. The average value of PM10 was found beyond the permissible limit at near power plant. The outcome of the study has been presented in the form of air quality index. AQI was found moderate for $PM_{10}$and $PM_{2.5}$, SO_2& NO_2, were observed in good range. Excess of PM10 is control in water spray system, road cleaning vehicles, choosing cleaner fuel system and consider alternative fuels such as gas instead of coal by reduced the coal. This research work presents data of the ambient air quality status of Thiruvallur district of Tamilnadu, India. Modern ESP are designed to have high collection efficiencies of all types of fly ash, some are marketed as applicable to worldwide coal firing; collection efficiencies are now up to 99%.

INTRODUCTION

Cement manufacturing is an energy intensive process. The production of cement (key binding component of concrete) is costly, consumes high energy, depletes natural resources and emits huge amounts of greenhouse gases (1 ton of cement production emits 1 ton of CO_2). Consequently, environmental degradation, serious pollution and health hazards associated with cement and concrete industries, have come under intense scrutiny from environmentalists and the governments.

The main component of cement is clinker, which is produced from raw materials, such as limestone and clay. Limestone supplies $CaCO_3$ for the cement production. Silica, alumina, and iron are considered to be other raw materials. The lime stone used for cement manufacturing contains 75-90 % of $CaCO_3$ and remainder is $MgCO_3$ and impurities. Raw material is extracted through mining and quarrying which follows drilling, blasting, excavating, handling, loading, hauling, crushing, screening, stockpiling, and storing. A specific composition of the raw materials are crushed and then milled into a raw meal for the quality and uniformity of cement.

Consuming energy from fossil fuels such as oil and coal creates carbon dioxide, the most important Greenhouse Gas causing climate change. In industrial sector, cement industry is the second largest emitter of carbon dioxide and accounts for 5 per cent of global manmade carbon dioxide emissions, of which 60 per cent is from the chemical process and 40 per cent from burning fuel. Majority of particulates emitted from cement industry may range from 0.05 to 5.0μm in diameter.

Concentration of CO_2, CO, NO_x and SO_2 in the flue gas emanating from the kiln stack was also measured by permanently installed gas sensors. Average concentrations of CO_2, CO, NO_x and SO_2 in the kiln stack emission were 16.1%, 222.6 mg/Nm^3 (Normal cubic meter), 1127mg/Nm^3 and 3.8 mg/Nm^3, respectively, and these values were similar to an earlier report done for cement kilns. These concentrations amounted to emissions of 160.1 Mt/h (Mt-megaton) of CO_2 and 123, 623 and 2.1 kg/h emissions of CO_2, CO, NO_x and SO_2, respectively.

The Emission Standards for Existing Cement Industry with plant capacity of 200 tonnes per day and less in all sections for protected area is 250 mg/Nm^3 and in other area 400 mg/Nm^3. Similarly the standard for plant capacity of greater than 200 tonnes per day in all sections for protected area is 150 mg/Nm^3 and in other area 250 mg/Nm^3. About 60 percent of emissions caused by making cement are from this chemical process alone.

Air Quality Index

Air quality index values are divided into six ranges, and each range is assigned a descriptor and a colour code. Standardized public health advisories are associated with each API range. These are as follows. "Good" AQI is 0 - 50. Air quality is

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considered satisfactory, and air pollution poses little or no risk. "Moderate" AQI is 51 - 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms. "Unhealthy for Sensitive Groups" AQI is 101 - 150. Although general public is not likely to be affected at this AQI range, people with lung disease, older adults and children are at a greater risk from exposure to ozone, whereas persons with heart and lung disease, older adults and children are at greater risk from the presence of particles in the air. "Unhealthy" AQI is 151 - 200.

Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects. "Very Unhealthy" AQI is 201 - 300. This would trigger a health alert signifying that everyone may experience more serious health effects. "Hazardous" AQI is greater than 300. This would trigger a health warning of emergency conditions. The entire population is more likely to be affected.

MATERIALS AND METHODS

The study was conducted at Cement Industry. Samples are collected for 8hrs at each site for every month at the time from 9AM to 5PM. Six sampling sites for ambient air monitoring were selected. They are near main gate, power plant, coal mill and dispensary. Monitored parameters were PM2.5, PM10, and gaseous pollutants such as SO_2& NO_2. Respirable Dust Sampler Envirotech APM 460(NL) was used for air sampling and analyzed as per standard methods. Air Quality index (AQI) was calculated.

Method of measurement

Sulphur dioxide emission was calculated by using, improved west and Geak method Jacob &Hoochheiser Modified(NaoH-Na Aso2) Method for Nitrogen di oxide High volume sampling method for particulate matter 2.5 Respirable Particulate Matter Sampler for particulate matter 10

Study Area

There are about 2 cement industries; India Cement and Zurai cement, Ponnery Taluk, in Thiruvallur district of Tamilnadu, India. It is facing multifarious problems of environmental pollution due to technological and industrial development and Cement plant having a total productions capacity 3.25 million tons per annum.

RESULTS AND DISCUSSION

National Ambient Air Quality Standards

Pollutant	Average weight	Concentration in ambient air	
		Industrial and Residential area	Sensitive area
SO_2	Annual average	50µg/m^3	20 µg/m^3
	24hrs average	80 µg/m^3	80 µg/m^3
NO_2	Annual average	40 µg/m^3	30 µg/m^3
	24hrs average	80 µg/m^3	80 µg/m^3
$PM_{2.5}$	Annual average	40 µg/m^3	40 µg/m^3
	24hrs average	60 µg/m^3	60 µg/m^3
PM_{10}	Annual average	60 µg/m^3	60 µg/m^3
	24hrs average	100 µg/m^3	100 µg/m^3

Average Ambient Air Pollution Level in Cement Industries in ThiruvallurDistric

Cement Industries Name	Pollutants in µg/m3			
	NOx	Sox	PM2.5	PM10
India Cement	48	44	26	78
Zurai cement	17	15	13	67

Air Quality Index - Range & Color from WHO

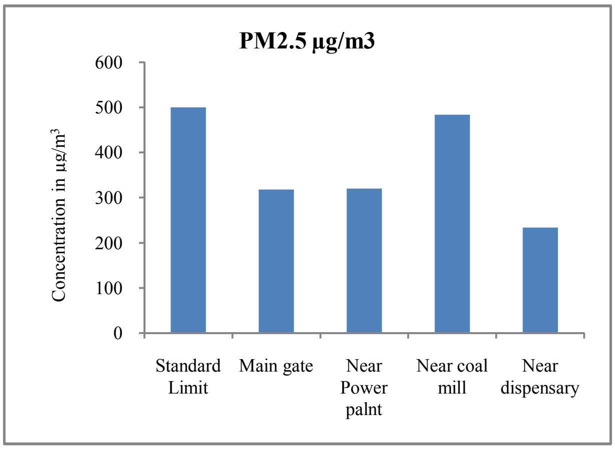
Air Quality Index Value (µg/M3)	Level Of Health Concern	Color
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for sensitive groups	Orange
151-200	Unhealthy	Red
201-300	Very unhealthy	Purple
301-500	Hazardous	Merrown

Emission concentration (µg/m^3) at Various Stations

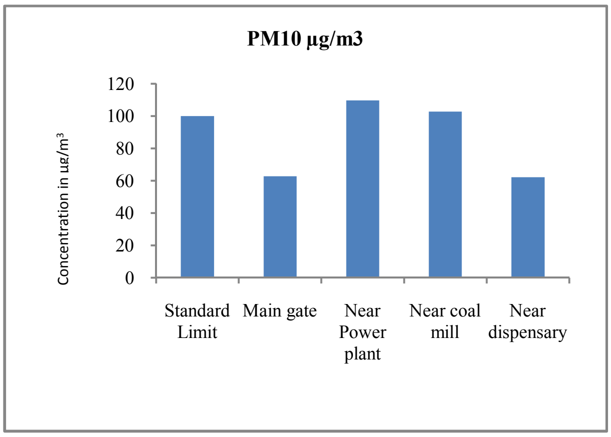
Parameters (µg/m^3)	Standard limit (µg/m3)	Sampling	Stations			
			Main gate	Near power plant	Near Coal mill	Near dispensary
$PM_{2.5}$(µg/m^3)	500	1	405	524	324	208
		2	212	229	244	300
		3	258	424	500	312
		4	397	320	484	234
		Average	318	374.25	388	263.5
PM_{10} (µg/m3)	100	1	55	101	120	85
		2	38	110	97	20
		3	80	130	102	55
		4	78	98	92	89
		Average	62.75	109.75	102.75	62.25
SO_2 (µg/m3)	80	1	11.0	12.8	11.9	10.5
		2	17.9	21.5	20.0	16.0
		3	16.3	17.99	22.2	14.4
		4	14.0	19.0	24.0	12.0
		Average	14.8	17.83	19.53	13.23
NO_2 (µg/m3)	80	1	13	19	25	24.2
		2	16.5	13.99	18.3	12.1
		3	12	15	20.4	12.9
		4	19.8	26.8	23.2	19.99
		Average	15.33	18.69	21.72	17.29

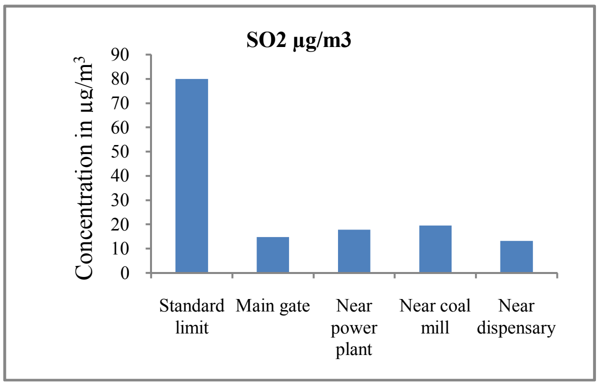
Air Quality Index Value for Cement Industries

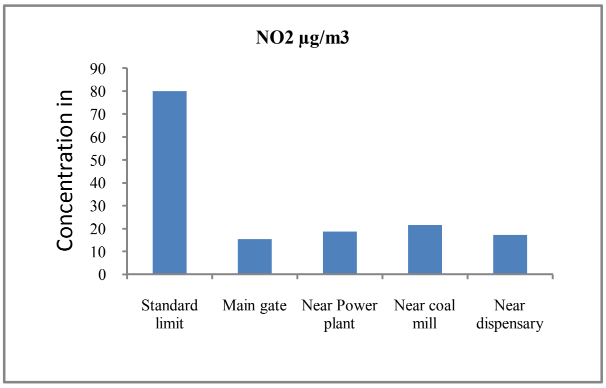
Pollutants	AQI value	Levels of Health concern	colour
SO_x	20	Good	Green
NO_x	20	Good	Green
PM 2.5	15.3	Good	Green
PM10	70	Moderate	Yellow



The maximum concentration of SPM was observed 524µg/m ^{3} beyond the permissible limit (500µ g/m^3) at near power plant and minimum value was found 208µ g/m^3 respectively at near dispensary and near main gate. The maximum concentration of PM_{10} was obtained 101µ g/m^3 at near power plant which was beyond the permissible limit 100µ g/m^3 and minimum value was observed 62.25µ g/m^3 near dispensary.







The maximum value of SO_2 was observed 24.0µg /m^3 at near coal mill and minimum value was found 10.5µ g/m^3 at near main gate. The maximum value of NO_2 was observed 24.2µg/m ^{3} at near dispensary. The maximum value of NO_x was observed 26.8µg/m ^{3} at near power plant.

Control system

Ambient air quality was assessed using six monitoring stations inside the cement industries ,the studies have clearly revealed the levels of air pollutants for PM2.5, PM10, NOx and SO2.The values of all these pollutants (particulates and gaseous) are observed to be very much below National Ambient Air Quality Standards except the PM10, that is the residential area.

Alternative Fuels Such as Gas Instead of Coal

Fuels made from waste have been used in many countries for over 10 years. They are used by power plants and various industrial plants using high-temperature processes, including cement plants. The fuels applied can be solid or liquid, made from municipal waste, industrial waste, or their mixtures. Replacement of some conventional fuels with alternative fuels brings both ecological and economic benefits. An industry that is especially suitable for the application of such fuels, from the technological and environmental points of view, is the cement industry. Alternative fuels are used in many cement plants throughout the world. Several cement plants in Poland are using alternative fuels.

Gaseous fuels - Refinery waste gas, landfill gas, pyrolysis gas, natural gas

Liquid fuels - Tar, chemical wastes, distillation residues, waste solvents, used oils, petrochemical waste, asphalt slurry, paint waste, oil sludge

Solid fuels - Petroleum coke (pet coke), paper waste, rubber residues, pulp sludge, sewage sludge, used tires, battery cases, plastics residues, wood waste, domestic refuse, rice husks, refuse derived fuel, nut shells, oil-bearing soils, diapers, etc.

There are several existing and potential pollution control technologies that have applicability to cement kilns. Some of these technologies have synergetic and counteractive interactions with other technologies and with pollutants they are not intended to control. Technologies that take advantage of the inherent characteristics of the pyro processes to which they are applied tend to be effective, reasonably energy-efficient, and cost-effective.

Electrostatic Precipitator

Modern ESP are designed to have high collection efficiencies of all types of fly ash, some are marketed as applicable to worldwide coal firing; collection efficiencies are now up to 99.81%

Wet Scrubber System

As indicated by Daniel and Paula [14], the waste gas flow rates are the most important parameters in designing a scrubber. For a steady flow involving a stream of specific fluid flowing through a cylindrical control volume of the scrubber system at sections 1 and 2;

$$\rho 1 A1\ V1 = \rho 2\ A2\ V2$$

where, $\rho 1$ and $\rho 2$ are respective densities, $A1$ and $A2$ the cross sectional areas and $V1$ and $V2$ are the velocities, respectively. By using value for the mass flow rate in Table-1, exit velocity of 1.5m/s and substituting $A2$ in (1), the diameter of the scrubber was determined to be 8.0m. The height of the spray tower system has been determined to be 16m by considering typical height to diameter ratio of cylindrical shell of approximately 2:1 in Cheremisinoff and Young. Using the curve fit model, the terminal settling velocities for the selected droplet sizes (500, 1000, 1500 and 2000µm) were estimated and the result is presented in Table.

Water droplet sizes and their corresponding terminal velocities

dD(µm)	Utd(m/s)
500	2.06
1000	4.03
1500	5.42
2000	6.50

Density of the cement particle, Pp

According to Ying [21], the solid particles are considered to be a rigid sphere; therefore their density is constant. From Portland cements test results, the density of the cement particle, ρPhas been found to be 3120 kg/m3 (Joao, [22]).

Dust-particle size, *dP*

Although the particle sizes of dispersed cementdust ranges between 0.1-205µm (Ghosh, [23]). In this study, three mean diameters of 1µm, 5µm and 10µm were considered.

Gas density and viscosity

The gas was assumed to be air at 300C, therefore from table of properties of air in Yunus and John [24], thegas viscosity, $\mu g$is 1.86 ×10-5 kg/ms and the density, ρgis1.18kg/m3.Having determined the required variables, the impaction numbers for the different particle and dropletsizes were calculated using and the result is shown in Table.

Impaction numbers for different particle sizes

dD (µm)	dP = 1µm ψ1	dP = 5 µm ψ2	dP = 10 µm ψ3
500	0.0384	0.960	3.840
1000	0.0376	0.939	3.756
1500	0.0337	0.842	3.367
2000	0.0303	0.757	3.029

Calculated values of the impaction efficiencies for different particle sizes

Re	dP =1µm ψ1			dP = 5µm ψ2			dP =10µm ψ3		
	ηvisc	*ηpot*	*ηI*	*ηvisc*	*ηpot*	*ηI*	*ηvisc*	*ηpot*	*ηI*
65.34	-94.74	4.16	-43.19	19.81	64.53	43.12	59.09	91.15	75.80
255.67	-94.74	4.16	-14.64	19.15	64.04	55.51	58.54	90.88	84.73
515.77	-96.45	3.10	-7.28	15.39	61.33	56.64	55.63	89.35	85.83
824.73	-96.45	3.10	-3.65	11.60	58.75	55.55	52.77	87.66	85.29

Considering the maximum removal efficiency of the 5µm dust particle in Table-3, the efficiencies were obtained to be 99.984% at 500µm droplet size and liquid to gas ratio of 2.7 l/m3 and this is followed by 99.595% and 89.657% at the same droplet size but liquid to gas ratio of 1.7 l/m3 and 0.7 l/m3, respectively. On the other hand, the minimum value of the removal efficiency was obtained to be 43.808%, 75.336% and 89.175% when the droplet size is 2000µm at different liquid to gas ratios of 0.7 l/m3, 1.7 l/m3 and 2.7 l/m3. The same trend follows the collection efficiency of 10µm dust particle shown in Table-4, in which the maximum efficiencies was obtained to be 100.000%, 99.994% and 98.147% at constant 500µm droplet size and different liquid togas ratios of 2.7 l/m3, 1.7 l/m3 and 1.7 l/m3 while the minimum value was obtained to be 58.728%, 88.343% and 96.708% at 2000µm, respectively.

But, for an increase in the liquid to gas ratio and a decrease in the droplet size the efficiency increases. From this analysis, it can be deduced that the proposed scrubber system can be used in controlling particle sizes of 5µm and 10µm and it will perform optimally when the droplet size is 500µm and liquid to gas ratio is 2.7 l/m3.

CONCLUSION

Ambient air quality was assessed using six monitoring stations inside the cement industries ,the studies have clearly revealed the levels of air pollutants for PM2.5, PM10, NO_x and SO_2.The values of all these pollutants (particulates and gaseous) are observed to be very much below National Ambient Air Quality Standards except the PM10, that is the residential area, dispensary. This increase in AQI at this site is probably due to the increased transportation on the road in front of it and the school that is responsible for this increase in traffic. The air quality is giving the holistic view of air pollution levels. So from the result, it is evident that for the time being, the ambient air inside cement industries do not need any attention from the policy makers except the residential area, but may be in the future we need to formulate some ways to counteract the increase in air pollution at specific sites as we may never know when the growing urbanization and the traffic will increase the air pollution level inside the cement industries much more than the maximum permissible limits, collection efficiencies are now up to 99%

From the study it can be concluded that overall management and control of air pollution and management is not satisfactory in term of SPM and PM10.

Finally from Indian AQI it can be said that the cement manufacturing system falls in yellow zone as it has not efficient management plan to avoid pollution to protect environment. Findings of SPM and PM_{10} indicate that people with asthma or other respiratory disease are the group most at risk.

Factors such as the dust particle properties, generation of the dust particles in the scrubber system, lognormal distribution analysis of the dust particles and liquid droplets and spray nozzle and atomization analysis were not considered. The conclusions drawn from the study is that, the proposed system can be used in controlling particle sizes of 5µm and 10µm that are emitted from industrial productions. It is expected that the information provided in this paper will be useful for engineers and researchers for many air pollution control applications especially in the areas of particulate matter (PM10) emissions.

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How to cite this article:

Nithya V and Sathya T.2016, Air Pollutant Emission from Cement Industries. *Int J Recent Sci Res.* 7(5), pp. 11102-11106.

ISSN 0976-3031