Effluent Effect from Lafargeholcim Cement Plant on Environment in Cross River State, South-South, Nigeria

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ABSTRACT

This Research work was carried out to determine the effect of effluent from Lafargeholcim cement production plants on the environment of host state Cross River State, south-south region of Nigeria. Samples were collected at the monitoring stations, while a sample collected 1km away from the factory serves as the control for both water and soil sample. Air quality assessment was monitor for three months at an interval of two weeks per month around the factory location .The outcome of studies for water analysis shows that T, H^2 ions (PH) and DO of the monitoring stations and the control did not show any significance difference while the TDS, TH of the monitoring stations were higher than that of control stations using basic statistical measures like the analysis of variance(ANOVA),simple bar chart to compare the field data of the monitoring stations and the control station. For the soil analysis, concentration level of potentially heavy metals (F_e, M_n, C_d, Z_n, C_u, N_l, P_b) were observed to be significantly higher in station A than station B and the control station. The contamination/pollution index assessment of the soils revealed that the soils belong to slight pollution to excessive heavy metal pollution soil category. The air quality analysis, shows that the average (variance) for the three month shows that NO_2 = 0.03ppm did not exceed 0.06ppm and 0.04ppm, while SO_2 = 0.40ppm and CO_2 = 193.26 which exceeded 0.01ppm ($S0_2$) and 10ppm (CO_2). Hence total average reading for the months for particulate matter was 872.25µg/m^3 exceeding standard value of 260µg/m^3.

KEY WORDS: Dissolved Oxygen (DO),Total Dissolved Solids(TDS),Temperature(T),Sulphur Dioxide(SO_2),Nitrogen(NO_2),Total Hardness(TH).

1.0 INTRODUCTION

The remarkable industrial development of the recent years has brought us a materialistic civilization of mass consumption and it is impossible to envisage a modern life without cement Shraddha andNehal (2014). The cement industry plays a major role in improving living standard as it is indispensable for construction activity, so it is tightly linked to the global economy. Despite its profitability, the cement industry faces many challenges due to the environmental pollution and health issues as a result of the effluent (i.e. solid, liquid and gaseous waste) that enter the environment as a by-product Potgieter (2012). The LafargeHolcim cement plant is located at Mfamosing, Akamkpa Local Government Area of Cross River State, 40km North-East of Calabar with latitude $5^0 7^1 0^{11}$N and longitude 8^O $31^1 0^{11}$ E. The area is largely rural, and the inhabitants are involved in mainly fishing, farming, and small scale trading. The major product of the cement company of Nigeria LafargeHolcim is Portland limestone cement which is of different grade, i.e. CEM II/B-L 32,5R and CEM II/A-L 42,5N and raw materials used for the production are limestone, gypsum, iron and red alluvium. The composition of the raw materials after been processed has negative impact which are associated with the handling and storage of materials, their grinding (particles) and the operation of furnace and clinker coolers (kiln dust) and fuel gas.

Air pollutants are dusts, aerosol, mists, acid rain, particulate matter vapour and gas. At LafargeHolcim cement factory the major air

pollutant is dust which results from the activities involved in the processing of cement.

Aims and Objectives of Study

The aim of the study is to propose various methods to prevent or possibly reduce the adverse effect of these effluents on the environment on host communities.

In other to achieve this aim, the study has the following objectives;

i To know if the effluents from the plant have any significant effect on the environment.

ii To compare the environment around the factory area to neighbouring area.

iii To possibly propose remedial measures at each stage of cement production or the re-design of some of the components to reduce the effect of the effluent.

This study has the following limitations:

I. Since the research is to enhance best practices in the industry, no access was given to carryout proper research studies.
II. Time availability was an issue (considering the short time frame required to carry out this study).
III. Inadequate financial resources at the researcher's disposal.
IV. Communication barrier, during our visit to the community where the plant is situated, as most of the residents were illiterates.

Scope of Study

This study focuses on the effect of effluent produced by LafargeHolcim cement on the environment where the plant is located, at Mfamosing in Akamkpa local Government Area and environ.

2.0 MATERIALS AND METHODS

The water quality and soil test were both carried out in the laboratories of chemistry and soil science while the air quality assessment was conducted at the field and later analyzed. The materials used includes; Tape rule, Thermometer, pH meter and batteries, DO meter with batteries, Conical Flask, Burette, beakers and measuring cylinder, Atomic Absorption Spectroscopy, stack of sieves, the Aeroqual series 500 and Aerocet 513S for air.

The air quality assessment test was done on the ambient environment of Plant site and the location was monitored for three months at an interval of two weeks per day, using Aeroqual for checking the gases and Aerocet for checking the particulate matter. The Aeroqual series 500 has different sensor head for the gases, when the sensor head is inserted it start warming up for three minutes before reading the gas. The auto-calibration function of the devices allows for easy calibration of the gas detector which helps to detect accurately the presence of the gases (e.g. carbon dioxide, methane, and nitrous oxide, sulphuric oxide, volatile organic compounds and particulate matters, which are the constituents of the cement dust resulting in air pollution. The different level of all the dust components in the surrounding atmosphere were recorded into a report book and was compared with the ambient air quality standard for the level of those gases in the atmosphere.

In conducting the water quality assessment, samples were collected and analyzed to determine the following; Dissolved Oxygen(DO), Water Temperature(T), PH of the hydrogen ion (H^+) concentration, Total Dissolved solids(TDS),Total Hardness (TH).

Soil analysis was carried out to check the presents of heavy metals in the soil that affect the soil composition, nutrient and organic matter content as a result of the effluent emitted by the cement factory.

The soil was first digested before using atomic absorption spectroscopy (AAS) to determine the heavy metals present in the soil. The heavy metals which include Mn, Fe, Zn, Ni, Cu, Pb, Cd were analyzed by determining the trace metal concentration of each soil. The soil samples were first digested and 3:1% Aqua Ragia reagent was used in the digestion and later analyzed.

3.0 RESULTS AND DISCUSSIONS

The result of water quality parameter and the analysis of variance of water quality are presented in table 2 and figure1.

Table 1: Result of Water Quality Parameters of the Samples Collected

S/N	Parameters	Station A Results			Station B Results			Station C Results			WHO'S Standard
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	
1	PH	5.6	5.8	5.4	5.5	5.7	5.6	5.7	5.6	5.5	5.5 – 9.0
2	Temperature (^{O}c)	22	23	23	23	21	22	24	23	23	10 - 50
3	Dissolved Oxygen (D0) (Mg/L)	4.10	4.20	4.20	3.80	3.80	3.90	3.1	3.2	3.2	5.0
4	Total Dissolved Solids (TDS) (Mg/L)	150	140	155	150	160	110	90	50	60	1000
5	Total Hardness (TH)	100	10	90	110	110	120	60	65	50	500

Table 2: Results of Analysis of Variance for Water Quality at a Significance Level of 5%.ANOVA

Source of variation	d.f	Sum of square	Mean square	Variance ratio
PH Between groups	2	0	0	0
Within groups	6	0.12	0.02	
Total	8	0.12		
TEMP Between groups	2	3	1.5	3
Within groups	6	3	0.5	
Total	8	6		
DO Between groups	2	-113.11	-56.6	2.29
Within groups	6	148.02	24.67	
Total	8	34.91		
TDS Between groups	2	12117	6059	15.26
Within groups	6	2383	397	
Total	8	14500		
TH Between groups	2	4939	2469.6	38.70
Within groups	6	383	63.8	
Total	8	5322		

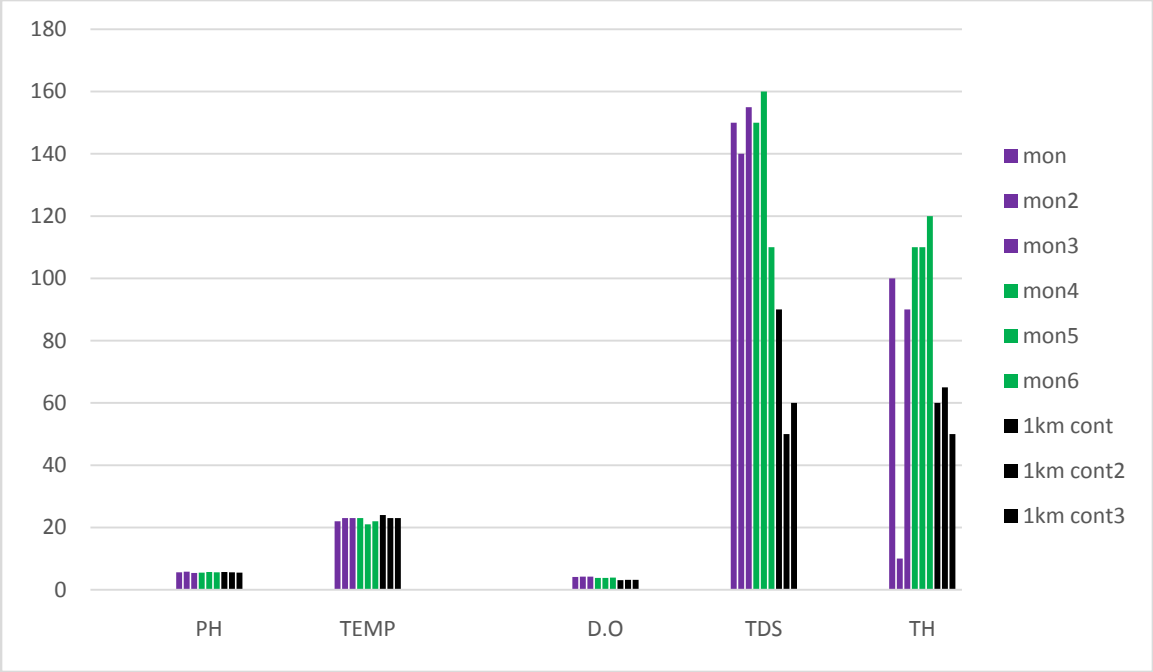

Figure 1: The comparison between monitoring station and control station for PH, TEMP, DO, TDS and TH of water samples collected from the three stations.

Table 3: Result of Gases for Air Quality Analysis for Three Month at an Interval of Two Weeks Per Month.

Gasses	August		September		October	
	Wk1	**Wk2**	**Wk1**	**Wk2**	**Wk1**	**Wk2**
NO_2	0.106	0.068	0.012	0.051	0.072	0.020
SO_2	0.31	0.15	0.35	0.43	0.27	0.84
VOC	0.30	0.40	1.40	0.70	1.1	39.70
CO_2	461	603	429	426	471	524

Table 4: Results for Particulate Matter.

Particulate Matter	August		September		October		Standard
	Wk1	Wk2	Wk1	Wk2	Wk1	Wk2	
PM1	11.7	11.8	19.0	11.1	17.1	12.0	-
PM2.5	17.6	25.4	34.7	15.7	24.4	34.5	25μg/m^3
PM5	30.5	75.6	76.8	22.0	34.2	79.1	-
PM7.5	54.7	235.8	101.9	29.4	46.7	150.6	-
PM10	70.1	371.0	263.6	34.5	54.2	190.8	50μg/m^3
TSP	92.8	577.9	384.0	41.1	57.6	231.3	10μg/m^3

Table 5: Contamination/Pollution Index for Heavy Metals in Soil, Station A, MPI = metal contamination/pollution index

Heavy Metal (Mg/Kg)	Depth (Cm)	Station A Mean (Mg/Kg)	Control C Mean (Mg/Kg)	MPI	Class Interval According To LACTUSU (2000)	Significance (Pollution).
Iron (F_e)	0 – 20	195.17	35.67	5.47	4.1 – 8.0	Severe
Zinc (Z_n)	0 – 20	40.07	4.03	9.94	8.1 – 16.0	Very severe
Nickle (N_i)	0 – 20	26.40	15.03	1.76	1.1 – 2.0	Slight
Lead (P_b)	0 – 20	3.0	0.07	42.86	> 16.0	Excessive
Manganese Mn	0 – 20	958.67	392.33	2.44	2.1 – 4.0	Moderate
Copper (C_u)	0 – 20	11.30	4.0	2.38	2.1 – 4.0	Moderate
Cadmium Cd	0 – 20	5.03	1.93	2.61	2.1 – 4.0	Moderate

Table 6: **Result of Soil Analysis for Heavy Metals**

S/N	Heavy Metals (Mg/Kg)	Station A Results			Station B Results			Station C Results		
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
1	Iron (F_e)	201.5	195	189	73	60	68	30	41	36
2	Zinc (Z_n)	40	38.2	42	13	12.8	14.7	4.0	3.9	4.2
3	Nickle (N_i)	26.4	27	25.8	18.51	19.1	18	15	15.3	14.8
4	Lead (P_b)	3.0	3.1	2.9	0.11	0.12	0.11	0.07	0.07	0.08
5	Manganese (M_n)	1032	989	855	487	459	492	393	395	389
6	Copper (C_u)	11.4	11.6	10.9	5.02	5.0	4.9	4.1	3.9	4.0
7	Cadmium (Cd)	4.9	5.0	5.2	2.0	2.1	2.2	1.91	2.0	1.9

Table 7: Mean Concentration of Heavy Metals at Station A, Station B, And Control Station C, Compared to Standard Limits of Heavy Metals in Soil in Mg/Kg.

Heavy Metal (Mg/Kg)	Depth (Cm)	Station A Mean (Mg/Kg)	Station B Mean (Mg/Kg)	Station C Mean (Mg/Kg)	United Kingdom Standard (Mg/Kg)
Iron (F_e)	0 – 20	195.17	67.0	35.67	-
Zinc (Z_n)	0 – 20	40.07	13.50	4.03	200
Nickle (N_i)	0 – 20	26.40	18.54	15.03	35
Lead (P_b)	0 – 20	3.0	0.11	0.07	70
Manganese (M_n)	0 – 20	958.67	479.33	392.33	-
Copper (C_u)	0 – 20	11.30	4.97	4.0	63

Cadmium (Cd)	0 – 20	5.03	2.1	1.93	1.4

Table 8: Contamination/Pollution Index for Heavy Metals in Soil, Station B

MPI = metal contamination/pollution index

Heavy Metal (Mg/Kg)	Depth (Cm)	Station B Mean (Mg/Kg)	Control C Mean (Mg/Kg)	MPI	Class Interval According To LACTUSU (2000)	Significance (Pollution)
Iron (F_e)	0 – 20	67	35.67	1.88	1.1 – 2.0	Slight
Zinc (Z_n)	0 – 20	13.5	4.03	3.35	2.1 – 4.0	Moderate
Nickle (N_i)	0 – 20	18.54	15.03	1.23	1.1 – 2.0	Slight
Lead (P_b)	0 – 20	0.11	0.07	1.57	1.1 – 2.0	Slight
Manganese (M_n)	0 – 20	479.33	392.33	1.22	1.1 – 2.0	Slight
Copper (C_u)	0 – 20	4.97	4.0	1.24	1.1 – 2.0	Slight
Cadmium (Cd)	0 – 20	2.1	1.93	1.09	1.1 – 2.0	Slight

4.0 Discussion

4.1 Water Quality Analysis

From the result of the analysis of variance presented above, each parameter of the monitoring stations was compared with their corresponding control station using analysis of variance in which the F-ratio was calculated and the significant differences drawn.

p>5, means there is no significance difference p< 5, means there is a significance different.

Also, a simple Histogram was used to compare the monitoring stations with the control station.

PH: Comparing the monitoring station with the control shows that there was no significance difference, df (2,6) = 0, P >5 and this is due to the burning of the raw material such as (limestone, gypsum, red alluvium) in the kiln at the factory area which is responsible for the phenomenon known as acid rain which causes the rainfall on the water surface to become highly acidic .The resulting acid rain makes the water less portable for human consumption and at a certain level kill aquatic animals. Also from the chats presented above, it shows that there are a no differences between the monitoring stations and the control station.

Temperature: As a result of the analysis comparing the monitoring stations with the control station shows that there is no significance difference, df (2,6) = 3, P > 5 and this indicates that the temperature at both the monitoring stations and the control station are the same. Also from the chats presented above, it shows that there are really no differences between the monitoring stations and the control station.

For Air quality analysis, the result was done for the major source of gases (NO_2, SO_2, CO_2) and particulate matter (PM2.5, PM10, TSP) using t – test to analyze; comparing the sample mean to the population mean at a significance level $\alpha = 0.05$.$H_0 = \mu_1 - \mu_2 < d$ there is no significant difference.$H_1 = \mu_1 - \mu_2 \geq d$ there is a significant difference.

Therefore, from the analysis comparing the gases to the Nigeria ambient air standard at a df (5) = 0.020, p < 0.06 ppm for NO_2, p < 0.01ppm for SO_2, and p < 5.16ppm for CO_2 shows that there is no significance difference between the sample mean of the gases to the population mean,hence we accept H_0 (the null hypothesis). Also the particulate matter at df (5) = 0.020, p < 25μg/m³ for PM2.5, p < 50μg/m³ for PM10, and p < 10μg/m³ for TSP shows that there is no significance difference. Nevertheless, from the standard deviation for the three month without making a statistical statement shows the average for NO_2 = 0.03ppm which does not exceed the standard value of 0.06ppm and 0.04ppm, while SO_2 = 0.40ppm and CO_2 = 193.26 which exceed the standard value of 0.01ppm ($S0_2$) and 10ppm (CO_2) due to the combustion of fuels and the calcinations process of limestone.

Consequently, the total average reading for the three months for particulate matter was 872.25μg/m³ concentration exceeding the standard value of 260μg/m³ which is generated as a result of hauling, quarrying, crushing, grinding of raw materials and clinkers; thereby causing numerous hazards to the biotic environment, which have adverse effects and toxicological risk to vegetation, animal health and ecosystem.

5.0 CONCLUSION

The gaseous and particulate emissions from cement plants are degrading air quality, contaminating the soil and also affect the water quality, thereby creating considerable environmental pollution. Therefore, it can be concluded from the analysis made for water and soil that there is a significant different from the monitoring station to the control station, although some parameters vary. While for the air, it shows that there are some degree of gases and particulate matter on the air above the standard for some of the gases.For water analysis, the temperature, degree of hydrogen ion (PH) and dissolve oxygen of the monitoring stations and the control stations were of the same value while the total dissolve solid (TDS) and total hardness (TH) of the monitoring stations were higher than that of the control stations and this is as a result of the effluent emanating from the cement plant. Also, the analysis of the air quality assessment shows that the gases and particulate matter has no significance difference between the sample mean to the population mean. Furthermore, the result for the soil revealed that the soil contains substantial level of heavy metals (F_e, M_n, C_d, Z_n, C_u, N_I, P_b) which affect the soil composition. The heavy metal load level and metal contamination/pollution index assessment revealed that the soil belongs to the class of slight pollution to excessive pollution category. Although some of the parameters for water, soil and air are in line with the safe limits standard but the toxic level of harmful materials can aggravate due to continuous generation of the effluents which can cause numerous hazards to biotic environment.

Recommendation

It is of primary necessity to evaluate the air quality around any industrial unit in order to emphasize the adverse effects to ecological system and human health. For cement production activity, the control of dust from hauling materials should be set up in the surrounding of cement plants. It is also recommended that complete analysis of cement dust containing all the toxic pollutant should be carried out in detail, and thereby controlling the dust by use of covered or enclosed conveyers, crushers, material transfer points and storage areas; installation of dust collectors and/or bag

filters where needed; vacuum sweepers for plant roads; sprinklers for plant roads and storage piles; latex stabilizing sprays for storage piles in order to mitigate dust and improve air quality.

Further study is needed not only to assess the distribution of metals in water and soil but also to examine variations on a small scale. More intensive sampling and examination will be required to know any changes or increase of metals in the investigated area.

REFERENCES

1. Potgieter Johannes H (2012). An overview of cement production: How green and sustainable is the industry.

2. Shraddha, Mishra and Nehal, A. Siddiqui (2014). Environmental and health impacts of cementmanufacturing emissions. International Journal of Geology, Agriculture and Environmental science, Volume 2.

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