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IMPACT OF CEMENT DUST POLLUTION ON PHYSICOCHEMICAL AND MICROBIOLOGICAL PROPERTIES OF SOIL AROUND LAFARGE CEMENT WAPCO, EWEKORO, SOUTHWESTERN NIGERIA

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ABSTRACT
A study was conducted to investigate the impact of cement dust pollution from LARFAGE cement WAPCO, Ewekoro on physicochemical and microbiological properties of surrounding soil. Soil samples were collected inside the cement plant and from fields located 100m, 300m, 500m and 1 Km away from the cement plant. Soil samples were taken from a depth of 0-10cm and analyzed for physicochemical and microbiological properties. The physiochemical characteristics determined were soil pH, moisture content, soil metals content (Fe, Cd, Cr, Cu, Pb, Zn and Ni). Population and diversity of culturable microbial species and soil enzyme activities were also examined. The pH ranged from 8.20 ± 0.20 - 9.50 ± 0.42. Temperature ranged from 27.50 ± 0.26 - 30.30 ±0.26. The areas closer to the factory site had higher temperatures and pH values. The soil moisture content ranged from 13.35±0.02 - 20.10±0.20, with values increasing progressively as you move away from the factory site. The levels of all the metals except Zn were higher within the factory than in the control. Cr, Fe, Pb and Ni were significantly higher in all localities than in control. Isolated microbial flora consists of 4 bacteria genera belonging to, *Alcaligenes*, *Bacillus*, *Pseudomonas* and *Micrococcus*, and 4 fungal genera belonging to, *Aspergillus*, *Penicillium*, *Alternaria* and *Fusarium*. The bacterial population ranged from 0.98±0.01 - 8.50±0.02, while the fungal population ranged from 0.04±0.02 - 0.48±0.02. Microbial diversity and population increased steadily as you move away from inside the factory. The isolates are considered tolerant to alkakine pH and heavy metals from cement dust. The soil enzyme activity varied with each sampling site. Dehydrogenase activity increases as you move away from the factory site. The variation is attributed to the impact of pH and heavy metals on microbial population.

KEY WORDS: Microbial diversity, microbial population, cement dust pollution, soil enzyme activity.

INTRODUCTION

The soil is often the repository of waste emanating from domestic and industrial processes. These pollutants are sometimes released deliberately into the soil or carried by wind and rain to great distance from source of pollution. One industry that emits pollutants in form of dust and gases which find their way into the soil is the production of cement (Addo, 2013). Cement production is often associated with significant dust particle pollution which can remain airborne and can spread over large areas through wind and rain, accumulating in soils and plants (Isikli *et al*., 2003; Bilen, 2010). Dust from cement and other factories leads to considerable change in pH and accumulation of emitted metals in soil which may affect both the composition and physiological processes of microorganisms leading to a reduction in microbial biomass and enzymatic activity (Zwolinski *et al*., 1988; Hemida *et al*., 1997; McCarthy, 2003; Biyik *et al*., 2005). Soil microorganism play important role in the overall soil metabolism. Enzymes primarily derived from microorganisms drive the biochemical processes of the soil. Microbial biomass and soil enzyme activity are good indicators for soil health monitoring and are sensitive to changes in soil properties due to presence of pollutants (Bilen, 2010). Attention has been drawn to pollution of soil surrounding cement factories because of the threat of toxicity of heavy metals on all life forms. When cement comes in contact with the soil surface its constituent metal undergo several reactions which can affect the soil properties. The cement dust which is highly alkaline give rise to high pH values (Mlitan *et al*., 2013a). Some of the metals associated with cement dust, such as sodium, potassium, copper, zinc, calcium, magnesium, manganese and iron are necessary for microbial growth and metabolism, but can become toxic if their concentration exceeds certain threshold (Mlitan *et al*., 2013a; Asadu and Agada, 2008). The analysis of microbial communities, enzymatic activities and heavy mental level in soil is therefore essential for ensuring soil health and quality (Neilsen and Winding, 2002; Jabeen and Sinha, 2011). Many studies on the effect of dust particles focus mainly on plants and animal life with little mention of its effect on soil microorganism. In this study, we tried to determine the impacts of cement dust pollution on microbial population and enzyme activity in the soil. The pH, moisture, and heavy metals content in the polluted soil were taken and compared with results from unpolluted soil samples.

MATERIALS & METHODS

Study Area

Lafarge cement WAPCO, Ewekoro is suituated in Ewekoro Local Government Area of Ogun State of Nigeria. Ewekoro borders Papalanto in the west, Abeokuta in the East and numerous villages along the northern and southern axis. It lies between latitude 60º 53' N and longitude 30º 14' E. The climate of the area is tropical with guinea savannah features. The rural dwellers in this area are mainly farmers with cassava, rice and yam as major crops. Limestone quarrying and Cement production activities have been going on in this area since 1960. Lafarge of France operates the Ewekoro works as one of the mills of West African Portland Cement Company (WAPCO).

Soil Sampling

Soil samples were collected from site A (inside the factory), B (100 m), C (300 m), D (500 m) and E 1km away from the factory to serve as the control. Soil samples were taken from a depth of 0-10 cm Soil. Triplicate soil samples were randomly collected at each sampling site and homogenized into a composite sample for pH, heavy metals, enzymatic activities and microbial biomass determination.

Soil Physicochemical Analysis

Soil moisture content and pH value were determined according to the method described by Chaturvedi and Sankar (2006). Heavy metals analysis was done according to Majolagbe *et al*. (2013) using Perkin-Elmer Model 403 atomic absorption spectrophotometer (AAS).

Isolation and Estimation of bacteria and fungi

Bacterial and fungal populations per gram of soil were estimated by using the dilution plate method for each type of soil samples as described by Biyik *et al*. (2005). For each amendment three replicates of Petri plates were prepared. After Incubation at ambient temperature of 28-30ºC for 2 days for bacteria and 5-7 days for fungi, the average colony forming units (CFU) per gram of soil was calculated by using colony counter. The different isolates were identified on the basis of their morphological, microbiological and biochemical characteristics as outlined in (Aneja, 2003; Raper and Fennell, l987).

Analysis of Soil Enzyme activity

Soil enzyme activity (total dehydrogenase) was done according to method described by Akmal and Jianming (2008).

Statistical Analysis

Statistical analysis was performed using the Analysis of Variance (ANOVA). The data represented means calculated from three replicates. A least significant difference test was employed for comparison of the changes and values at p≤0.05 are said to be significant.

RESULTS

Soil Physiochemical Properties

The measured physicochemical properties of the soil are given in Table 1. The pH ranged from 8.20 ± 0.20 - 9.50 ± 0.42. Temperature ranged from 27.50 ± 0.26 - 30.30 ±0.26. The areas closer to the factory site had higher temperatures and pH values. The soil moisture content ranged from 13.35±0.02 - 20.10±0.20, with values increasing progressively as you move away from the factory site. The levels of all the metals except Zn were higher within the factory than in the control. Cr, Fe, Pb and Ni were significantly higher in all localities than in control (Table 2).

TABLE 1: Soil physicochemical properties

	A	B	C	D	E
pH	9.50 ± 0.42	8.90 ±0.10	8.40 ±0.32	8.20 ± 0.20	8.70 ± 0.20
Temperature ºC	30.30 ±0.26	30.10 ± 0.01	29.10 ±0.17	28.70 ± 0.20	27.50 ± 0.26
Moisture content (%)	13.35 ±0.02	12.62±0.30	14.46±0.01	17.30±0.11	20.10±0.20

Values are mean ± standard deviation

TABLE 2: Heavy Metals Concentrations (mgkg-1) in soil

	A	B	C	D	E
Fe	55.70±0.03	41.30±0.23	37.30±0.04	36.30±0.53	22.20±0.01
Cd	0.070±0.002	0.06±0.03	0.04±0.01	0.037±0.002	0.03±0.01
Cr	0.70±0.36	0.56±0.04	0.46±0.03	0.26±0.25	0.31±0.03
Cu	1.10±0.04	1.13±0.036	0.98±0.40	0.83 0±0.17	0.86±0.20
Pd	2.20±0.32	2.10±0.40	1.80±0.35	1.60±0.60	1.50±0.10
Zn	13.60±0.26	16.20±0.08	17.90±0.26	20.30±0.42	21.20±0.02
Ni	0.78±0.01	0.56±0.03	0.44±0.01	0.46±0.02	0.34±0.04

Values are mean ± standard deviation

Microbial diversity and population

Table 3 shows the microbial counts and diversity in soil from the sampling areas. Isolated microbial flora consists of 4 bacteria genera belonging to, *Alcaligenes, Bacillus, Pseudomonas* and *Micrococcus,* and 4 fungal genera belonging to, *Aspergillus*, *Penicillium*, *Alternaria* and *Fusarium*. The bacterial population ranged from 0.98±0.01 - 8.50±0.02, while the fungal population ranged from 0.04±0.02 - 0.48±0.02. Microbial diversity and population increased steadily as you move away from inside the factory.

TABLE 3: Microbial counts and diversity in soil around Lafarge cement WAPCO, Ewekoro

	Bacterial population x 10^4	Fungal population x 10^2	Isolated microorganism
A	0.98±0.01	0.04±0.02	*Bacillus* sp$_1$, *Bacillus* sp$_2$, *Aspergillus niger, Fusarium* sp.
B	2.85±0.03	0.12±0.04	*Bacillus* sp$_1$, *Bacillus* sp$_2$, *Alternaria sp, Aspergillus niger, Fusarium* sp.,
C	3.04±0.23	0.19±0.03	*Bacillus* sp$_1$. *Aspergillus niger, Aspergillus flavus, Alcaligenes latus, Micrococcus* sp., *Fusarium* sp.,
D	3.95±0.11	0.28±0.01	*Bacillus* sp$_1$., *Aspergillus niger, Aspergillus fumigatus, Alcaligenes latus, Micrococcus* sp., *Fusarium* sp., *penicillium* sp.,
E	8.50±0.02	0.48±0.02	*Bacillus* sp$_1$., *Pseudomonas aeruginosa, Pseudomonas fluorescence, Micrococcus* sp., *Aspergillus niger, A. flavus, A. fumigatus, penicillium* sp., *Fusarium* sp.,

Soil enzyme activities

The soil enzyme activity measured is total dehydrogenase activity and the result is given in Table 4. The soil enzyme activity varied with each sampling site. Dehydrogenase activity increased with increase in distance from the factory site (Figure 1).

TABLE 4: Dehydrogenase activity of soil around Lafarge cement WAPCO at Ewekoro

Distance	Dehydrogenase activity
0	23.6
100	25.4
300	32.8
500	35.6
1000	40.5

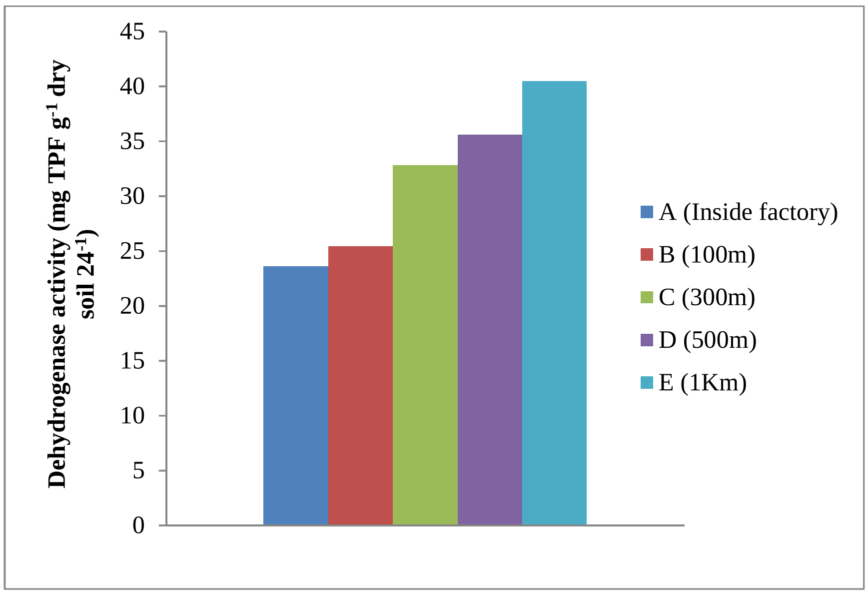

FIGURE 1: Dehydrogenase activity of soil around Lafarge cement WAPCO at Ewekoro

DISCUSSION

The study of physicochemical and microbiological properties of soil around Larfage cement WAPCO, Ewekoro revealed a strong influence by the particulate pollutants that have settled on the soil from the cement factory. It can be seen that the effect of dust on soil metals content, water content and pH of soil depended on the distance from the factory. There was alteration in the soil properties arising from the cement dust. The cement dust particles entering the soil increased the pH of the soil, making it more alkaline. The highest pH observed in this study was 9.70 and this was from soil collected from inside the factory, where particulate pollution is highest. This finding is so because the principal component of cement is limestone which is alkaline in nature. Bilen (2010) reported that soil pH changes is connected with content of cement dust of the soil, with the cement dust pollution affecting soil pH directly, and affecting soil acid phosphatase enzyme activity indirectly. The soil water content and temperature and levels of all the metals except Zn were higher within the factory than in the control as shown in Table 2. The result revealed that the level of Cr, Fe, Pb and Ni were significantly lower ($p \leq 0.05$) in the control (1km from factory site) than in the other sites of sampling, with values increasing steadily from inside the factory. This finding agrees with the report of Majolagbe *et al*. (2013) in their study of environmental media in the study area but differs from the findings of Frederick *et al*. (2014) who reported higher values in the control than at other sampling sites close to Nigerchem cement factory in South-Eastern Nigeria. The level of Zn was significantly higher in control than at other points of sampling, similar to the findings of Frederick *et al*. (2014). Cu maintained almost the same concentration at all the distances and in the control. Strong positive correlation was observed in Fe, Cd and Pd, which is an indication that they are from the same source. The concentrations of all the metals analyzed in the environment samples are within permissible limits for soil (Iqbal, 2011) but their accumulation over time but can adversely affect the type and number of soil microorganisms. Isolated microbial flora from cement impacted soil consists of 3 bacteria genera belonging to, *Alcaligenes*, *Bacillus* and *Micrococcus,* and 4 fungal genera belonging to, *Aspergillus*, *Penicillium*, *Alternaria* and *Fusarium*. Fungal species belonging to four genera reported in this study have been isolated from cement polluted soil in Libya (Mlitan *et al*., 2013a, Mlitan *et al*., 2013b). The microbial diversity from soil samples from inside the factory and adjourning areas was scanty. Two *Bacillus* sp., were able to grow in soil from inside the factory. Desai *et al*. (2004) isolated obligate alkaliphiles belonging to the genera *Bacillus* and *Micrococcus.* Ali *et al.* (2009) isolated alkalphiles belonging to the genera *Alcaligenes, Pseudomonas* and *Micrococcus.* The fungal isolates found in the cement impacted soils were more both in number and in types than the bacterial isolates. Microbial diversity and population increased steadily as you move away from inside the factory. Our findings show that soils impacted by cement dust have lower enzyme activity compared to the control. This is in concordance with the works of Bilen (2010), Frederick *et al.* (2014) who reported that soil enzyme activities are affected by pH, heavy metals and microbial community density. The low soil enzyme activity is as a result of the negative impacts of the cement dust on soil microbial populations and metabolic activities.

CONCLUSION

This study showed the levels of heavy metals and pH inside the cement factory and adjourning areas were high. The adverse effect of this is noticeable by the population and diversity of the soil micro biota, which were generally low. An indicator of the soil health is the soil enzyme activities, which was negatively impacted by the cement dust. Since agricultural activities are going on in this area crop yields will be greatly affected. Although the present levels of the heavy metals pollutants do not pose immediate threat to animal lives, accumulation over time can lead to greater danger. Further studies on the effect of cement dust on rhizosphere microorganisms need to be conducted.

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