NJBAS

Available online at http://ajol.info/index.php/njbas/index ISSN 0794-5698
Nigerian Journal of Basic and Applied Science (2010), 18(1):58-64

Fertility Status of Fadama Soils in Gantsare Village, Wamakko Local Government, Sokoto State As Affected by Cement Dust.

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ABSTRACT: A study was conducted in Gantsare village, Wamakko local government, Sokoto state to determine the effect of cement dust emitted from Sokoto cement factory on the fertility of fadama soils. Soil samples were collected in June, 2008 from the eastern, northeastern, and southeastern parts of the village and Girabshi; a nearby village with least effect of the dust. The samples were collected at two depths (0-15 and 15-30 cm) using simple random sampling method. Randomized complete block design (RCBD) was employed, replicated three times, making a total of 24 samples. The samples were analyzed for pH, OC, CEC, total N, available P, exchangeable bases (Ca, Mg, K and Na) and particle size. Almost all parameters determined were found to be statistically significant ($P < 0.01$). OC was found to be lower in concentration in the areas closer to the factory; eastern part<northeastern part<southeastern part<Girabshi village; 1.31<1.36<1.50<2.59 g kg^{-1} respectively, available P also followed similar trend. While pH indicated a reverse trend; eastern part>northeastern part>Southeastern part>Girabshi village; 7.77>7.76>7.75>6.25 respectively, likewise CEC and exchangeable bases. The trend in the results observed may be attributed to possible adverse effects of the dust on microbial population, reduction in the availability of some nutrients and a favour on the concentrations of exchangeable bases and CEC. The topsoils showed better results of all the soil chemical properties. The study recommends minimization of the amount of dust reaching agricultural soils and the use of phosphorus and nitrogen fertilizer supplements as soil management practices to enhance soil fertility status and enhance adequate crop yield in the area.
Key words: Cement dust, fertility status, fadama soils, soil chemical properties, soil management.

INTRODUCTION

Arable lands close to cement production factories are subjected to the effect of cement dust emitted during the production process, which contains oxides, sulphides, calcic and dolomitic limestone among others (Sivakumar and Britto, 1995). This dust is mostly deposited in areas close to the factories (Adejumo *et al;* 1994) and even areas far from the factory because of its light weight making it easily carried by air to even far distances (Oyedele *et al;* 1990). The dust is mostly deposited on plants and soils leading to the modification of soil properties due to reactions taking place in the soils between the contents of the dust and water molecules to form various products. This could cause degradation of the soil through changes in soil structure, pH, exchangeable bases and cation exchange capacity that could lead to a negative effect on soil fertility (Epebinu and Udo, 1994; Sivakumar and Britto, 1995; El-din and El-sarnagawy, 1985). Cement dust is also likely to affect both terrestrial and aquatic organisms like fishes, horticultural and other crops through changes in soil chemical properties. Cement dust has been established to contain small quantities of heavy metals such as zinc, iron, manganese, copper and cobalt present as impurities in the raw materials of cement production (Adejumo *et al;* 1994; Epebinu and Udo, 1994; Sivakumar and Britto, 1995). It was also found to affect microbial activities in the soil through changes in soil pH, thus adversely affecting the concentration of other chemical properties due to impediment to organic matter decomposition rate (Wasserbauer *et. al.,* 1998). The deposition of cement dust has consequently been associated with reduction in yield of rice and wheat grown in areas close to cement factories in China, and a reduction in vegetative cover of some trees was also reported (Mandre and Tuulmets, 1997).

Fadama soils are poorly drained and texturally finer and nutritionally richer than upland soils (Singh and Babaji, 1990). They retain high level of moisture in any season of the year, therefore more suitable for many forms of agricultural crop production (Singh, 1998), especially vegetable and horticultural crops and other cultivated crops year round Scoone, 1992). Therefore, fadama lands are regarded as "a garden or a little paradise" in the semi arid Northern Nigeria, as they remain green virtually all year round, contrary to the uplands (Singh, 1998).

Gantsare village receives the direct effect of the dust discharged from Sokoto cement factory, being the immediate village boardering it, with farmlands of the villagers up to the fence of the factory. Consequently, high amount of the dust get deposited in agricultural soils, fadama soils inclusive. Other studies conducted in the area did not focus on the village or on the effect of the dust on fadama soils, hence, the need for this study. The aim of the research is therefore, to study the impact of the dust particularly on fadama soils of the area, being the resort of the farmers year round, through rainfed and irrigated crop production practies. The study could give an indication of the soil management practices to be adapted and possible remediation measures to be taken to maintain the fertility of the soils for improved crop production in the area. The study attempted to determine the effect of the dust on the chemical properties of the fadama soils of Gantsare village, the variation of the effect in different locations within the village and at different soil depths.

MATERIALS AND METHODS

Study area: The study was carried out in Gantsare village, Wamakko local government area, Sokoto state, where Sokoto cement factory is located. The inhabitants have their farmlands extend to the wall of the cement factory, and receive the direct impact of cement dust, which could be visible on their plants, soils, roofing and virtually every open structure. The factory is located at the western part of Sokoto metropolis on latitude $13^{o}\,01'$ N and longitude $5\ ^{o}\ 15'$ E (Kowal and Knabe, 1972) in the Sudan Savannas zone of Nigeria. The climate is semi arid, characterized by long dry (October to May) and short rainy (June to September) seasons and reaches maximum in August, with mean annual rainfall of 680 - 850mm minimum and maximum respectively. It has annual maximum and minimum temperatures of 40^{o}C and 15^{o}C, respectively (Arnborg, 1988). The natural vegetation of the area is Sudan savanna, characterized by few trees and grasses.

Soil sampling and Experimental Design: The soil samples were collected in June, 2008 from fadama areas in four different locations, three within Gantsare village, representing three different areas most effected by the dust emission; eastern, northeastern and southeastern parts of the village. The fourth location was Girabshi village, an area relatively far away from the factory (about 10 km) in the eastern part of the factory for comparison. The samples were using simple random sampling (from each plot) in a randomized complete block design (RCBD) and three farmers plots of an average of 0.25 ha size each were identified in each of the locations as replications, since land slopes towards the cement factory. The criteria for selection of the plots was the farmers practice of application of only organic sources of nutrients, mainly animal manure, household waste, farm yard manure and crop residues for fertilization, without the application of inorganic fertilizers. Composite samples were then collected using soil auger from each plot at two depths; 0 - 15 and 15 - 30 cm, a total of twenty four (24) samples. The samples were then air dried, and sieved through 2 mm mesh sieve and subsequently stored in labeled polythene bags for further analysis.

Soil Analyses: The samples were then analyzed for various soil chemical properties; Soil reaction (pH) was determined potentiometrically in 1: 2.5 soil to 0.01 M $CaCl_2$ solution ratio (which gives pH values closer to soil conditionn than in water) using pH meter. Total nitrogen was determined using Kjedahl digestion method (Jackson, 1962), available phosphorus was determined using Bray No.1 method (using HCl and ammonium fluoride extract ant) (Bray and Kurtz, 1945), organic carbon was determined by Dichromate oxidation method (Nelson and Sommers, 1982), cation exchange capacity was determined by the neutral ammonium acetate saturation method buffered at pH 7 (Kundsen *et. al.*, 1982). The extract for CEC determination was reserved for exchangeable bases determination; flame photometer was used to determine exchangeable potassium and sodium, while exchangeable calcium and magnesium were determined using EDTA method (Devis and Feitas, 1970). Particle size analysis was carried out using the method of Gee and Bauder (1986) and the textural classes determined using the textural triangle.

Statistical Analyses: Analysis of variance (ANOVA) was used for test of significance among the different locations and between the two depths for all the data obtained, the difference among treatment means were separated using Duncan new multiple range test using SAS (1998) statistical package. The method of Saa *et al.* (1994) was used to calculate enrichment factors for the various soil chemical properties as a result of the effect of the dust deposition and these have been illustrated using bar charts.

RESULTS AND DISCUSSIONS

The results of chemical properties of fadama soils in Gantsare village as affected by cement dust are shown in Table 2. The effect of the dust on organic carbon and available phosphorus was found to be statistically significant ($P < 0.01$). Girabshi village (the relative control) was found to have higher concentration of both organic carbon and available phosphorus compared to the affected areas; 2.59 g kg^{-1} and 10.01 mg kg $^{-1}$ respectively. The least organic carbon concentration was obtained in the Southeastern part of the village (1.5 g kg $^{-1}$) and the lowest concentration of available phosphorus was obtained in the eastern part of the village (3.25 mg kg $^{-1}$). Although, the organic carbon content was generally medium to high and the available phosphorus low in concentration according to the rating of Esu (1991), the values conform with the findings of Ladon (1991) . The effect could be linked to the impact of the dust on microbial activities as a result of the high pH induced or possible toxic effect of heavy metals (not determined), which are established component of the dust (Adejumo *et. al.,* 1994).

Table 1. Some properties of cement dust.

Property		Quantity
Sand	g kg^{-1}	-
Silt	,,	-
Clay	,,	-
Texture		-
pH		8.14
Organic C	g kg^{-1}	-
Total N	,,	-
Available P	,,	0.28
CEC	$cmol_c\ kg^{-1}$	-
Ca	,,	42
Mg	,,	2.5
Na	,,	3.5
K	,,	0.2

Adapted from Ibrahim and Noma (1999)

This could lead to low level of organic matter decomposition, in turn due, thus effecting other soil chemical properties (Wasserbauer *et al.,* 1998). In addition, the lower level of available phosphorus, particularly in the affected areas could be due to phosphorus fixation into unavailable forms, such as calcium phosphates (Brady and Weil, 1999), which could be attributed to large quantities of calcium deposited in the highly dusted areas. The topsoil (0 - 15 cm) had higher organic carbon and available phosphorus concentrations; 2.49 g kg $^{-1}$ and 5.33 mg kg $^{-1}$, respectively, compared to the subsoil (15 - 30 cm) with values of 1.64 g kg $^{-1}$ and 4.37 mg kg $^{-1}$ (Table 2). This could not be unconnected with higher level of organic matter and microbial activity inherent in topsoils relative to subsoil, which will equally be relatively effected by of the dust.

Table 2. Effect of cement dust on chemical properties of fadama soils in Gantsare village, Wamakko local government, Sokoto state

Treatments	pH	Organic C g kg^{-1}	Avail. P mg kg^{-1}	Total N g kg^{-1}	CEC ←	Exch. Ca	Exch. Na cmol$_c$ kg^{-1}	Exch. Mg	Exch K →
Site									
Eastern part	7.77a	1.31d	3.25d	0.52	9.81a	4.13a	1.80b	0.88ab	0.37c
Northern part	7.76a	1.36c	3.28b	0.48	9.17b	2.49b	2.19a	0.91a	0.14ab
Southern part	7.75b	1.50b	3.32c	0.51	6.81c	1.84c	2.10ab	0.77b	1.16a
Girabshi village	6.25	2.59a	10.01a	0.50	7.00c	1.14c	0.98c	0.81ab	1.10b
Significance	**	**	**	NS	**	**	**	*	**
Depth									
0 - 15 cm	7.74a	2.49a	5.33a	0.60a	8.38a	3.68a	2.02a	0.95a	1.25a
15 - 30 cm	7.26b	1.64b	4.73b	0.41b	7.02b	1.62b	1.51b	0.73b	0.51b
Significance	*	**	**	**	**	**	*	**	**
S x D	NS	*	*	*	NS	**	NS	NS	**
CV	3.58	9.36	4.32	8.05	6.61	11.47	10.63	10.90	13.88
SE	0.51	0.44	0.47	0.20	0.71	0.55	0.51	0.30	0.37

Means within a column anMeans on same column and treatment having a same letter are not significant. * significant at 5%, ** significant at 1%.

The effect of the dust on soil pH, cation exchange capacity and exchangeable bases was also found to be significant ($P < 0.01$) (Table 2). The pH was slightly acid in Girabshi village and neural in all the affected areas in Gantsare village (affected by the dust). The cation exchange capacity and exchangeable bases, both medium according to the rating of Esu (1991), were also found to be higher in the areas affected by the dust and lowest in Girabshi village. The effect generally increased in the order; Eastern part > Northeastern part > Southeastern part > Girabshi village, with pH and CEC values of 7.77 > 7.76 > 7.75 > 6.25 and 9.81 > 9.17 > 7.00 > 6.81 cmol$_c$ kg $^{-1}$ respectively, cleaarly corresponding to the proximity of the various areas to the source of the dust, this is in line with the findings of Arnold (1998). The effect on soil pH could be attributed to the liming effect of the dust, given its calcic and dolomitic limestone content. Similarly, the effect on exchangeable bases could be due to their accumulation in the affected areas being components of the dust (Ibrahim and Noma, 1994) (Table 1), subsequently leading to higher CEC (Sivakumar and Britto, 1995; Singh, 1998). The difference in pH was not statistically significant (P>0.05) between the two depths; however, CEC and all the exchangeable bases had statistically significant (P<0.05) between the two depths, with higher values at the topsoil (Table 2). This could be because the topsoil is the immediate receipient of the dust, thus having an advantage over the subsoil, where it gradually leaches down to.

The interaction between the locations and depths for all the parameters determined were also found to be significant (P < 0.05) (Table 2), indicating a relationship between them in terms of the influence of the dust. The calculated enrichment ratios as a result of the effect of the dust, as an indicator of the relative contribution of the dust to each soil property at the different locations, with available phosphorus having the lowest enrichment ratios in all the parts of the village. The eastern part is clearly leading in Ca and Na enrichment and Na generally having higher enrichment in all parts of the village, while phosphorus clearly had the lowest enrichment in all the parts, showing its possible fixation as earlier speculated (Figure 1).

A slight indication of the effect of cement dust on particle size distribution could be seen in Table 3. All the areas affected by the dust are predominantly sand in texture, except for the eastern and northeastern parts of the village at 0 - 15 cm depths. However the soils in Girabshi village are loamy and sandy loam at 0 - 15 cm and 15 - 30 cm depths respectively, possibly due to higher level of decomposition of organic matter and microbial activity at this area relative to the affected areas as earlier indicated, thus improving the texture, a property favourable to soil fertility.

Conclusion: A significant effect of cement dust was obtained at the different locations of Gantsare village. Organic carbon and available phosphorus both decreased with the effect of the dust, which was attributed to the negative effect on microbial population and hence, organic matter decomposition rate, while soil pH, CEC and exchangeable bases increased with increasing tendency for the dust acccumulation (closiness of the areas to the source), which could be attributed to the established contents of the dust. Thus the dust has a tendency to adversely affect the fertility status of the soils relative to essential chemical properties as organic C and available phosphorus, especially when large in quantities. The location of farmlands away from the source of the dust, incoporation of good sources of organic matter and application of nitrogenous and phosphatic fertilizers to supplement the fertility status of the soils would improve the fertility of the soils. There is a need for further research to quantify the effect of the dust on soil chemical and physical properties on application of specified quantities of the dust to the soils under controlled conditions.

Table 3. Effect of Cement dust on particle size distribution of soils in Gantsare village, Wamakko local government, Sokoto state

Treatments	% Sand	% Silt	% Clay	Texture
ED_1	83.65	4.60	11.75	L.S.
ED_2	88.99	3.92	7.09	S.
NED_1	88.23	5.88	5.89	L.S.
NED_2	89.54	5.23	5.23	S.
SED_1	94.12	1.96	3.92	S.
SED_2	90.84	7.19	1.97	S.
GD_1	80.39	7.85	11.76	L.S.
GD_2	75.81	9.80	14.37	S.L.

Where; E : Eastern part, NE: Northeastern part, SE: Southeastern part and G: Girabshi village. L.S: Loamy sand, S. L: Sandy loam and S: Sand. D_1: 0 - 15 cm and D_2: 15 - 30 cm.

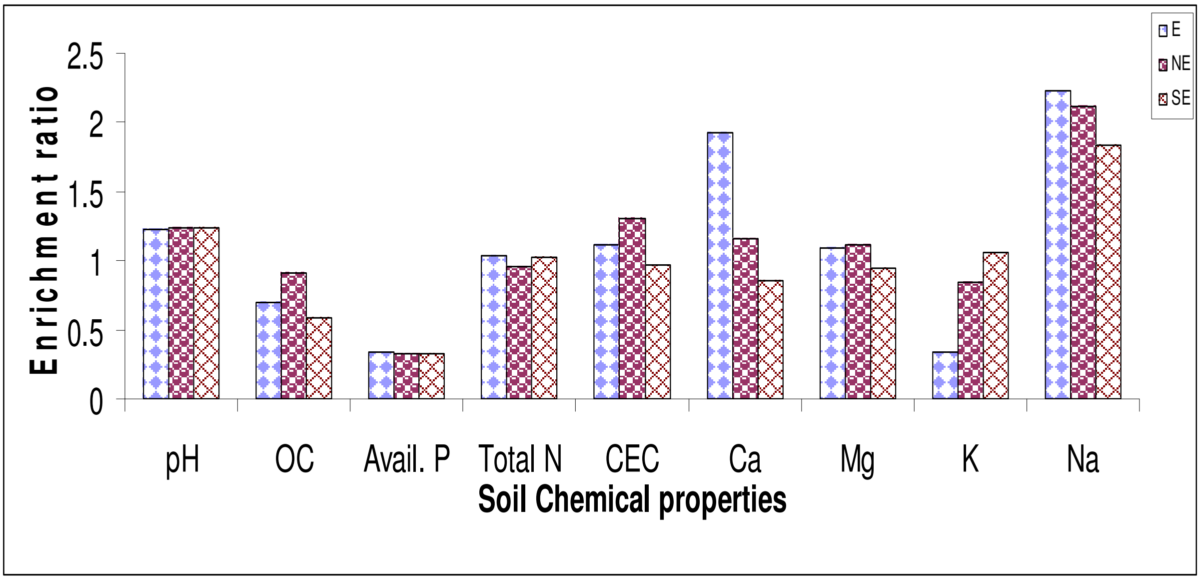

Figure 1. Enrichment ratios for chemical properties of fadama soils as a result of the effect of cement dust in Gantsare village, Wamakko local government, Sokoto state.
Where; E: Eastern, NE: Northeastern and SE: Southeastern parts of Gantsare village.

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