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EVALUATION OF SOIL CONTAMINATION STATUS IN APPROVED MECHANIC VILLAGES IN LAGOS STATE, NIGERIA

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ABSTRACT

Soil contamination is a threat to soil integrity. This work was carried out to evaluate soil contamination status in approved mechanic villages in Lagos State, Nigeria. Soil samples were collected from the surface layer (0 – 15 cm) of Ilasamaja, Animashaun, Idi-Odo, Ojota and Owutu mechanic villages in Lagos State. Samples were also taken 1 km from each of the aforementioned mechanic villages. All the soil samples were analysed for zinc, iron, lead, copper, sodium, potassium, manganese, cadmium, silver, nickel and chromium using an Atomic Absorption Spectrophotometer. The geoaccumulation index for iron, lead, sodium and manganese varied between 14.81 and 17.95, 4.15 and 9.67, 5.01 and 8.12, 5.10 and 10.89 respectively in the investigated soil. The contamination factor for lead and copper ranged between 1.03 and 58.05, 1.03 and 41.87 respectively. The results showed that the mechanic village soils investigated have a very high contamination factor as well as high pollution load index. Based on the results obtained, it is recommended that urgent and immediate actions are required to ameliorate the conditions of the investigated soils.

1. INTRODUCTION

Contamination occurs when the concentration of chemicals, nutrients or elements in the environment becomes more than its normal or natural level as a result of human actions. Soil contamination is a problem the world is currently battling (Mortula and Rahman, 2002; Adeniyi and Afolabi, 2002; Alam et al., 2003; Arora et al., 2008; lim et al., 2008; Ahmed et al., 2009; Bhuiyan et al., 2011). One way of contaminating soil is through disposal of wastes used in mechanic workshops during daily operation. Some scholars have worked on soil contamination status of mechanic workshops (Onianwa, 2001; Akoto et al., 2008; Adie and Osibanjo, 2009; Adelekan and Abegunde, 2011; Ololade, 2014).

Mmolawa et al. (2011) assessed the heavy metals pollution in soil along major roadside area in Botswana. The assessment indicated that the soils along the major roadside areas are polluted as a result of human activities, vehicular emission and lithogenic occurrences. Olayiwola (2011) investigated the contribution of different sections in auto-repair workshops to heavy metal pollution in soil of Osun State. The results showed the individual contribution of various allied artisans to soil pollution in automobile workshops. Michael et al. (2011) researched on trace metal dispersion in soil from auto-mechanic village to urban residential areas in Owerri, Nigeria. The research presented a mobility order of Fe > Pb > Mn > Zn > Cu > Ni > Cd and a pollution order of Pb > Ni > Mn > Zn > Fe > Cu > Cd. Alewo et al. (2011) studied heavy metals contamination of soil in mechanic workshops in Zaria. The study indicated there was an increased in the metal content of soil in all types of mechanic workshops studied. Adewoyin (2013) worked on the impacts of auto-mechanic workshops on soil and groundwater in Ibadan metropolis. The work revealed that the daily activities in auto-mechanic workshops have negative impacts on both soil and water. Idugboe et al. (2014) studied the soil pollution in auto-mechanic villages in Benin City, Nigeria. The study showed pollution in the soils of the auto-mechanic villages which were due to the waste generated in the auto-mechanic market. Chokor and Ekanem (2016) studied the heavy metals contamination profile in soil from automobile workshops in Sapela, Nigeria. The study revealed that the concentrations of heavy metals in soil investigated were higher than the control values.

Works on soil contamination status of Ilasamaja, Animashaun, Idi-Odo, Ojota and Owutu approved mechanic village in Lagos State are very scare in the literature. This work is aimed at evaluating the soil contamination status of the aforementioned approved mechanic villages in Lagos State, Nigeria. It is imperative that the evaluation of soil contamination status is carried out in order to make available fundamental soil contamination data base which can be used by environmental engineers, chemical engineers, scientists and other users of such materials who might work on soil contamination which justifies this work. This work is different from the works of previous authors who had worked on soil contamination of mechanic villages as works in the selected mechanic villages in Lagos State are hardly found in the literature which further justifiesthe need for this work.

2. THEORY

2.1. Geoaccumulation Index

The index of geoaccumulation (I_{geo}) enables the assessment of contamination by comparing the current and pre-industrial concentration originally used with bottom sediment (Muller, 1969). It can also be applied to the assessment of soil contamination. It is computed using Equation (1) (Syed et al., 2012).

$$Igoe = \log_2 \frac{C_n}{1.5B_n} \quad (1)$$

C_n is the measured concentration of the element in the mechanic village soil sample. B_n is the concentration of the element in the background sample. The factor 1.5 is introduced in Equation (1) to minimize the effect of possible variation in the background values. Index of geoaccumulation method assesses the degree of metal pollution in terms of seven enrichment classes based on the increasing numerical values of the index as shown in Table 1 (Muller, 1969).

Table 1: Index of geoaccumulation for contamination level in soil

I_{geo} Class	I_{geo} Value	Contamination Level
0	0	Uncontaminated
1	$0 \le I_{geo} < 1$	Uncontaminated to moderately contaminated
2	$1 \le I_{geo} < 2$	Moderately contaminated
3	$2 \le I_{geo} < 3$	Moderately to strongly contaminated
4	$3 \le I_{geo} < 4$	Strongly contaminated
5	$4 \le I_{geo} < 5$	Strongly contaminated to extremely contaminated
6	> 5	Extremely contaminated

2.2. Contamination Factor and Degree of Contamination

Contamination factor (CF) is the level of contamination of soil by metals which can be expressed using Equation (2) (Syed et al., 2011). Table 2 shows the different contamination factor level and class according to Hakanson (1980).

$$CF = \frac{C_n}{B_n} \quad (2)$$

C_n and B_n are as defined in Equation (1).

Table 2: Different contamination factor level and class

CF Class	Contamination Factor and Level
$CF < 2$	Low contamination factor
$1 \le CF < 3$	Moderate contamination factor
$3 \le CF < 6$	Considerable contamination factor
$6 \le CF$	Very high contamination factor

2.3. Modified Degree of Contamination

The Hakanson modified and generalized form of equation presented by Abrahim and Parker (2008) shown in Equation (3) is used for calculation the overall degree of contamination at a given sampling or coring site as follows (Syed et al., 2012): (i) the modified degree of contamination (${}_mC_d$) is defined as the sum of all the contamination factors for a given set of estuarine pollutants divided by the number of analysed pollutants (ii) the mean concentration of a pollutant element is based on the analysis of at least three samples (iii) the baseline concentrations are determined from standard earth materials.

$${}_mC_d = \frac{\sum_i^n CF}{n} \tag{3}$$

n and CF are as defined in Equation (2).

The modified degree of contamination allows the incorporation of many metals as possible as there is no upper limit. There are seven graduations for classification and description of modified degree of contamination according to Abrahim and Parker (2008). The different modified degrees of contamination for soil are presented in Table 3.

Table 3: Different modified degree of contamination for soil

${}_mC_d$ Class	Modified degree of contamination level
${}_mC_d \prec 1.5$	Nil to very low degree of contamination
$1.5 \le {}_mC_d \prec 2$	Low degree of contamibation
$2 \le {}_mC_d \prec 4$	Moderate degree of contamination
$4 \le {}_mC_d \prec 8$	High degree of contamination
$8 \le {}_mC_d \prec 16$	Very high degree of contamination
$16 \le {}_mC_d \prec 32$	Extremely high degree of contamination
$32 \le {}_mC_d$	Ultra high degree of contamination

2.4. Pollution Load Index

The pollution load index (PLI) developed by Thomilson et al. (1980) is presented in Equation (4). PLI is aimed at providing a measure of the degree of overall contamination at a sampling site (Mmolawa at al., 2011). It is also used for detecting pollution which permits a comparison of pollution levels between sites and at different times (Syed *et al.*, 2012). The PLI gives an estimate of the metal contamination status and the necessary action required to be taken. A PLI value < 1 denotes perfection, a PLI value = 1 means only the baseline level of pollution is present and a PLI value > 1 indicates a deterioration of soil quality (Getachew, 2015).

$$PLI = \sqrt[n]{CF_1 \times CF_2 \times CF_3 \times \ldots CF_n} \tag{4}$$

n and CF are as defined in Equation (2).

3. MATERIALS AND METHODS

3.1. Soil Sampling

Soil samples were collected from five different points during June, 2016 from the surface layer (0 – 20 cm) soil of Ilasamaja approved mechanic village in Lagos State with the aid of stainless steel auger. The soil samples were stored in 1 litre plastic bottles which had been cleaned by soaking in 10% nitric acid and rinsed with distilled water. The auger was washed with distilled water each time it was used for collection of sample before using it again. The five samples collected were properly mixed and homogenized using treated mortar and pestle to form one sample which was transferred into a polythene bag and labeled SS1. A control sample was taken 1 km from the Ilasamaja approved mechanic village surface layer (0 – 20 cm) soil with the aid of stainless steel using 1 litre plastic bottle which had been treated with 10% nitric acid and rinse with distilled water. The sample was labeled SC1. The same procedure was used for collection of samples at Animashaun, Idi-Odo, Ojota and Owutu approved mechanic villages in Lagos State. The soil samples from Animashaun, Idi-Odo, Ojota and Owutu were labeled SS2, SS3, SS4 and SS5 respectively while the control samples were labeled SC2, SC3, SC4 and SC5 respectively.

3.2. Analytical Methods

The soil samples were first air dried overnight in an oven at 32^oC. The dried samples were mechanically ground and sieved through 200 mesh size sieve. Five grams of each sieved samples was placed in an Erlenmeyer flask and 2.5ml of extracting solution (0.05M HCl + 0.024M H_2SO_4) was added after which the mixture was placed in a mechanical shaker for 15 minutes. The resulting solution was filtered through Whatmann filter paper into a 50ml volumetric flask and diluted to 50ml with the extracting solution. The treated samples were analysed for zinc, iron, lead, copper, sodium, potassium, manganese, cadmium, silver, nickel and chromium using an atomic Absorption Spectrophotometer (AAS Perkin Elmer, Model 2380). All the experiments were carried out in triplicate and data were statistically analysed by setting up and calculating a correlation matrix using the built-in solver tool in Microsoft Excel version 2007.

4. RESULTS AND DISCUSSION

Table 4 presents the experimental values of soil samples in the study areas. The concentrations of zinc in soils of the mechanic villages investigated in Lagos State ranged between 3.78 and 19.51 mg/kg with Idi-Odo and Owutu mechanic village soils having the highest and the lowest values respectively. The of zinc in the background soil samples varied between 2.77 and 16.39 mg/kg in the mechanic villages investigated with Owutu and Ojota having the highest and lowest values respectively. The values of zinc in the soil investigated exceeded the World health Organisation (WHO) standard.

The concentrations of iron in soils of the approved mechanic villages investigated varied between 262.01 and 591 mg/kg with Ilasamaja and Ojota mechanic village having the highest and lowest values respectively. The concentrations of iron in the background soils ranged between 162.92 and 966.88 mg/kg with Owutu and Ojota having the highest and lowest values respectively. The maximum allowable limits for iron in the soil of mechanic villages according Lagos State Environmental Protection Agency (LASEPA), National Environmental and Safety Regulation Agency (NESREA) and World Health Organization (WHO) are 5, 20 and 30 mg/kg respectively. The concentrations of iron in the soils of mechanic villages as well as the background soils investigated exceeded the limits of the regulatory bodies considered in this work. The lead concentrations in the soil of the approved mechanic villages investigated varied between 14.67 and 226 mg/kg with Animashaun and Ojota mechanic village having the highest and lowest values respectively. The background soils investigated had lead concentrations ranging between 1.616 and 14.232 mg/kg with Ojota and Ilasamaja having the highest and lowest values respectively. The threshold limit for lead according to LASEPA and NESREA are 5.0 and 1.0 mg/kg respectively. The concentrations of lead in the mechanic village soil investigated exceeded the limits set by LASEPA and NESREA.

Table 4: Heavy metal content of soil samples in the study areas

S/N	Metal	Sample concentration (mg/kg)							
		SS1	SC1	SS2	SC2	SS3	SC3	SS4	SC4
1	Zn	8.87	5.31	6.07	5.37	19.51	6.53	8.09	2.77
2	Fe	591	372.5	237.98	248.15	253.97	169.92	262.01	480.89
3	Pb	24.79	1.62	266	4.58	18.86	1.42	14.69	14.23
4	Cu	30.11	0.72	4.15	1.90	5.29	0.71	2.14	6.48
5	Na	67.05	6.24	33.22	17.55	18.20	2.66	23.85	7.43
6	K	4.33	14.12	58.15	36.52	35.46	18.34	0.00	62.32
7	Mn	28.77	7.36	7.90	7.70	18.05	2.85	21.97	23.36
8	Cd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Ag	0.12	0.00	0.00	0.04	0.10	0.00	0.191	0.0487
10	Ni	0.00	0.00	0.00	0.00	0.14	0.00	2.141	0.00
11	Cr	4.33	1.23	2.17	1.00	1.60	1.05	2.05	3.52

Table 4: Heavy metal content of soil samples in the study areas (continuation)

S/N	Metals	Sample concentration (mg/kg)				
		SS5	SC5	[a]LASEPA Standard	[b]NESREA Standard	**WHO Standard
1	Zn	3.78	16.387	< 1	1	5
2	Fe	392.43	966.88	5.0	20	30
3	Pb	125.31	5.17	5.0	1	-
4	Cu	1.38	0.85	-	1	-
5	Na	4.58	24.05	-	-	-
6	K	0	119.77	725	-	-
7	Mn	44.62	63.77	-	-	0.04
8	Cd	0	0	-	-	-
9	Ag	0.10	0.143	-	-	-
10	Ni	1.38	0	-	1	-
11	Cr	1.25	3.64	5.0	0.05	0.05

[a]Lagos State Environmental Protection Agency (2016), [b] Idugboe *et al.*, (2014)

Cadmium was absent in both the mechanic villages soil and background soils analyzed. Moreover, nickel was also absent in the background soils analyzed but present in the mechanic villages soils analyzed for Idi-Odo, Ojota and Owutu with concentrations of 0.14, 2.14 and 1.38 mg/kg respectively. This is a clear indication that the waste from the activities of the artisans especially the engine oil contributed to the presence of nickel in the soil. Silver was absent in the background soils of Ilasamaja and Idi-Odo mechanic but present in the soils of the Ilasamaja and Idi-Odo mechanic village. This is a pointer that the activities of artisans especially the waste from car batteries contributed to the presence of silver in the soil.

Table 5 shows the geoaccumulation index of different approved mechanic villages investigated in Lagos State.Geoaccumulation index enables the assessment of soil contamination.

Table 5: Geoaccumulation index of different approved mechanic villages in Lagos State

S/N	Metal	Geoaccumulation index				
		Ilasamaja	Animashaun	Idi-Odo	Ojota	Owutu
1	Zn	4.97	4.44	6.41	3.90	5.37
2	Fe	17.16	15.27	14.81	16.36	17.95
3	Pb	4.74	9.67	4.15	7.12	8.76
4	Cu	3.85	2.40	1.32	3.21	-0.35
5	Na	8.12	8.60	5.01	6.88	6.20
6	K	5.35	10.47	8.76	-	-
7	Mn	7.14	5.34	5.10	8.42	10.89
8	Cd	-	-	-	-	-
9	Ag	-	-13.09	-	-7.33	-6.77
10	Ni	-	-	-	-	-
11	Cr	1.82	0.53	0.16	2.27	1.59

In Ilasamaja mechanic village, the geoaccumulation index for iron, sodium, potassium and manganese were 17.16, 8.12, 5.35 and 7.14 respectively. This shows that the soil of Ilasamaja mechanic village was extremely contaminated in terms of iron, sodium, potassium and manganese. The geoaccumulation index for zinc and lead were 4.97 and 4.74 respectively which implies the soils of Ilasamaja mechanic village were strongly contaminated in terms of zinc and lead. Moreover, the geoaccumulation index of iron, lead, sodium, potassium and manganese were 15.27, 9.67, 8.60, 10.47 and 5.34 respectively in the soils of Animashaun. This shows clearly that the soils of Animashaun mechanic village were extremely contaminated in terms of iron, lead, sodium, potassium and manganese. The geoaccumulation index of zinc, iron, sodium, potassium and manganese were 6.41, 14.81, 5.01, 8.76 and 5.10 respectively in the soils of Idi-Odo mechanic village. This reveals that the soils of Idi-Odo mechanic village were extremely contaminated in terms of zinc, iron, sodium, potassium and manganese. In the soils of Ojota mechanic village, geoaccumulation index for iron, lead, sodium and manganese were 16.358, 7.13, 6.88 and 8.42 respectively. This means the soils of Ojota mechanic village were extremely contaminated with iron, lead, sodium and manganese. Furthermore, the geoaccumulation index for zinc, iron, lead, sodium and manganese were 5.37, 17.95, 8.76, 6.20 and 10.89 respectively in the soils of Owutu mechanic. This is an indication that the soils of Owutu mechanic village were extremely contaminated with zinc, iron, lead, sodium and manganese. This contamination may be attributed to liquid wastes like oil normally dump on the soil by the artisans during their daily activities.

Table 6 shows the contamination factor of different approved mechanic villages investigated in Lagos State.Contamination factor indicates the level of contamination of soil. The contamination factor for lead, copper and sodium were 15.34, 41.88 and 10.75 respectively in the soils of Ilasamaja mechanic village which means the soils of Ilasamaja mechanic village have a very high level of contamination in terms of lead, copper and sodium. In the soils of Animashaun mechanic village, the contamination factor for lead, zinc, copper, sodium, potassium, manganese and chromium were 58.053, 1.13, 2.18, 1.89, 1.59 and 2.16 respectively. This indicates that the soils of Animashaun mechanic village also have a very high contamination in term of lead but a moderate contamination factor in terms of zinc, copper, sodium, potassium, manganese and chromium. In Idi-Odo mechanic village soils, the contamination factor for lead, copper, sodium and manganese were 13.32, 7.49, 6.84 and 6.33 respectively which implies the soils of Idi-Odo mechanic village have a very high level of contamination in terms of lead, copper, sodium and manganese. The contamination factor for sodium, silver, zinc, lead and copper were 3.21, 3.92, 2.92, 1.03 and 1.03 respectively for soils in Ojota mechanic village. This shows that the soils in Ojota mechanic village have considerable contamination in terms sodium and silver but moderate contamination factor in terms of zinc, lead and copper. The soils in Owutu mechanic village have a contamination factor of 24.22 for lead which indicates the soils have a very high contamination factor.

Table 6: Contamination factors of different approved mechanic villages in Lagos State

S/N	Metal	Contamination Factors				
		Ilasamaja	Animashaun	Idi-Odo	Ojota	Owutu
1	Zn	1.67	1.13	2.99	2.92	0.23
2	Fe	1.59	0.96	1.49	0.54	0.40
3	Pb	15.34	58.05	13.31	1.03	24.22
4	Cu	41.87	2.18	7.48	1.03	1.62
5	Na	10.75	1.89	6.84	3.21	0.19
6	K	0.31	1.59	1.93	0.00	0.00
7	Mn	3.91	1.03	6.33	0.94	0.70
8	Cd	-	-	-	-	-
9	Ag	-	0.12	-	3.92	0.67
10	Ni	-	-	-	-	-
11	Cr	3.51	2.16	1.53	0.58	0.34

Table 7 presents modified degree of contamination and pollution load index for different approved mechanic villages in Lagos State.The modified degree of contamination calculates the overall degree of contamination in a given particular site. The modified degree of contamination obtained in this work were 10.24, 7.90, 5.6, 1.81 and 3.49 for soils of Ilasamaja, Animashaun, Idi-Odo, Ojota and Owutu approved mechanic villages respectively. These values reveal that the soils in Ilasamaja mechanic village have a very high degree of contamination. Animashaun and Idi-Odo have a high degree of contamination while that of Ojota and Owutu have a low and moderate degree of contamination respectively. The soils investigated by Syed et al. (2012) obtained a modified degree of contamination value of 244.44 in Bangladesh soils which indicated that the soils had ultra high degree of contamination. None of the soils investigated in this work has ultra high degree of contamination which means that the soils in approved mechanic villages investigated in Lagos State are less severe when compare to soils in Bangladesh.

PLI gives an estimate of metal contamination status in a particular soil and the necessary action needed to be taken. The PLI values in the soils of Ilasamaja, Animashaun, Idi-Odo, Ojota and Owutu approved mechanic village were 4.081, 1.69, 3.93, 1.16 and 0.79 respectively. All the PLI values are greater than 1 except that of Owutu mechanic village. This indicates that the quality of soils in the mechanic villages investigated in Lagos State has deteriorated this can be attributed to the wastes generated during the activities of the artisans that is dumped on the soils of the mechanic villages. The PLI values obtained in this work shows that urgent and immediate actions are required to ameliorate the conditions in the soils of the mechanic villages investigated. The PLI in the work of Syed et al. (2012) was 50.047.50 which is far above the values obtained in this work.

Table 7: Modified degree of contamination and pollution load index for approved mechanic villages in Lagos State

S/N	Mechanic Village	${}_mC_d$	PLI
1	Ilasamaja	10.24	4.08
2	Animashaun	7.90	1.69
3	Idi–Odo	5.61	3.93
4	Ojota	1.83	1.16
5	Owutu	3.49	0.79

Table 8 shows the correlation coefficient matrix for metals in soil of approved mechanic villages investigated in Lagos State.Correlation analysis is a preliminary descriptive technique to estimate the degree of association among the parameters involved in a study (Suman *et al*., 2006). The purpose of the correlation analysis is to measure the intensity of association observed between two variables. In the soil of mechanic villages investigated in Lagos State, iron had a strong positive correlation with copper and chromium, a moderate positive correlation with potassium and manganese. Lead had a strong negative correlation with silver, copper correlated strongly and positively with manganese and chromium. Potassium had a negative strong correlation with manganese while nickel had a negatively weak correlation with chromium. The correlation observed among the metals is attributed to the likely reactions among the metals

Table 8: Correlation coefficient matrix for the metals in soil of approved mechanic villages in Lagos State

Parameters	Zn	Fe	Pb	Cu	Na	K	Mn	Ag	Ni	Cr
Zn	1.0									
Fe	-0.24	1.0								
Pb	-0.52	-0.31	1.0							
Cu	0.06	0.86	-0.33	1.0						
Na	0.00	-0.65	-0.14	0.92	1.0					
K	0.28	0.55	0.65	-0.22	0.00	1.0				
Mn	-0.37	0.56	-0.31	0.09	-0.25	-0.81	1.0			
Ag	0.12	0.17	-0.86	0.07	-0.02	-0.82	0.37	1.0		
Ni	-0.37	-0.23	-0.29	-0.51	-0.52	-0.65	0.42	0.71	1.0	
Cr	-0.05	0.76	-0.23	0.96	0.98	-0.17	-0.08	0.10	-0.43	1.0

4. CONCLUSION

The soil contamination status of mechanic villages in Lagos State has been evaluated. The concentrations of iron, lead and copper in the soils of mechanic villages investigated exceeded the threshold limits stipulated by the regulatory bodies considered in this work while cadmium was absent in all the soils of the mechanic villages. The geoaccumulation index revealed that the soils were extremely contaminated. The soils also have a very high contamination factor except for Ojota mechanic village which has a lesser degree of contamination factor. The toxic metals in the soils showed different correlations with one another. The degree and modified degree of contamination varied in the soils of mechanic villages investigated. The PLI values obtained showed that urgent and immediate actions are required to ameliorate the conditions of the investigated soils.

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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