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EFFECTS OF AUTOMOBILE BATTERY WASTES ON PHYSICOCHEMICAL PROPERTIES OF SOIL IN BENIN CITY, EDO STATE

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ABSTRACT

Difference in soil qualities has been noticeable in many soils due to anthropogenic sources, especially of automobile battery wastes. This study examines the effects of automobile battery wastes on the physicochemical properties of the soil. Soil samples for this study were collected in triplicates from three battery chargers' workshops: Adolor, Edaiken and Uwelu in Benin City, Edo State at 0-15cm depth, in the months of August, September and October. The soil physicochemical parameters analyzed indicate variations of values in the contaminated soil over uncontaminated soil (control). Among the parameters examined, conductivity was significantly ($P<0.01$) higher in the contaminated soil (59.3-184mho/cm) than in the uncontaminated soil. Notably, a more acidic pH value of 3.7-4.5 was also recorded beyond standard limits of 6.5~8.5. Meanwhile phosphorus was relatively high (1.95-3.35) and nitrogen (0.08-0.15) was low as against the control value of 2.71 and 0.18 respectively. Heavy metals such as Lead (Pb), Zinc (Zn), Cadmium (Cd), Chromium (Cr) and Copper (Cu) were present in different concentrations in contaminated soil sample which ranges from far above acceptable standard limit between (0.288-0.875, 0.757- 1.342, 0.108-0.279, 0.718-1.062 and 0.272-0.518 mg/kg) compared to their values in the control soil sample having 0.003, 0.125, 0, 0 and 0.063 mg/kg respectively. Battery wastes were found to be significant sources of Cadmium and Chromium, as none of both was detected in the control soil sample. The daily activities of auto-mechanic battery workshops have negative impacts on soil physicochemical properties. Note, the soil in mechanic battery workshops needs urgent cleanup to minimize contamination of ecological materials and public health implication. This work will prove valuable in providing baseline information for further soil quality monitoring studies in study area

KEYWORDS: Physicochemical, Heavy metals, Battery wastes, Contaminated and uncontaminated soil.

INTRODUCTION

Unorganized, indiscrimate and unscientific dumping of wastes is very common disposal method in many cities which causes adverse impact to the environment (Mahar *et al*., 2007). Nearly all human activities generate wastes and the way, in which this is handled, stored, collected and disposed of, can pose risk to the environment and to public health (Zhu *et al*., 2008). Different sources such as electronic goods, used batteries etc, when dumped with municipal solid wastes raise the heavy metals concentration in the dumpsites and dumping devoid of the separation of hazardous wastes can further elevate noxious environmental effects. One of the most prominent soil hazardous waste is battery wastes. Varieties of batteries are found based on the appliances that require it e.g. lead-acid batteries for automobiles. Some cars use more exotic starter batteries—the 2010 Porsche 911 GT3 RS which offer a lithium-ion battery as an option to save weight over a conventional lead-acid battery (Balfour *et al.,* 2011).

Wastes from Automobile Battery Manufacturing Companies (ABMC) are known to release a high percentage of heavy metals like lead (Pb) on soil, the resultant effects also affect the soil physicochemical and its heavy metal properties (Greenpeace 1993; Catwright *et al.,* 1977).

The man-made wastes including automobile wastes introduced into the soil environment amplify the magnitude of the trace element almost to an extent of threatening life and entire ecosystem (Oliveira and Pampulha, 2006). In many cases, the wastes are taken up by roots and shoot of plants and in turn gets into other higher organisms including man when ingested (Kabata-Pendias, 2002). On the other hand, physicochemical properties play vital role in the soil quality and these physical properties include soil color, soil texture, soil structure, bulk density etc., while chemical properties include Cation Exchange Capacity (CEC) and soil reaction, (pH) (Brady, 1990). The situation where the soil is contaminated by wastes, the proportion of its component is adversely affected, resulting in plants, animals and human health disorder.

Several reports have it that pollution inhibits soil microbial activities but there is scarce information on effect of battery waste contaminated soil in spite of extensive

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use of batteries and its various activities on soil (Smejkalova *et al*., 2003). In Nigeria, being a developing country with little or no policy on disposal of automobile battery waste, such adverse effect is almost unnoticed. Hence, the study tends to examine the effects of automobile battery wastes on the physico-chemical of the soil.

STUDY AREA

Soil samples were collected from three automobile battery waste mechanic workshops in Adolor, Edaiken, Uwelu areas of Benin City, Edo State and in a non-mechanic site at Isihor to serve as a negative control while the uncontaminated soil was mixed with an artificial battery waste of I00g in the laboratory to serve as a positive control.

MATERIALS AND METHODS

The soil samples were collected at 0-15cm depth with auger from three points at interval of 10cm in each mechanic workshop. The collected samples were air dried, crushed with mortar and pestle to pass through 2mm sieve and stored in the sealed plastic bags at room temperature (28^{0}C) for 24h for further laboratory experiment. The soils were placed in polyethylene bags and labeled dry soil 1, dry soil 2, wet soil, amended soil and uncontaminated soil as elaborated in Table 1 below:

Table 1: Sample Collection at Designated Areas

Sample	Depth collected	Description
Dry soil 1	0-15 cm	Sample collected in dry season in mechanic workshop at Adolor, Benin City.
Dry soil 2	0-15cm	Sample collected in dry season in mechanic workshop at Edaiken, Benin City.
Wet soil	0-15cm	Sample collected in wet season in mechanic workshop at Uwelu, Benin City
Amended soil (Positive control)	0-15 cm	1.5 kg of uncontaminated soil mixed with 100 g of automobile battery waste.
Control (Negative control)	0-15 cm	Uncontaminated soil only, collected from a fallow bush in Isihor, Benin City

PHYSICO-CHEMICAL ANALYSIS

Physico-chemical analysis such as pH, conductivity, phosphorus, carbon, nitrogen, calcium, magnesium, potassium, bulk density and Cation Exchange Capacity (CEC) were analyzed. The pH and conductivity were measured in a soil suspension (1:10w/v dilution) by digital pH meter (Labotronics-L-T-1) and conductivity meter (Systronics-304) respectively. Bulk density was determined following Blake and Hartage (1986). Carbon content was determined by adopting chromic acid wet digestion method as standard procedure of Walkley and Black (1934) method using diphenylamine indicator, Nitrogen was determined by Kjeldahl digestion method and the digest was measured calorimetrically (Odu *et al.,* 1986). Phosphorus was determined by the method of Bray and Kurtz (1945). Calcium, sodium, magnesium and potassium were extracted with 1N neutral ammonium acetate solution. Thereafter, potassium, sodium and calcium were determined by spectrophotometry while the magnesium was determined by atomic absorption spectrometer (AAS).

HEAVY METALS ANALYSIS

Total metals concentration of heavy metals such as lead (Pb), Cadmium (Cd), Zinc (Zn), Copper (Cu) and Chromium (Cr) were analyzed for heavy metals analysis. One gram sample of soils were digested separately in the presence of $HN0_3$ following the procedure of Ogundiran and Osibanjo (2008). Atomic absorption spectrometer (AAS, ECIL-4141) was used to analyze total metals concentrations of digested soil samples. Procedural blanks and internal standards were also used where appropriate.

DATA ANALYSIS

Data from the laboratory were analyzed using Microsoft Excel 2013 and Statistical Package for Social Science (SPSS Inc., Cary, NC, USA, version 17.0). Chi square test was carried out to determine significance in values across the treatments in the sampled locations, $p<0.05$ is declared significant, and a posteriori test was used to determine the source of significance. The results are presented in tables and illustrative charts.

Table 2: Test of difference between Physico-chemical properties and heavy metal concentrations of battery-contaminated soil samples and control samples using Pearson's Chi square.

Parameters	Uncontaminated soil (Control)	Contaminated soil				FMenv Permissible Limit	WHO limit	X^2 (Chi Square)	df	P-Value
		Dry soil 1 (Adolor)	Dry soil 2 (Edaiken)	Wet soil (Uwelu)	Amended soil					
PHYSICO-CHEMICALS										
pH	5.8	3.7	4.5	3.7	4.9	6.5-8.5	6.5-8.5	0.583	4	P>0.05
Conductivity (mho/cm)	6.5 [e]	184 [a]	127.4[b]	59.3 [d]	85.6 [c]	0.41	0.3	194.786	4	**P<0.001**
Carbon (%)	0.93	3.26	2.57	1.89	2.03	0.94	1.72	1.273	4	P>0.05
Nitrogen (%)	0.18	0.08	0.11	0.15	0.1	20	4-4.5	0.857	4	P>0.05
Phosphorus (%)	2.71	3.35	2.64	1.95	3.04	5	5	0.286	4	P>0.05
Bulk density (g/cm3)	1.48	1.75	1.9	2.69	1.7			1.000	4	P>0.05
Sand (%)	83.4	91.8	92.1	80.03	83.84			1.401	4	P>0.05
Silt (%)	5.9	1.29	1.33	2.76	5.35			6.500	4	P>0.05
Clay (%)	10.7	6.91	6.57	17.21	10.81			6.340	4	P>0.05
Calcium	0.96	5.21	4.74	2.43	2.95	200	200	4.000	4	P>0.05
Magnesium	0.47	1.08	0.88	0.5	0.96	200	200	0.000	4	P>0.05
Sodium	0.18	0.49	0.36	0.21	0.25	200	200	2.125	4	P>0.05
Potassium	0.1	0.7	0.54	0.35	0.48	N/A	N/A	0.000	4	P>0.05
ECEC	1.71	7.48	6.52	3.49	4.64	N/A	1000	4.333	4	P>0.05
HEAVY METALS										
Lead (mg/kg)	0.003	0.875	0.606	0.421	0.288	0.05	0.01	0.000	4	P>0.05
Zinc (mg/kg)	0.125	1.342	1.216	0.757	0.605	1.0	5.0	0.000	4	P>0.05
Cadmium (mg/kg)	ND	0.279	0.215	0.108	0.153	0.5	0.5	1.000	3	P>0.05
Chromium (mg/kg)	ND	1.062	1.04	0.651	0.718	0.05	0.05	0.000	3	P>0.05
Copper (mg/kg)	0.063	0.518	0.394	0.272	0.194	0.1	1.2	3.333	4	P>0.05

Key: ND: Not Detected, P>0.05= Not significant, P<0.01=Very Highly Significant
FMEnv -Federal Ministry of Environment,
WHO- World Health Organization

Some of the parameters are represented in figures 1 – 10 below when compared with the control sample soil.

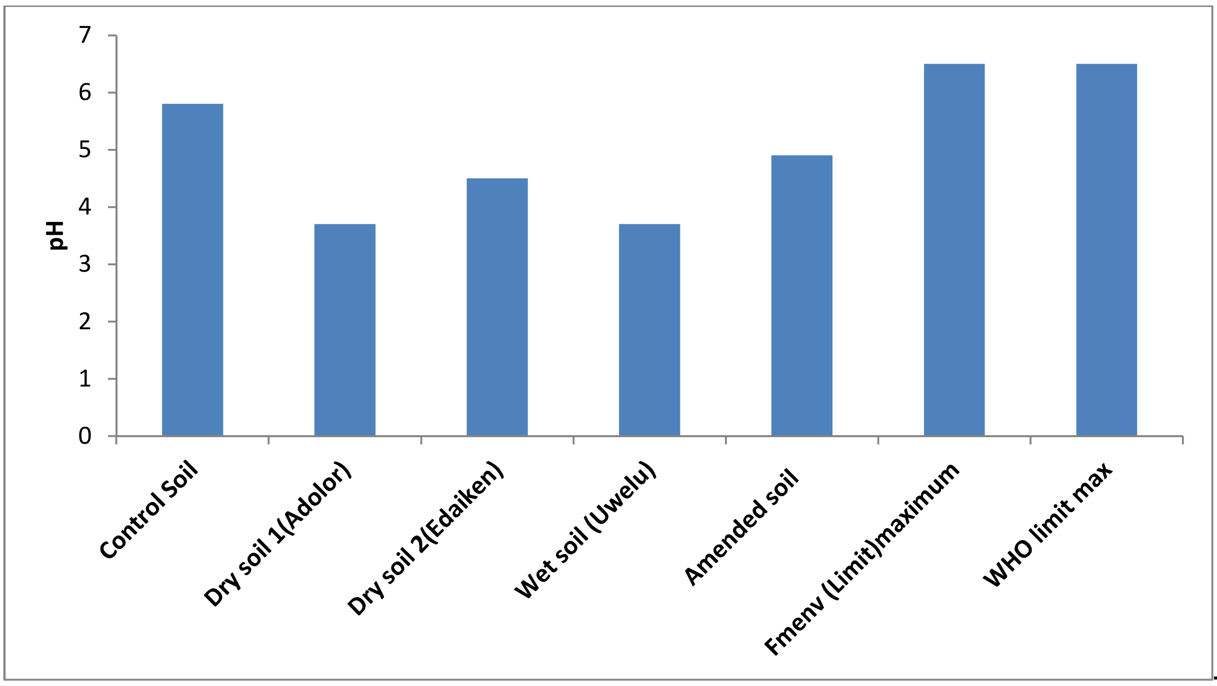

Figure 1: pH of battery –contaminated soil and control samples

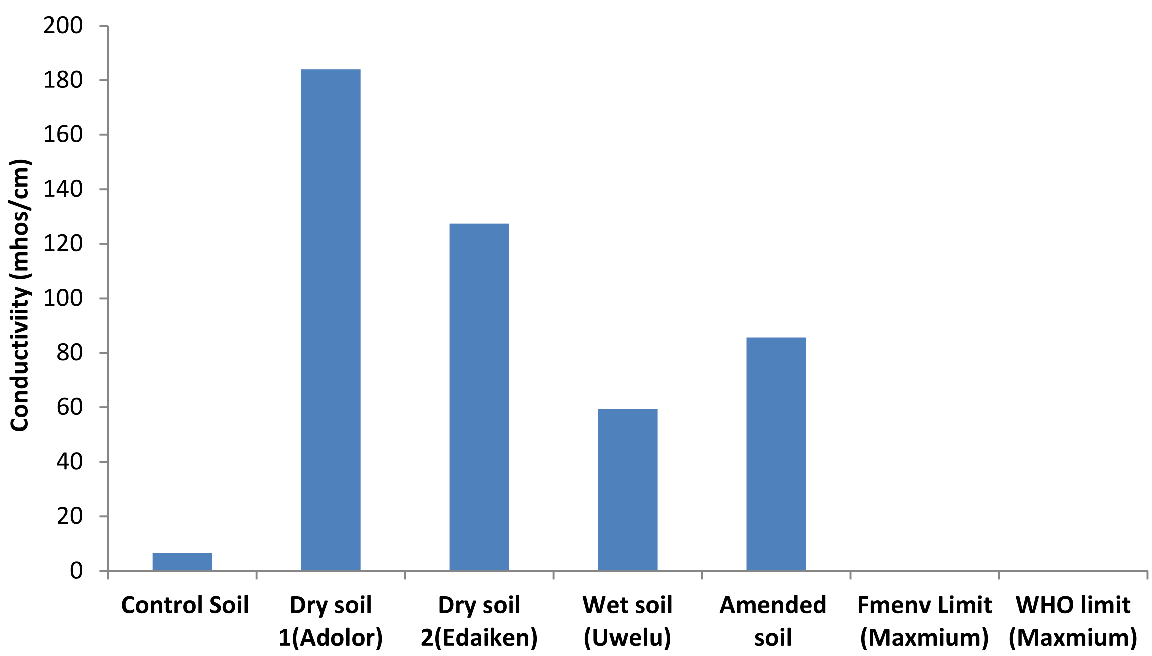

Figure 2: Conductivity of battery –contaminated soil and control samples

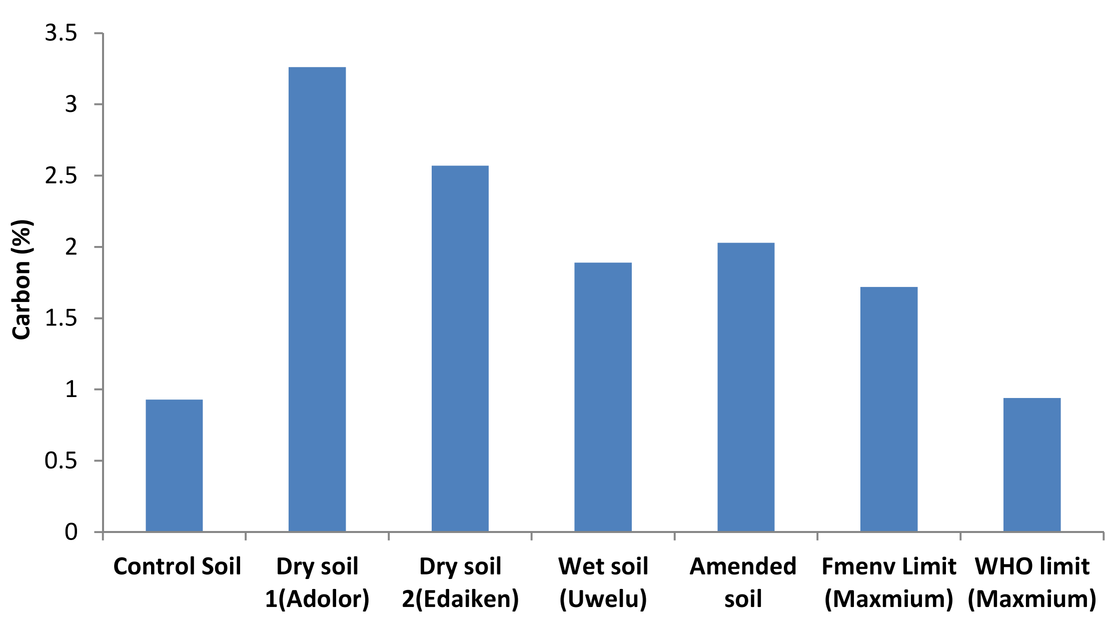

Figure 3: Carbon content in contaminated soil

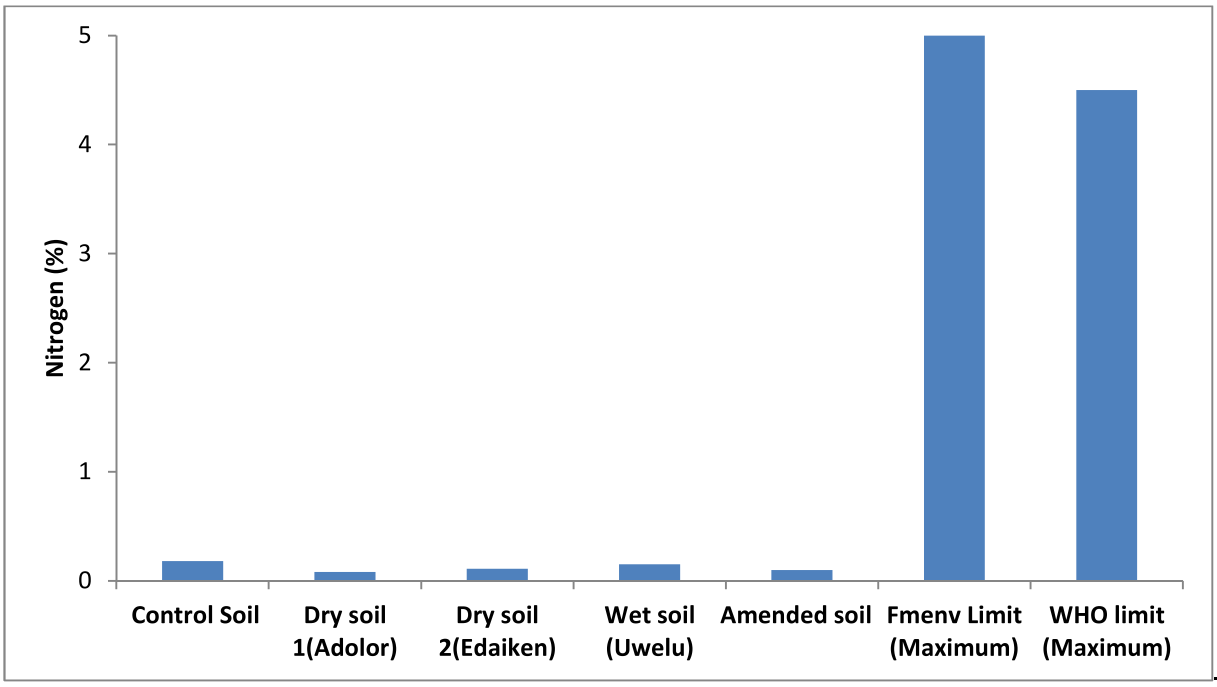

Figure 4: level of Nitrogen in soil samples

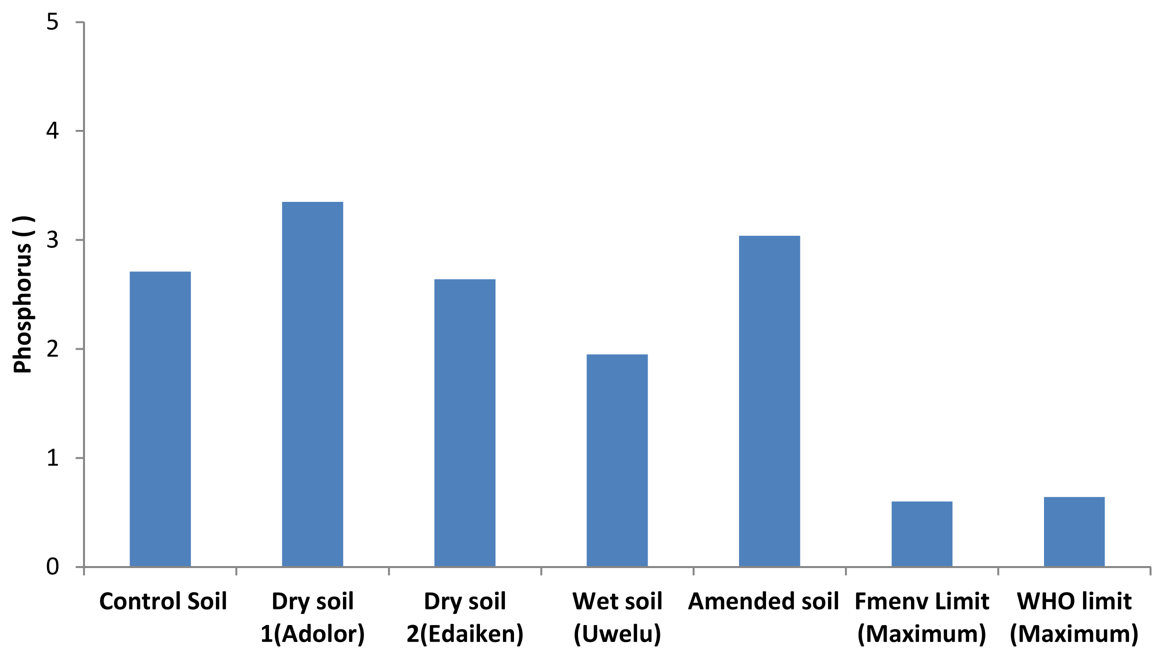

Figure 5: level of Phosphorus in soil samples

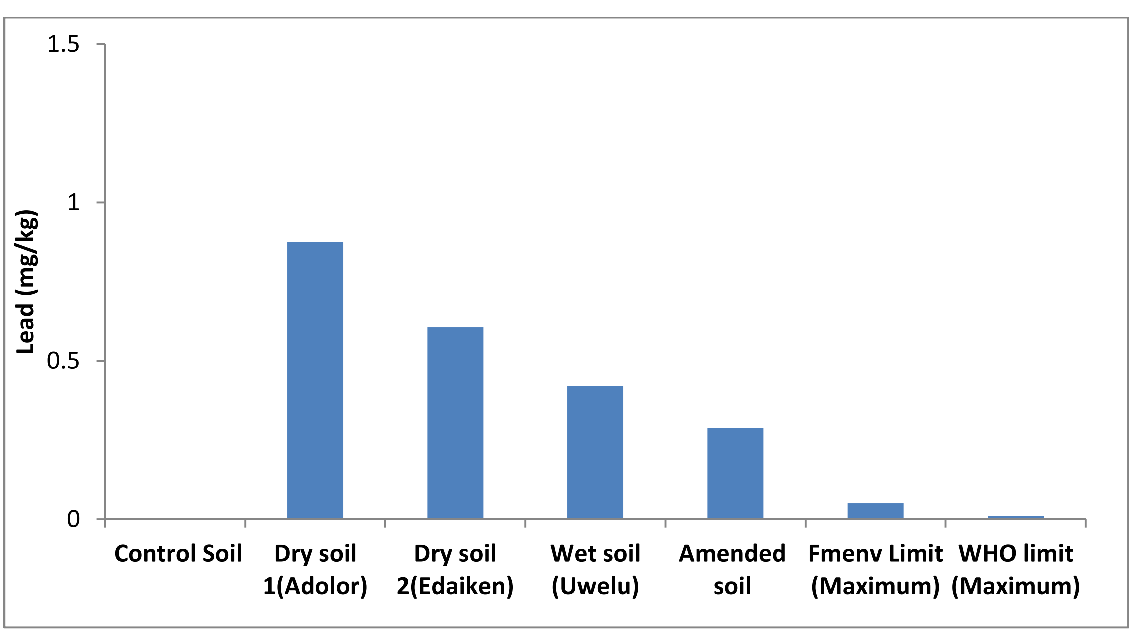

Figure 6: Level of Lead in soil samples

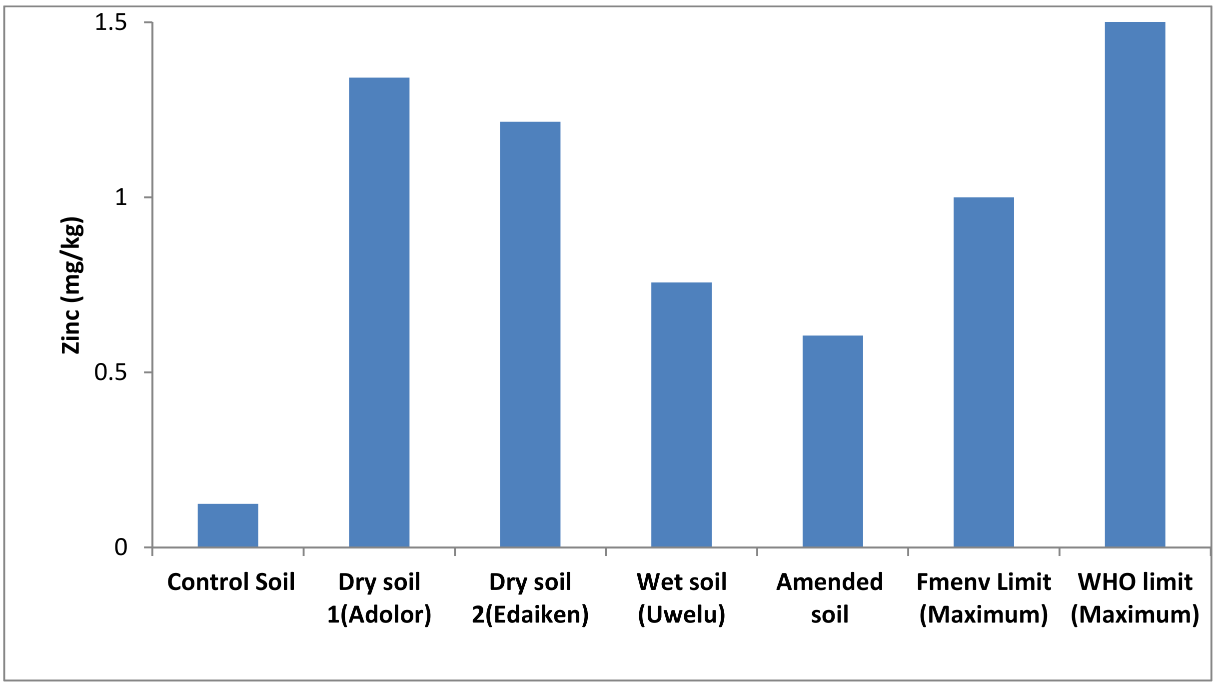

Figure 7: Level of Zinc in soil samples

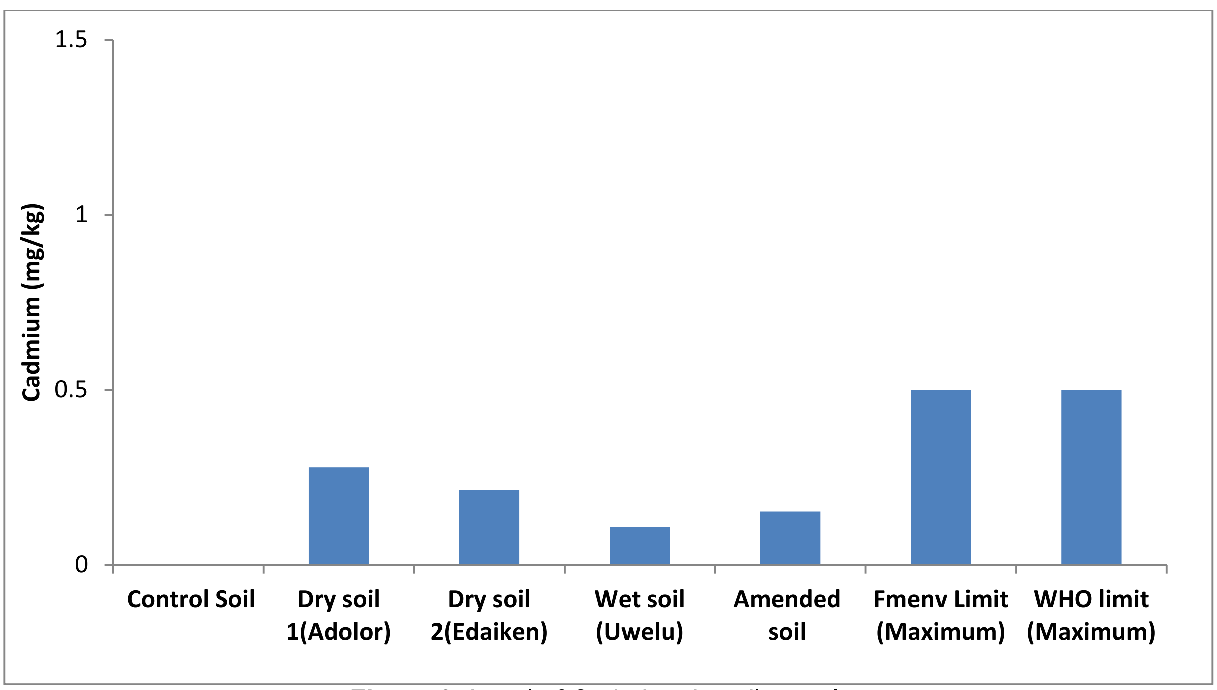

Figure 8: Level of Cadmium in soil samples

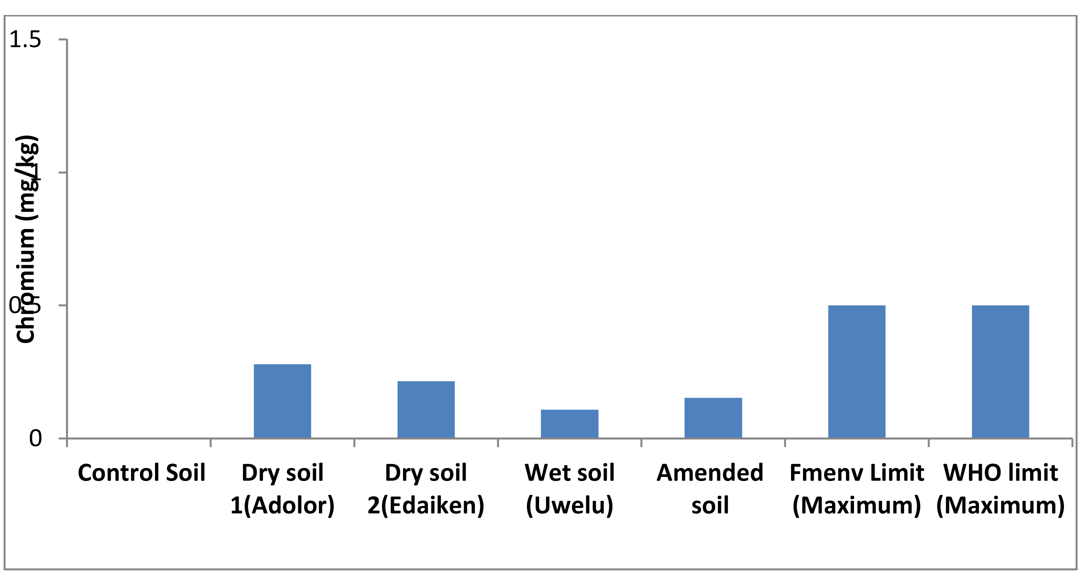

Figure 9: Level of Chromium in soil samples

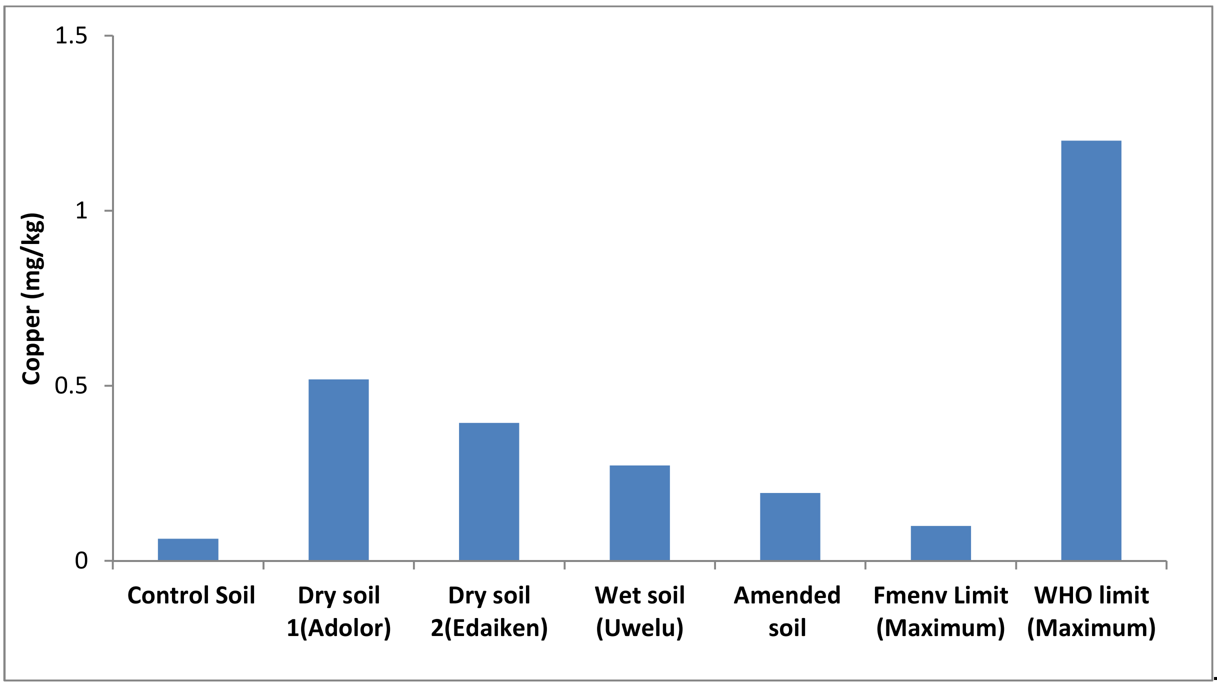

Figure 10: Level of Copper in soil samples

RESULTS AND DISCUSSION

PHYSICOCHEMICAL PARAMETERS:

Table 2 above shows the physico-chemical and heavy metals parameters examined. Conductivity was very significantly higher ($P<0.01$) in contaminated soil than uncontaminated (control) soil samples indicating a very significant value ($p<0.01$) in contaminated soil samples. As supported by Hartsock *et al* (2000) 'the higher the dissolved material in water or soil sample, the higher the EC will be in that material'. Excessive electrical conductivity in soil is caused by excess of salts and indicates soil salinization.

Other physico-chemical parameters such as pH, carbon, calcium, ECEC etc have significant difference ($P>0.05$) between the soil and control samples. The pH values recorded are generally acidic ranging from most acidic value of 3.7 in contaminated to least acidic value of 5.8 in the uncontaminated soil. This is an indication that the battery waste contamination causes soil acidity. A pH range of 6.0 to 6.8 is ideal because it coincides with optimum solubility of the most important soil nutrient (Porteus, 1985). This suggests that the difference in the contaminated soil may be reversed when there is soil treatment e.g. manures to correct nutrient imbalance

Nitrogen concentrations was reduced in contaminated soil than uncontaminated soil due to the presences of battery wastes introduced by anthropogenic sources, hence the effect could result in loss of soil nutrients. Phosphorus was relatively increased in contaminated soil than in the uncontaminated soil. This could be as a result of percolation of the soil nutrient especially in wet season or hydrolysis of microbial polyphosphates (Barel and Barsdate, 1974).

Furthermore, the percentage of silt composition in the soil was altered, relatively lesser in contaminated soil than in the uncontaminated soil; it was observed that dry soil (1.29-1.33%) has less silt composition than the wet (2.76%) and amended soil (5.35%). This could also be as a result of soil humidity especially in wet season that held the soil particles together.

HEAVY METALS:

Also, the mean values of natural contaminated soil samples was recorded in different concentrations namely; Pb, Zn, Cd, Cr Cu, and of (0.634, 1.105, 0.201, 0.918 and 0.395 mg/kg) respectively. Unlike control soil sample that has only Pb, Cu and Zn concentrations as 0.003, 0.125, 0, 0 and 0.063 mg/kg respectively (Amusan *et al.,* 2005; Esakku *et al.,* 2003).

Only Lead concentration recorded in the contaminated soil (wet, dry and amended) exceeded the permissible limit of Federal Ministry of Environment (FMEnv) and World Health Organization (WHO) while Zinc, Chromiun, Copper and Cadmium were within the limits. This indicates that battery waste contaminated soils are toxic. Cadmium and Chromium were not detected in the uncontaminated soil. This shows that both are products of human anthropogenic activities like battery wastes released into the soil. However, in the uncontaminated soil, Lead, Zinc and copper were available in minute quantities as natural soil micro minerals within permissible limit of Federal Ministry of Environment and World Health Organization.

CONCLUSION

The automobile battery wastes alter the physicochemical properties of the soil and are direct source of most deadly heavy metals. Hence, these wastes are potential source of pollution and are deadly to human health. The result of this study has confirmed that battery wastes are sources of Lead (Pb), Cadmium (Cd) and Chromium (Cr) in the soil. All of these are poisonous to human health especially if found in large quantities.

RECOMMENDATION

Soil in automobile mechanic battery workshop requires remediation to minimize soil pollution. The battery wastes can be recycled and properly disposed following the best scientific method.

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