https://dx.doi.org/10.22161/ijaers.4.11.3 ISSN: 2349-6495(P) | 2456-1908(O)

Interactive effect of tillage and wood ash on heavy metal content of soil, castor shoot and seed

Nweke I A[1], Ijearu S I[2], Dambaba N[3]

[1,2]Department of Soil Science Chukwuemeka Odumegwu Ojukwu University, Anambra State
[3]National Cereal Research Institute, Baddagi, Bida, Niger State

Abstract— *Organic waste when used as soil amendment improves the fertility status of soil and crop yield, but unrestricted application on soil could lead to accumulation of heavy metals to a level, toxic to plants themselves and the animals that consumes them. Thus a field experiment was conducted in three (3) different planting seasons using three tillage methods (mound, ridge, flat) and four different rates (0t/ha, 2t/ha, 4t/ha, 6t/ha) of wood ash to evaluate the effect of tillage and wood ash on heavy metal; copper (Cu), boron (B) and lead (Pb) content of soil and uptake by castor shoot and seed. Data generated from the study was analyzed using crop start version 7.2 and mean separation was done using least significant difference (LSD0.05). The findings from the study showed that the interactive effect of tillage and wood ash on heavy metals content of soil, castor shoot and seed were significant ($P<0.05$). The values obtained decreased as the planting season increased, while the amount was found to increase as the rates of wood ash application increased. For soil heavy metal contents it was observed that tillage methods had no effect on virtually all the parameters assessed. The values obtained from ridge and flat were higher when compared to the value of mound with regard to soil and castor shoot heavy metal contents. The result of the shoot also show that interaction of flat and wood ash at the rates of 2t/ha, 4t/ha, and 6t/ha (Ft2, Ft4, Ft6) show statistically similar results. The result of heavy metal content of seed indicated that tillage method had no effect in most of the heavy metal contents of the castor seed, while Cu in 3rd year planting season were not significant among the rates of wood ash applied. The interaction effect of ridge and wood ash at the rates of 2t/ha, 4t/ha and 6t/ha (Rd2, Rd4, Rd6) on Cu, 1st and 2nd season were statistically similar, while the result from mound method was found to increase the seed up take of most of the tested parameters. The observed values of these tested parameters (Cu, B, Pb) in wood ash amended plots in the three planting seasons were within acceptable limits.*

Keywords*— *Heavy metal, castor shoot, castor seed, tillage, wood ash.

I. INTRODUCTION

Soil has been bequeathed by nature a natural medium for waste disposal and filter to many contaminants and toxic elements that might be harmful to crops, animals and man. However, continuous disposal or the use of waste as soil amendment can lead to the accumulation of the toxic metals to a critical level where they become phototoxic to plants and ecto-toxic to animals and man that will directly and indirectly depend on plants for their livelihood. There are increases in incurable diseases such as cancer; kidney problems etc and most of these diseases are traced to our food and water. One of the hopeless situations of pollution of the soil with heavy metals according to Lone et al., (2008) and Jing et al., (2007) is that they cannot be biologically degraded; they can only be transformed from one oxidation state or organic complex to another. Moolenar and Lexmond (1999) found out that lead (Pb) and cadmium (Cd) is cumulative toxins that are indestructible and can only be eliminated through excretion. When accumulate in human body according to Wildlife, (2000) they cause health hazards that include but not limited to central nervous system, reduce intellectual capabilities and hypertension (Stassen, 2002).

Though most of the trace elements are found naturally in soil inform of their complexes or bound form their accumulation in the environment are intensified by human activities. According to the works of Okoronkwo et al., (2005); Jing et al., (2007) Lone et al., (2008) and Umeoguaju (2009) mining and purification of lead, zinc and cadmium, steel production, burning of wastes, and coal burning, discharges from industrial effluents as well as excessive use of fertilizers, pesticides application and use of sewage and other organic wastes in farming operations are man's activities on soil that are capable of creating good condition for heavy metals to enter and accumulate in the soil environment.

However, from the agricultural point of view, most of the organic wastes are applied in agricultural lands with a view to improve the fertility status of the soil. Basically many tropical soils like southeastern soils of Nigeria have low organic matter content, plant nutrient deficiency resulting from high rainfall and temperature. Consequently these soils lack the strength and ability to sustain crop production at optimum level, hence the need for organic waste as soil amendment to increase soil nutrients and crop yield**.** The work of Pierzynstic et al**.,** (2002) have portrayed that lack of effective waste management can have substantial negative effects to plants and animals including man through the introduction of pollutants into the soil environment. In Nigeria, the efficiency of wood ash as well as tillage systems in improving soil productivity and crop yield has been documented in the works of Agbede et al., (2008), Mbah et al., (2010), Ojeniyi et al., (2012), Omoju and Ojeniyi, (2012), and Nwachukwu et al., (2012). However, no attention has been given to contents of heavy metals of wood ash as soil amendment. Thus the present study tend to report on the uptake of selected heavy metals like Cu, B, Pb, by castor shoot and seed and their accumulation in soil following four different rates of wood ash application and three tillage methods.

The work is intended to recommend an appropriate rates of wood ash and frequency of application with appropriate tillage method, all with a view to avoid excessive soil accumulation and up take by castor plant, because oil from the seed is very useful to man medically and industrially.

II. MATERIALS AND METHODS

Location of Experiment

This study was carried out in three different cropping seasons at Teaching and Research Farm of Faculty of Agriculture and National Resources Management Ebonyi State University, Abakaliki**.** The area of the study is located within latitude 06^o19^1 N and Longitude 08^o06^1 of the southeast in the derived savannah agro-ecological zone of Nigeria. The rainfall distribution is bimodal with wet season from April to July and peak in June and September to November. It has an average annual rainfall range of 1700 – 1800mm. The temperature of the area ranges from 27^oC – 31^oC. The relative humidity of the study area is between 60 – 80% and the soil is ultisol and classified as Typic Haplustult by FDALR (1985).

Land preparation and Treatment Application

A land area measuring 41m x 15m (0.0615ha) was mapped out and used for the study. The experimental site was cleared of the natural vegetation using cutlass and the debris removed. Tillage operation was done manually using hoe. The tillage treatments are mound (Md), ridge (Rd) and flat (Ft). Wood ash of different levels was spread uniformly on the soil surface and buried in their respective plots immediately after cultivation. The details of treatments used are as follows:

1. Md0 – Mound without wood ash (Md0)
2. Rd0 - Ridge without wood ash (Rd0)
3. Ft0 - Flat without wood ash (Ft0)
4. Md + 2 t/ha of wood ash (Md2)
5. Md + 4 t/ha of wood ash (Md4)
6. Md + 6t/ha of wood ash (Md6)
7. Rd + 2t/ha of wood ash (Rd2)
8. Rd + 4t/ha of wood ash (Rd4)
9. Rd + 6t/ha of wood ash (Rd6)
10. Ft + 2t/ha of wood ash (Ft2)
11. Ft + 4t/ha of wood ash (Ft4)
12. Ft + 6t/ha of wood ash (Ft6)

Two castor seeds per hole were planted at a spacing of 0.9m between rows and 0.45m within rows at a depth of 8cm. There was basal application of NPK fertilizer to all plots two weeks after planting. The seedlings were thinned down to one plant per stand two weeks after germination. Weeding was done manually with hoe at 3-weeks interval till harvest. Harvesting was done when the capsules containing the seed turn brown. The harvested spikes was dried in the sun 2-3 days and then threshed to release the seeds used for heavy metal content determination. The shoot was also harvested for heavy metal studies. The same procedure was repeated in the 2^{nd} and 3^{rd} year of the experiment but without application of wood ash in the 3^{rd} year to test the residual effect.

Experimental Design

The total land area used for the study was 0.0615ha. The experiment was laid out as split plot in a randomized complete block design (RCBD), with 12 treatments replicated 3 times to give a total of 36 plots each measuring 3m x 4m ($12m^2$). A plot was separated by 0.5m alley and each replicate was 1m apart. Four (4) rates of wood ash viz control ($0tha^{-1}$); wood ash (WA) at the rate of $2tha^{-1}$ equivalent to 2.4kg/plot, WA at $4tha^{-1}$ equivalent to 4.8kg/plot and WA at $6tha^{-1}$ equivalent to 7.2kg/plot was used for the study. Each treatment was replicated 3 times along with the three tillage methods (Mound, Ridge and Flat) used for the study.

Soil Sample Collection

Auger soil samples were randomly taken from ten (10) observational points in the experimental area at the depth of 0 – 20cm prior to planting. The auger soil samples were mixed thoroughly to form a composite soil sample and used for pre-planting soil analysis of which the result is shown in Table I. Also the wood ash treatment used was analyzed for determination of its heavy metal values, quantity and chemical composition. The result is presented in Table 2. At the end of each cropping season that is after crop harvest, auger soil samples were collected from three observational points in each plot, the soil samples were air dried, sieved and used for the determination of soil heavy metal content.

Laboratory Method

Heavy Metals (trace elements)

Heavy metals otherwise known as trace elements (metals) are plant essential micro-nutrient elements but adversely become toxic to plants and animals and indirectly to humans in excess quantities. Hence they are inorganic pollutant particles in soil.

Determination of Heavy Metals

The determination of heavy metals (Cu, B, and Pb) was by using the method outlined by Miller et al**., (1986).**

Data Analysis

The data obtained from the study were subjected to an analysis of variance test based on RCBD using CropStat software version of 7.0, while statistically significant difference among treatment means was estimated using the least significant difference (LSD < 0.05).

III. RESULTS

Initial properties of the soil of the study site and wood ash before the beginning of the study

The heavy metal content of the soil show medium values in lead (Pb) and copper (Cu) and lower value in boron (B). The order of their increase in the soil was Pb > Cu > B (Table 1). The ash showed higher values in the tested heavy metal contents, the order of their increase in the ash were Cu > B > Pb (Table 2). There were high level content of lead, copper and boron in ash visa-vies their content in soil.

Table.1: Initial soil parameters before treatment application

Test Parameter	Value
Lead (Pb)	48.60 mgkg^{-1}
Copper (Cu)	26.50 ‘’
Boron (B)	5.60 ‘’

Table.2: Chemical composition of the wood ash before application

Test Parameter	Value
Lead (Pb)	52.28 mgkg^{-1}
Copper (Cu)	148.00 ’’
Boron (B)	54.60 ’’

Effect of Tillage and Wood ash on soil heavy metals (Cu, B, Pb mgkg^{-1})

The result of the effect of TM on heavy metals of the soil studied (Cu, B and Pb) is presented in Table 3. The result obtained showed that tillage methods had statistical significant (P<0.05) effect in all the parameters tested. Although non-significant differences in the values of B (1st year), and 2nd year values of Cu, B and Pb were observed. The result of Mound showed that the value of Cu decreased in the 2nd year planting, but increased rapidly in the residual year to the extent that the fractional differences in value of the 1st and 2nd year value from 3rd year result were large with 35.128mgkg^{-1} and 44.55mgkg^{-1} respectively. The result of Boron (B) from Mound indicated decrease in value as the planting year increased. There was a radical decrease in value of B in the residual year when compared to the 1st year result as the percentage decrease in value was 98.75%. The result of lead (Pb) showed gradual decrease in value as the year of planting increased. The result order was 1st year result > 2nd year result > 3rd year result. The result of Ridge for Cu showed an order of 3rd year result >1st year result > 2nd year result. The percentage decrease in value of Cu in the 2nd year relative to the 3rd year planting result was 78.04%, this value showed that there was a rapid decrease in the value of Cu in the 2nd year planting period.

https://dx.doi.org/10.22161/ijaers.4.11.3 *ISSN: 2349-6495(P) | 2456-1908(O)*

Table.3: Effect of Tillage and Wood ash on Soil heavy Metals (Cu, B, Pb, mgkg^{-1})

Treatment	***1st Year***			***2nd Year***			***3rd Year***		
	Cu	B	Pb	Cu	B	Pb	Cu	B	Pb
Md0	4.440	96.340	157.800	4.800	116.000	7.200	7.900	0.940	24.400
Md2	17.900	204.600	48.220	8.950	147.400	58.600	96.450	1.940	85.080
Md4	28.000	136.300	76.400	16.600	108.300	109.500	95.800	2.000	95.110
Md6	56.200	94.800	240.400	38.500	106.600	246.100	46.900	1.750	95.380
Mean	26.635	133.010	130.705	17.213	119.575	105.350	61.763	1.658	74.993
Rd0	9.600	37.200	10.400	2.440	98.700	8.860	11.080	0.750	113.700
Rd2	12.000	248.100	88.200	18.100	144.500	56.200	88.400	2.370	79.967
Rd4	84.400	158.700	54.116	9.600	113.800	148.100	116.400	7.500	94.200
Rd6	65.400	266.800	116.700	42.200	122.600	202.900	114.500	17.600	129.000
Mean	42.850	177.700	67.354	18.085	119.900	104.015	82.595	7.055	104.217
Ft0	3.840	140.300	8.540	2.350	96.200	5.400	6.540	0.550	33.990
Ft2	5.790	133.467	170.400	3.800	100.500	206.400	14.100	2.370	63.760
Ft4	24.100	204.000	46.600	9.600	156.400	124.500	33.950	2.450	46.410
Ft6	60.233	142.800	10.240	32.100	240.200	235.800	48.200	8.810	96.640
Mean	18.491	155.142	58.945	11.963	148.325	143.025	25.697	3.545	60.198

LSD 0.05									
TM	20.37	NS	53.88	NS	NS	NS	29.49	3.66	24.17
WA	15.27	51.55	65.37	4.09	34.35	56.60	30.56	3.54	28.75
TM x WA	0.70	14.09	0.14	0.23	0.44	85.27	0.19	0.28	28.11

TM= Tillage method; WA= Wood ash; Md0 = Mound without wood ash (WA); Md2 =Mound +2t/ha WA; Md4 = Mound + 4t/ha WA; Md6 = Mound + 6t/ha WA; Rd0 = Ridge without WA ; Rd2 = Ridge +2t/ha WA; Rd4 = Ridge + 4t/ha WA; Rd6 = Ridge + 6t/ha WA; Ft0 = Flat without WA; Ft2 = Flat + 2t/ha WA; Ft4 = Flat + 4t/ha WA; Ft6 = Flat + 6t/ha WA

The results of B showed an increased value as the years of planting increased, but the residual year result presented drastic reduction in the value of B. The reduction in value of B in 3rd year planting relative to 1st and 2nd year planting were 96.03% and 94.12% respectively. Lead (Pb) for Ridge showed a rapid increase in value as the planting year increased, though the value of Pb in 2nd and 3rd year planting are relatively similar as their difference in value was merely 0.202mgkg^{-1}. However, its decrease in value in 1st planting year was 35.37% relative to the 3rd year planting. The result of Cu in Flat method indicated decrease in value as planting year increased, though the value which increased in the 3rd year planting was higher than the 1st and 2nd year planting result. The result of B showed reduction in value as the planting year increased with drastic reduction in value in residual year. The result of Pb from Flat showed rapid increase in value in the 2nd year planting result when compared to the 1st year planting result however, this value decreased rapidly in the 3rd year result. When the tillage methods are compared, it showed that for 1st planting period, the result order was Ridge > Mound > Flat for Cu result. Boron showed an order of Ridge > Flat > Mound and for Pb Mound > Ridge > Flat. The same result scenario of 1st year was observed in 2nd year result for Cu, but B had a contrary order as the values of Mound and Ridge are the same with the highest value observed in Flat. The 2nd year result of Pb showed highest value in Flat, hence the order Flat > Mound >Ridge though the value of Ridge and Mound are relatively alike as the fractional difference in their values is 1.335mgkg^{-1}. The residual year result presents an order of result for Cu as Ridge > Mound > Flat. The observed value of Cu in Flat when compared to the other methods was relatively very low. The result order of B showed that highest value of B was observed in Ridge, next in rank was Flat, while the least value was observed in Mound. The order of Pb result was Ridge > Mound > Flat. The Ridge result showed very much increased value when compared to value obtained from Mound and Flat.

The changes in soil heavy metals contents following the application of wood ash on the soil are shown in Table 3 for the three cropping years. The soil heavy metal contents (Cu, B and Pb) were significantly ($P<0.05$) different among the rates of wood ash applied. The effect of wood ash application on Mound, showed that the value of Cu in 1st and 2nd year result was dependent on the quantity of ash applied, as the value increased with attendant increase in WA applied hence the result order for 1st and 2nd year was Md6 > Md4 > Md2 > Md0. The 3rd year result depicts Md2 as having the highest content of Cu the next in rank was Md4 among all the other rates. For the 3 years' study Md0 consistently showed lowest value of Cu. The result of B showed that Md2 recorded the highest value in 1st and 2nd year planting, the next in rank was Md4 hence the result order Md2 > Md4 > Md0 > Md6 (1st and 2nd year planting result). The residual year presented a different order of result whereby the highest of 2.0mgkg^{-1}B was observed in Md4 and the least value (0.94mgkg^{-1}) was recorded in Md0 relative to other rates of WA applied. The result of Pb in 1st year planting indicated non-dependent of values on the quantity of ash applied. The 1st year planting showed highest value of Pb was recorded in Md6, next in rank was Md0 and the least value was obtained in Md2. The 2nd and 3rd year result of Pb showed that values obtained are dependent on the quantity of ash applied, because the values observed increased with increase in the rates of ash applied. The result variation of 1st and 2nd year present an order of Md6 > Md4 > Md2 > Md0 for the two cropping years, the value recorded in Md6 and Md4 were higher compared to the other two rates of WA. The effect of ash on Ridge indicated that higher value of Cu was observed in Rd4 relative to other rates in 1st year planting, the next closest value in rank was obtained in Rd6. The 2nd year result showed Rd6 to have recorded the highest value (42.20mgkg^{-1}) and the least value (2.440mgkg^{-1}) from Rd0, while the 3rd year present an order of Rd4 > Rd6 > Rd2 > Rd0. For the 3 years' under study, the lowest values of Cu were observed in Rd0s' rate of which the lowest among them is from 2nd year result. The result of B showed an increased value on the rates in 1st and 2nd year planting, but these values decreased drastically in the residual year. The 1st year result of B showed an order of Rd6 > Rd2 > Rd4 > Rd0 and 2nd year Rd2 > Rd6 > Rd4 > Rd0. The residual year showed dependency of value on the rates of WA applied. An increased value was observed in Rd6, compared to the values recorded in the other rates. The result variation was Rd6 > Rd4 > Rd2 > Rd0. The lowest value of Pb (10.4mgkg^{-1}) was recorded in Rd0 and the highest from Rd6 (116.700mgkg^{-1}) relative to the values obtained from the other rates in the 1st year planting. The 2nd year result showed an increased value in the recorded value of Rd6 and Rd4, though the result order showed Rd6 > Rd4 > Rd2 > Rd0. The 3rd year result scenario changed as the Rd0 which consistently recorded the lowest value of Pb in 1st and 2nd planting turned out to record the next in rank to the highest value that was obtained from Rd6, hence the order Rd6 > Rd0 > Rd4 > Rd2. The effect of rates of WA on Flat for Cu follows a particular order. The 1st, 2nd and 3rd year planting result indicated increase in value as the rate of WA applied increased and decreased in value as the planting year increased especially when the 1st year and 2nd year planting result values are compared. Therefore, the result order for Cu 1st, 2nd and 3rd year results were Ft6 > Ft4 > Ft2 > Ft0. The result of B showed an increased value in all the rates in 1st and 2nd year results but these values decreased rapidly in the residual year. The 1st year result however showed Ft4 to record the highest value, next to Ft4 in value was Ft6 and the least value obtained in Ft2.The 2nd year and 3rd year result showed that value of B obtained was dependent on the quantity of ash applied, hence result order was Ft6 > Ft4 > Ft2 > Ft0. For the 3 years' of study the lowest value of 0.55mgkg^{-1} B was observed in Rd0 of 3rd year planting result. The 1st year planting result of Pb showed that very low values were obtained in Ft0 and Ft6 compared to the values of Ft2 and Ft4. Among these rates the highest value of Pb was recorded in Ft2 and next in rank was Ft4. In 2nd year planting result an increased value of Pb was observed in all the rates except for Ft0 were very low value was recorded compared to the values of the other rates of WA, the result order is Ft6 > Ft2 > Ft4 > Ft0. The 3rd year result showed decreased values relative to the values of 2nd year result except for Ft0 that showed rapid increase in value in the 3rd year result. The 3rd year result show a result variation of Ft6 > Ft2 >Ft4 > Ft0.

The effect of tillage and wood ash presented in Table 3 showed significant differences among the tillage methods and rates of WA applied. The result indicated that the combination of tillage and WA has great effect on the amount and quantity of soil heavy metals contents obtained. The results also showed that the values of the soil heavy metals (Cu, B and Pb) increased as the rates of WA applied increased in the entire TM. Their values were observed to be higher in the 1st and 2nd year planting and decreased in the 3rd year planting period. The values observed in 4tha^{-1} (Md4, Rd4, Ft4) and 6tha^{-1} (Md6, Rd6, Ft6) rates of WA and TM were relatively similar, but higher in value compared to the values obtained from 2tha^{-1} (Md2, Rd2, Ft2) and 0tha^{-1} (Md0, Rd0, Ft0) rates of WA. The result equally showed that the value of Cu obtained from Mound and Ridge in 1st and 3rd year planting results was statistically similar. The values of these parameters observed in Ridge and Flat for the 3 years' study were

https://dx.doi.org/10.22161/ijaers.4.11.3 ISSN: 2349-6495(P) | 2456-1908(O)

relatively similar and higher in value when compared to the values of rates of WA in Mound. Significantly, higher values of B > Pb > Cu were observed in 1st and 2nd year planting period. However, these values decreased much at 3rd year planting period, while the value of Cu which was relatively small in the 1st and 2nd year planting increased sharply in the 3rd year planting, though the increase was not greater than the value of Pb. The results obtained also attest that the values of these heavy metals obtained from the control soils (Md0, Rd0, Ft0) significantly were small when compared with values obtained from the other rates of WA applied which are the ash amended soils. The results of Cu, B (1st year), B (2nd year) and Cu (3rd year) in 4tha^{-1} (Md4, Rd4, Ft4) and 6tha^{-1} (Md6, Rd6, Ft6) were statistically similar but significantly different with control plots. Also the values of B (1st and 2nd year), and Cu, Pb (3rd year) obtained from 2tha^{-1} and 4tha^{-1} WA respectively were statistically similar but significantly better than the values of control plots.

Effect of Tillage and Wood ash on the Heavy Metal content of Shoot of Castor (Cu, B, Pb mgkg^{-1})

The effect of tillage methods on the heavy metal contents (Cu, B, Pb) of castor shoot shown in the Table 4 showed significant differences ($P<0.05$) among the tillage methods studied. The result of Mound showed that for 3 years' planting the value of Cu was observed to be highest in the 1st year planting of which decreased as the year of planting increased. B and Pb result also show the same result scenario of increased value in 1st year planting result with attendant decrease in value as planting year increased and there was a rapid decrease in value of the 3rd year result when compared to the 1st and 2nd year values. The result of Ridge and Flat for the three (Cu B and Pb) parameters for the years of study showed decreased value as planting year increased hence the order 1st >2nd >3rd year results. The 3rd year results for the tested parameters in the two tillage methods (Ridge and Flat) showed very sharp reduction in value when compared to their values recorded in 1st and 2nd year result. In comparison of the TM in 1st year planting Mound showed higher value of Cu than the Ridge and the least value from Flat while B showed an order of Ridge >Mound> Flat.

Table.4: Effect of Tillage and Wood ash on the heavy metal content of Shoot of Castor (Cu, B, Pb mgkg^{-1})

Treatment	1st Year			2nd Year			3rd Year		
	Cu	B	Pb	Cu	B	Pb	Cu	B	Pb
Md0	1.010	20.250	1.030	0.060	19.300	0.080	0.000	1.150	0.017
Md2	1.320	12.650	1.170	0.370	11.700	0.220	0.018	1.270	0.055
Md4	1.060	23.950	1.830	0.110	23.000	0.880	0.011	1.250	0.028
Md6	0.650	32.050	1.430	0.700	21.100	0.480	0.016	1.080	0.034
Mean	1.260	22.225	1.365	0.310	18.775	0.415	0.011	1.188	0.034
Rd0	0.980	32.350	1.280	0.030	31.400	0.930	0.012	0.950	0.022
Rd2	1.120	21.850	1.200	0.170	20.900	0.250	0.035	1.250	0.031
Rd4	1.370	33.950	2.110	0.420	33.000	1.160	0.030	1.510	0.028
Rd6	1.260	43.650	1.230	0.310	42.700	0.280	0.028	1.350	0.033
Mean	1.183	32.950	1.455	0.233	32.000	0.505	0.026	1.265	0.029
Ft0	1.030	21.750	1.150	0.080	20.800	0.200	0.013	1.750	0.016
Ft2	1.090	15.450	1.060	0.140	14.500	0.110	0.011	1.500	0.011
Ft4	1.100	16.010	1.070	0.150	15.060	0.120	0.016	1.680	0.024
Ft6	1.150	6.040	1.130	0.200	5.090	0.180	0.019	1.640	0.040
Mean	1.093	14.813	1.103	0.143	13.863	0.153	0.015	1.643	0.023

LSD 0.05									
TM	0.15	5.93	0.25	0.14	5.27	0.24	0.01	0.13	0.01
WA	0.14	9.46	0.24	0.15	9.34	0.23	0.01	0.24	0.01
TM x WA	0.04	0.17	0.08	0.10	1.04	0.03	0.003	0.10	0.003

TM= Tillage method; WA= Wood ash; Md0 = Mound without wood ash (WA); Md2 =Mound +2t/ha WA; Md4 = Mound + 4t/ha WA; Md6 = Mound + 6t/ha WA; Rd0 = Ridge without WA ; Rd2 = Ridge +2t/ha WA; Rd4 = Ridge + 4t/ha WA; Rd6 = Ridge + 6t/ha WA; Ft0 = Flat without WA; Ft2 = Flat + 2t/ha WA; Ft4 = Flat + 4t/ha WA; Ft6 = Flat + 6t/ha WA

https://dx.doi.org/10.22161/ijaers.4.11.3 *ISSN: 2349-6495(P) | 2456-1908(O)*

The reduction in the value of B recorded in Flat relative to the Ridge value is of much value 55.04%. The variation in the result of Pb indicates an order of Ridge >Mound >Flat, the reduction in value in Flat was 24.19% relative to the value obtained from Ridge. The 2nd year result showed Cu to be higher in Mound of which the decreased value in Ridge and Flat were 24.84% and 53.87% respectively. Boron (B) showed increased value in Ridge, this value decreased in Mound but lowest in Flat. Pb result presents an order of Ridge > Mound > Flat. The result of the 3rd year for Cu and B present a variation of Ridge > Flat >Mound, while Pb present a contrary result order of Mound > Ridge >Flat. For the 3 years' of study the lowest value of Cu and B was observed in Mound in the 3rd year planting, while that of Pb was observed in Flat in 3rd year planting.

The rates of WA application showed decrease in value as the year of planting increased in the entire TM and lowest values were recorded in the 3rd year planting. The result variation in Mound in 1st year for Cu, show Rd2 to be higher in value compared to the other rates while the lowest value of 0.65mgkg^{-1} Cu was recorded in Md6. B result presented Md6 as the highest, next in rank was Md4 and least value of 12.65mgkg^{-1} B was obtained in Md2. For Pb result the highest value was observed in Md4 and its decreased value in Md0 was 43.72%. The 2nd year result variation for Cu, B and Pb showed a variation of Md6 > Md4 > Md2 > Md0 (Cu), for B, Md4 >Md6 >Md0 >Md2 and Pb, Md4 >Md6> Md2> Md0. The result of Mound showed non-presence of Cu in the shoot of castor from Md0 plots an indication that tend to suggest that Mound method without soil amendment and continuous cultivation can drastically reduce or remove entirely heavy metals from the soil, thereby making it impossible for the growing plants to pick them up. The other rates however showed increased value of Cu. B showed an order of Md2> Md4 >Md0 >Md6 and Pb, Md2 > Md6 > Md4 >Md0. The result variation indicated that higher value of B and Pb were observed in Md2 respectively. The rate of ash on Ridge indicated higher Cu content in Rd4 and the least in Rd0 compared to the other rates. The B result indicated an increased value from Rd2-Rd6, but the value of Rd0 was higher than the Rd2 values. For Pb higher value was recorded in Rd4 and the next closed value was obtained in Rd0. The 2nd year result for the three elements was of the same scenario with the 1st year result, only that lower values were obtained in the rates compared of their values in the 1st year result. The 3rd year result of Cu and B showed increased value as rate of ash applied increased, though a decreased value for the elements were observed in Rd_6 respectively, but higher than their values in Rd0. The Flat result for Cu showed that the value of Cu in 1st and 2nd year was dependent on the rate of ash applied, hence result order of Ft6 > Ft4 > Ft2 > Ft0. Its 3rd year result presents a contrary order of Ft6 > Ft4 > Ft0 > Ft2, but in the 3 years' study higher value was shown to be observed in Ft6 relative to other rates. The 1st year result of B indicated an increased value in Ft0 of which its decreased value in Ft6 was of much value 72.23% while for Pb higher value was still observed in Ft0 and its decreased value in Ft2 the least value was merely 7.83%. The 2nd year result of B and Pb was in line with the result variation obtained from the 1st year result only that lower values were obtained compared to their values in the rates of 1st year result. The 3rd year planting present a result order of Ft0 > Ft4 > Ft6 > Ft2 for B and Pb, Ft0 > Ft6 > Ft4 > Ft2 the two results indicated higher values to have been obtained in Ft0 while the values of Ft4 and Ft6 were relatively alike.

The result presented in Table 4 showed that the effect of tillage methods and rates of wood ash (TM x WA) on the heavy metal content of the shoot were significantly different ($P < 0.05$) among the rates of WA and tillage methods studied. The values of the tested elements (Cu, B and Pb) decreased as the years of planting period increased. The values obtained for these parameters (Cu, B and Pb) from 4tha^{-1} and 6tha^{-1} rates of WA among the tillage methods were found to be relatively higher than the values obtained from 0tha^{-1} and 2tha^{-1} rates. Continuous cultivation and non-application of wastes can even lead to exhaustion or non-uptake of some of these heavy metals as was found in Cu in the third year planting. Tillage (Flat) and WA at the rate of 2tha^{-1}, 4tha^{-1} and 6tha^{-1} (Ft2, Ft4, Ft6) showed statistically similar results for Pb and Cu in 1st and 2nd year planting periods respectively. The yield values obtained in Ridge and Flat were relatively higher than the values obtained from Mound. The ash application also influences changes in the values obtained for the parameters and the trend of changes was observed to be in consistent. For instance, the values of Cu in 1st and 2nd years planting were found to increase as the rate of WA applied increased, while the values of B and Pb decreased as the rates of WA increased to 2tha^{-1} and then increased in 4tha^{-1} and decreased again in 6tha^{-1} rates of WA. Also the values of Cu, B and Pb in 3rd year planting obtained from 2tha^{-1}, 4tha^{-1} and 6tha^{-1} respectively were not significantly different among the rates. The value trend for the 3 years of study from the rates of WA applied showed B > Pb > Cu.

Effect of Tillage and Wood ash on heavy metal content of Castor seed (Cu, B, Pb mgkg^{-1})

The effect of tillage methods on the heavy metal contents of seed presented in Table 5 indicated non-significant differences for B 1st and 2nd year planting and Pb for the 3 years of study. However, significant differences in Cu were observed among the tillage methods for the years under study. The result obtained from Mound method in 1st year planting indicated that highest values of Cu, B and Pb were observed in the 1st planting year of which decreased in value as the planting year increased, with sharp reduction in the 3rd year planting. The result of the parameters from Ridge and Flat follow the same result order of Mound, whereby the 1st year recorded the highest value and the value decreased as planting year increased with greatest decrease in value in the 3rd year planting. The result of B in Ridge 1st and 2nd year planting however, are close as its percentage decrease in 2nd year planting was relatively small with a value of 3.17%. When the TM are compared, Ridge method showed higher content of Cu, compared to Flat and Mound that made least value. The reduction in Cu content of Mound in the 1st year planting result was observed to be 35.04% relative to the Ridge value. The variation in B and Pb result for 1st and 2nd year planting among the tillage methods were not much, though result order showed Mound > Ridge > Flat. The residual (3rd) year result showed that higher value of Cu content was obtained in Mound with a value of $0.098 mgkg^{-1}$ and the least value $0.045 mgkg^{-1}$ obtained in Flat method. The result of B presents a different order of Ridge > Mound > Flat while Pb showed that Mound > Flat > Ridge.

The rates of WA application in Table 5 showed significant differences ($P<0.05$) for the tested elements except for residual year result of Cu. The result of its application on Mound methods in 1st year planting indicated that highest values of Cu, B and Pb were observed in Md2, Md4 and Md6 respectively. For Cu the least values were obtained in Md6 of which its percentage decreased value relative to Md2 was 85.95%. This value showed greater reduction of Cu value in Md6 while B showed 76.27% value reduction in Md0 relative to Md4. Pb value showed dependence of value on the rate of ash applied as order was Md6 > Md4 > Md2 > Md0. It showed much reduction in value in Md0 with a value of 49.746% relative to the Md6 value. The 2nd year planting result indicated that Md2 was higher in Cu content compared to the other rates of WA the next in rank was Md6 and the least value from Md0. B showed least value in Md0 and the highest value from Md4. The value of Pb showed dependent on the rate of ash as the result order was Md6 > Md4 > Md2 > Md0 but greater reduction in Md0 with 96.078% relative to Md6 value. The 3rd year result showed the Cu content to be high in Md6 the closest in rank was the value of Md2, but the Cu value decreased in Md0 with 32.20% relative to Md6 value. The result of B showed a result order of Md2 > Md6 > Md0 > Md4. However, the values of Md2 and Md6 as well as Md0 and Md4 did not vary much from the other as the fractional difference in their values were $0.017 mgkg^{-1}$ and $0.005 mgkg^{-1}$ respectively. The result from Mound in the residual year for lead (Pb) indicated non-uptake of the element by the castor seed in Md0 and Md6 plots, but its uptake in Md2 and Md4 showed that among the two rates, much of Pb content was observed in Md4 relative to Md2. The rate of ash on Ridge in 1st year planting indicated that higher content of Cu was obtained from Rd2 plots, the next in rank was observed in Rd6 plots, but the value decreased in Rd0 plots with a value of 32.97% relative to the Rd2 plots. The B content indicated a variation of Rd6 > Rd4 > Rd0 > Rd2 of which the percentage decrease in value of the element in Rd2 was 45.80% relative to the plots that recorded the highest B value. The content of Pb increased as the rate of ash increased. Although a decreased value was observed in Rd6 of which was higher in value than the Rd0 value the percentage difference in value between the Rd6 and Rd0 plots was 22%. The 2nd year planting result showed a decrease in value from the 1st year planting result. The result of Cu in this 2nd year result showed that Rd2 and Rd6 had the same value of Cu, while there was a greater decrease in the value of Rd0 relative to the Rd6 and Rd2 values. The value of B content in this 2nd year result still observed the scenario of 1st year result whereby the higher content of B was obtained from Rd6 of which is greater than the value of Rd4 and Rd0. While the least value was observed in Rd2 of which is 46.93% decreased compared to the value from Rd6 plots. When compared to its 1st year results, it means that the content of B decreased with a value of 1.13% in 2nd year planting result. The result of Pb showed increased value as the rate of ash applied increased to

Rd4, but decreased in Rd6. Though the observed value of Pb in the Rd6 was decreased, it was still higher than the value obtained in the Rd0 plots. The residual year result for the parameter showed sharp decrease in values obtained. The Cu content showed much decreased value in Rd4 with a value of 76.77% relative to the value of Cu obtained from Rd0 plots. The result of B increased in Rd4 relative to other rates of ash applied, the next increased value was observed in Rd0. Pb result, however, showed a variation of Rd4 > Rd2 > Rd0 > Rd6. The values obtained for Pb also show that there was much decreased value in Rd6 with 60.98%

https://dx.doi.org/10.22161/ijaers.4.11.3 ISSN: 2349-6495(P) | 2456-1908(O)

relative to the value from Rd4. The result of ash on Flat showed higher value of Cu in Ft6 and the next in rank from Ft2 while the least value was obtained in Ft0 from the 1st year planting result. The B and Pb content showed a variation result order of Ft4 > Ft2 > Ft6 > Ft0 and Ft4 > Ft6 > F2 > Ft0 respectively. The values of the tested parameters in 2nd year planting result showed decrease in value when compared to the 1st year result. The value of Cu showed decreased value in Ft4 when compared to the value Ft6, while the B content showed decreased value in Ft0 relative to the value of Ft4. The Pb value showed higher value in Ft6 with much decreased value in Ft0 with a value of 86.96%. The residual year result showed a greater decrease in value of the elements when compared to the 1st and 2nd year results. The result of Cu showed an increased value in Ft0 though the value did not vary much from the value obtained in Ft4 as the fractional difference in their values was merely 0.001mgkg^{-1}. The B content showed higher value in Ft2 with very much decreased value in Ft4 which was 96.66% showing greater reduction of B in Ft4 relative to Ft2 value. While Pb result indicated decrease in value as the rate of ash applied increased, hence the result order of Ft0 > Ft2 > Ft4 > Ft6.

The effect of tillage methods and rates of WA application were significant (Table 5). However, the effect of Ridge and WA at the rates of 2tha^{-1} (Rd2), 4tha^{-1} (Rd4) and 6tha^{-1} (Rd6) on Cu 1st and 2nd year planting were statistically similar. The same kind of result was observed for B in the 3rd year where the Mound and the four different rates of WA (Md0, Md2, Md4 and Md6) were statistically similar.

Table.5: Effect of Tillage and wood ash on heavy Metal Content of Castor Seed (Cu, B, Pb mgkg^{-1})

Treatment	**1st Year**			**2nd Year**			**3rd Year**		
	Cu	**B**	**Pb**	**Cu**	**B**	**Pb**	**Cu**	**B**	**Pb**
Md0	1.040	11.150	0.990	0.090	10.200	0.040	0.080	0.250	0.000
Md2	1.210	24.550	1.170	0.260	23.600	0.220	0.100	0.350	0.086
Md4	1.070	46.990	1.210	0.120	46.040	0.260	0.095	0.245	0.099
Md6	0.170	39.850	1.970	0.220	38.900	1.020	0.118	0.333	0.000
Mean	1.123	30.635	1.335	0.173	29.685	0.385	0.098	0.295	0.046
Rd0	0.990	27.910	1.180	0.040	26.960	0.230	0.095	0.270	0.020
Rd2	1.477	21.430	1.200	0.520	20.480	0.250	0.066	0.650	0.022
Rd4	1.440	30.960	1.510	0.490	30.010	0.560	0.019	0.830	0.041
Rd6	1.470	39.540	1.400	0.520	38.590	0.450	0.030	0.460	0.016
Mean	1.344	29.960	1.323	0.393	29.010	0.373	0.043	0.553	0.025
Ft0	1.040	13.850	1.013	0.090	12.900	0.060	0.065	0.176	0.054
Ft2	1.100	32.150	1.180	0.150	31.200	0.230	0.013	0.510	0.050
Ft4	1.030	40.750	1.500	0.080	39.800	0.200	0.064	0.017	0.038
Ft6	1.130	27.850	1.410	0.180	26.900	0.460	0.040	0.075	0.016
Mean	1.075	28.650	1.188	0.125	27.700	0.237	0.046	0.195	0.040

LSD 0.05

TM	0.11	NS	NS	0.10	NS	NS	0.02	0.14	NS
WA	0.15	0.22	0.17	0.14	0.21	0.16	NS	0.20	0.02
TM x WA	0.04	0.41	0.06	0.02	0.14	0.03	0.03	0.13	0.002

Md0 = Mound without wood ash (WA); Md2 =Mound +2t/ha WA; Md4 = Mound + 4t/ha WA; Md6 = Mound + 6t/ha WA; Rd0 = Ridge without WA ; Rd2 = Ridge +2t/ha WA; Rd4 = Ridge + 4t/ha WA; Rd6 = Ridge + 6t/ha WA; Ft0 = Flat without WA; Ft2 = Flat + 2t/ha WA; Ft4 = Flat + 4t/ha WA; Ft6 = Flat + 6t/ha WA

It was also observed that tillage methods, especially Mound and Non-application of organic waste like WA influence greatly the uptake of heavy metals like Pb as can be seen from the presented result in Table 5. From the obtained values, it was observed that the effect of tillage and WA increased the seed uptake of B relative to the other elements. Though these obtained values of the heavy metals (Cu, B and Pb) content of seed decreased as the years of planting increased. The tillage methods increased the uptake of B by the castor seed. Statistically similar results were obtained from Ridge and Flat for Cu in 3rd year planting as well as Mound and Flat for Cu in the 2nd year and B in the 3rd year planting period. Among the tillage methods Mound was found out to increase the uptake of tested parameters, followed by Ridge method. The WA application showed that the values obtained from $4tha^{-1}$ and $6tha^{-1}$ rates of WA for the parameters tested were found to be statistically similar, but significantly different from the control plots. Examples are Cu, B (1st and 2nd year planting) and B (3rd year) planting periods. It was equally observed that the values of heavy metal contents (Cu, B and Pb) of seed in each rate of WA applied decreased as the year of planting increased and in some cases increasing the rates of WA application increased the uptake of these heavy metals.

IV. DISCUSSION

Soil Heavy Metals

The result of soil heavy metals after 3 years' of study showed that higher values are observed in 1st and 2nd year planting compared to the 3rd year planting values in all the tillage methods studied. The values of these parameters observed in the Ridge and Flat for the 3 years planting were relatively similar and higher in value when compared to their values obtained from Mound. The value of Cu obtained from Mound and Ridge in 1st and 3rd year plantings were statistically similar. The yield of these parameters could be dependent on the soil type, climate and drainage. Griffith *et al*., (1993) noted that effect of tillage systems on yield and soil parameters are highly dependent upon soil type, drainage and climate. The nature of the results obtained could also be attributed to the tillage depth and rooting depth of castor plant as tillage methods affect the sustainable use of soil resources through its influence on soil properties. Strudley *et al*., (2008) found out that tillage depth and intensity alter soil physical and chemical properties that affect plant growth and yield. The management effect of tillage methods and organic waste application on a near-soil surface is vitally important considering the effect of soil surface on water infiltration, nutrient conservation, trace metals distribution and erosion control. Thus, good soil quality not only produces good crop yield, but also maintains environmental quality and consequently plant, animal and human health (Action and Gregorich, 1995; Franzluebbers, 2002).

The wood ash application for the 3 years study showed that the result of Cu, B, (1st year), B (2nd year) and Cu (3rd year) in $4tha^{-1}$ and $6tha^{-1}$ were statistically similar but significantly different with control plot. Also the values of B (1st year), B (2nd year) and Cu, Pb (3rd year) obtained from $2tha^{-1}$ and $4tha^{-1}$ WA respectively were statistically similar but significantly better than the control plots. The values of B decreased as planting years increased and among the soil heavy metals tested it was B that decreased most in value in the 3rd year planting season. Heavy metals concentrations in soils are always a guide to the potential redevelopment of the field sites. The nature of the result obtained may have been influenced by the pH, cation exchange, organic matter and to some extent the available P content of the soil. The result of the 3 years study also show that the soil heavy metals vary with the rate of WA application. The heavy metals obtained from $0tha^{-1}$ significantly were small when compared with the values obtained from the other rates of WA applied. Alloway (1996) put the normal range of Cu to be from 2 – 250 $mgkg^{-1}$, while Malcon (1991) put Cu range to be from 2 – 100 $mgkg^{-1}$ the values obtained for the element is within the range. Anthropogenic activities such as amendment of soils with agricultural wastes increased soil heavy metals concentration. The following authors: Asadu *et al*., (2008), Nwite *et al*., (2008), LASEPA (2005) and WHO (1996) reported significant increases in these soil heavy metals in organic waste amended soils compared to the control plots. Lead, (Pb) in its own case, is believed to be absorbed by the soil and is highly insoluble. The values obtained for these heavy metals differed greatly with that of the results of Mba *et al*., (2006), (2009) and (2011) which could be associated with the type of organic waste applied, test crop used, planting period observed and the state of climate and precipitation at the time of study. Tillage and WA effect showed that the values of the soil heavy metals (Cu, B, Pb) increased as the rate of WA applied increased irrespective of the tillage method the ash was applied. The effect on the values were observed to be higher in the 1st and 2nd years planting and decreased in the 3rd year planting season. Also their values obtained from $4tha^{-1}$ and $6tha^{-1}$ irrespective of the TM the WA was applied were found to be relatively similar, but higher in value compared to their values obtained from $2tha^{-1}$ and $0tha^{-1}$ rate of WA. The result obtained could be associated with the type of tillage method, waste applied and water content and infiltration rate of the soil. Soil water content is affected by tillage because of changes produced in infiltration, surface run-off and evaporation. These factors are capable of influencing the soil heavy metal contents, as some of them can be soluble and transformed in the soil into their carbonate or hydroxyl content which might be of help to soil nutrient distribution and plant growth, while in water stress situation some of them can become insoluble and adsorbed by soil particles. Tillage methods influenced soil water storage more than the degree of canopy formed by the different crop varieties, according to Fabrizzi *et al*., (2006).

Heavy Metal Content of Shoot of Castor

The effect of tillage methods on the heavy metal contents of castor shoot showed significant difference at $P < 0.05$ among the TM studied (Table 4). The values obtained in each of the TM decreased as the planting years increased. Their recorded values in Ridge and Flat were relatively higher than the values obtained from the Mound. In most of the parameters such as Cu and Pb (3rd year) their values in Ridge and Flat were statistically similar. The same statistical similarity applies to the values obtained from Mound and Ridge with regard to the values of Cu, Pb (1st and 2nd) years planting and B, Pb in the 3rd year planting periods. The result obtained for the parameters could be attributed to some factors such as tillage method used, waste applied, root development and soil aggregation. For instance, when soil is annually cultivated, roots develop more extensively below 10 cm than with no-till systems while intermediate root distribution occurs with minimum tillage system and when residues are removed, there is greater root growth in the 15 cm soil surface (Larson, 1999). This affected the yield contents of these parameters much on the 3rd year planting period where their values decreased remarkably, probably due to non-application of WA. Also, the ability of Ridge and Mound to conserve limited soil moisture might have influenced the statistical similarity in values of the parameters observed. Rowland (1993) observed that the traditional system of Ridge and Mound cultivation improve aeration for roots and facilitates the growth and development of crops. Continuous cultivation reduces aggregate size, because small aggregates are less stable than large ones (Nweke and Nnabude, 2014, 2015) and soils with small aggregates are more prone to compaction, crusting, soil erosion and reduced yield. All these invariably may have influenced the uptake of heavy metals by the castor plant.

The trend of change in these parameters was observed to be inconsistent irrespective of the TM. For example the values of Cu in 1st and 2nd years planting were found to increase as the rates of WA applied increased. While the values of B and Pb decreased as the rates of WA increased to 2tha^{-1} and then increased in 4tha^{-1} and decreased again in 6tha^{-1} rates of WA. The value of the parameters Cu, Pb and B are within the tolerable limits and, therefore, may not cause toxicity problems to the crop nor cause any injury to humans. Comparison of the rates of WA on TM indicated that the rates of WA on Ridge show relatively higher values in these parameters compared to Mound and Flat values. Though the tested parameters are within the tolerable range, they have the potential to build up rapidly to critical levels in the soil due to continuous application of wastes in the soil. Increasing the heavy metal contents of soil may not only be deleterious to soil productivity but harmful to humans and animals that invariably will depend on soil for their livelihood. Thus, Naidu *et al*., (1997) stressed that continuous application of organic waste amendment were the greatest threat to the environment as a result of surface input to soil system of heavy metals.

The values obtained for the parameters (Cu, B, Pb) from 4tha^{-1} and 6tha^{-1} rates WA among the tillage methods were found to be relatively higher than the values obtained from 0tha^{-1} and 2tha^{-1} rates. Continuous cultivation and non-application of wastes can even lead to exhaustion or non-uptake of some of these heavy metals as was found in Cu in the 3rd year planting. The effect of tillage (Flat) and WA at the rate of 2tha^{-1}, 4tha^{-1} and 6tha^{-1} showed statistically similar results for Pb and Cu in 1st and 2nd year planting periods respectively. Soil disturbance and subsequent changes in soil organic matter strongly affect the stability of soil aggregates and other soil properties (Boivin *et al*., 2001; Nweke, 2015). These changes in turn will have feedback effect on the uptake ability of the heavy metals by the castor plant.

Heavy Metal contents of Seed

Statistically similar results were obtained from Ridge and Flat for Cu in 3rd year planting as well as Mound and Flat for Cu in the 2nd year and B in 3rd year planting result. Among the TM, Mound was found out to increase the uptake of most of the tested parameters followed by the Ridge method and the least is Flat. Tillage is an integral part of the crop production system that influences plant nutrients and heavy metal uptake by plants. According to Arshad *et al*., (1999), tillage is crucial for optimising productivity by alleviating physico-chemical and biological constraints of soil. Hence, nature of the result obtained from the three tillage methods collaborated with the findings of Dick *et al*., (1991) and Okpoku *et al*., (1997) who postulated that yield reduction have often been observed in no-tillage compared to other methods, especially when used in poorly drained fine textured soils. Also, it should be noted that crop responses to tillage methods depend upon the number of years a tillage system has been established, amendment used and the history of the field.

The values obtained from 4tha^{-1} (Md4, Rd4, and Ft6) and 6tha^{-1} (Md6, Rd6, Ft6) rates were found to be statistically similar but significantly different from the control plots. Heavy metal contents of seed in each rate of WA applied decreased as the year of planting increased. The observed remarkable decrease in the uptake of these heavy metals in third year planting by the castor seed could be due to non-application of WA, which tend to portray that organic waste application on agricultural soils can be one of the common sources of soil contamination as the crops source out the nutrients from the soil. Thus, Jones *et al*., (1991) reported that heavy metals were absorbed at particle surface, bound to carbonates or occluded in iron or manganese hydroxides, organic matter and sulphide. The value of rates of WA on Mound was observed to be relatively higher compared to the values of rate of WA on Ridge and Flat.

From the obtained values it was equally observed that the combined effect of tillage methods and rates of WA increased the uptake of heavy metal like B. The observed variations in the tested parameters among the tillage methods and rates of WA and the three years of study collaborated with the findings of Vousta and Samara (1996) who reported that harvested crops show large variations in heavy metal concentration from year to year in the same field. This they attributed to plant uptake, variable emission rates, deposition process and atmospheric transport. The values obtained from Pb uptake by castor seed is in line with the findings of Miller and Miller (2000) who observed that Pb is not taken by plants to any degree. This observation particularly with the present study can equally be associated with the result of Cu.

V. CONCLUSION

Results of the study show that tillage methods and rates of wood ash application as soil amendments increase the heavy metal contents of soil, castor shoot and seed to non-toxic level, the values of heavy metal increased as the rates of wood ash increased and decreased as the planting seasons increased. The values obtained from Ridge and Flat were higher than the values obtained from Mound method though Mound method was found to increase the uptake of heavy metal contents of seed. Based on the results of the study the use of wood ash as soil amendment on continuous basis especially at higher rates should not exceed three consecutive years on the same piece of land in order not to constitute pollution problems at the near future.

REFERENCES

[1] Action, D.F. and Gregorich, L.J. (1995). The health of our soils: Toward sustainable agriculture in Canada, Agriculture and Agricultural food, Canada, CDR, 960 Carlingn.

[2] Agbede, F.M., Ojeniyi, S.O. and Awodun, M.M 2008). Effect of tillage methods on growth grain yield. Northeastern Thailand J. 34:197-200.

[3] Alloway, B.J. (1996). Heavy metals in soil. Halsted Press, John Wiley and Sons Inc. London, pp. 230 – 239.

[4] Arshad, M.A., Franzuebbers, A.J. and Azooz, R.H. (1999). Components of surface soil structure under conventional and no-tillage in North Western Canada. Soil Till. Res. 53:41 – 47.

[5] Asadu, C.L.A., Ucheonye Oliobi, C. and Agada, C. (2008). Assessment of sewage application in south-western Nigeria. part I, impact on selected soil morphological and physical properties. Outlook on Agriculture, 37(1):57 – 62.

[6] Awodun M.A. (2007). Effect of saw dust ash on soil chemical properties and cowpea performance in south western Nigeria IJSC 2(1): 78-81.

[7] Boivin, H.B., Bummer; G. W. Horn, R; Randeler, E., Kogel Knabner, I.; Kretschmar, R.; Stabr, K. and Wike, B.M. (2009). Lehrbuch der Bodekunde. Spektrum, 500pp.

[8] Dick, W.A., McCoy, E.L., Edwards, W.M. and Lal, R. (1991). Continuous application of no-tillage to Ohio soils. Agron. J. 83:65-73.

[9] Fabrizzi, K.P., Garcia, F.O., Costa, J.I. and Picone, L.I. (2006). Soil water dynamics, physical properties and corn and wheat responses to minimum and no-tillage systems in the southern pampas of Argentina, soil and Tillage Research, 81:57 – 69.

[10] Federal Department of Agriculture and land Resources (1985). Reconnaissance soil survey of Anambra State of Nigeria soil report 1985, Federal department of Agriculture and Land Resources Lagos Nigeria.

[11] Franzluebbers, A.J. (2002). Soil organic matter stratification ratio as an indicator of soil quality, Soil and Tillage research 66:95 – 106.

[12] Gallardo-Lara, F., Robles, J., Esteban, E., Azeon, M. and Nogales, R. (1984). Poder fertilizant de un compost de fey Zn: In proceeding of J. Congreso Nacional de la Ciencia del silo. Vol. I, SECs, Madrid, 393 – 403.

[13] Griffith, D.R., Mannering, J.V., Galloway, H.M., Parson, S.D. and Richey, C.B. (1993). Effect of eight tillage planting systems on soil temperature, percent stand, plant growth and yield of corn on five Indiana soils Agron. J. 65:321 – 326.

[14] Islam, E.U., Yang, X., HE, Z and Mahmood, Q. (2007). Assessing potential dietary toxicity of heavy

metals in selected vegetables and food crops, J. Zhejiang Univ. Sci. B. 8:1-13.

[15] Jing, Y. He, Z., and Yang, X. (2007). Role of soil rhizobacteria in phytoremediation of heavy metal contaminated soils. J Zhejiang Univ. Sci. B. 8, 192-207.

[16] Jones, A.S., Suter, H.G.W. and Hull, R.N. (1991). Toxicological benchmark for screening potential contaminants of concern for effects on sediment-Associated Biota. Oak Ridge National Laboratory, Tenn.

[17] Kos, B., Greman, H. and Lestan, D. (2003). Phyto-extraction of lead, zinc and cadmium from soil by selected plants. Plant Soil Environ. 49:548 – 563.

[18] Lagos State Environmental Protection Agency (LASEPA) (2005). Lagos State Environmental Report 3:28 – 33.

[19] Lal, R. (1993). Soil erosion and conservation in West Africa, P.7 -26. In D. Pimentel (ed), world soil erosion and conservation. Int union for conservation of nature and natural resources, Switzerland

[20] Larson, W.E. (1999). Soil Parameters for evaluating tillage needs and operations, Soil and water management and conservation. Soil Science and Society Proceedings, 118-122

[21] Lone, M. I. He, Z., Stoffela, P. J. and Yang, X. (2008). Phytoremediation of heavy metal polluted soils and water, progress and perspectives. J. Zhejiang Univ. Sci. B. 9, 210-220.

[22] Malcon, E.S. (1999). Bioavailability of nutrients: In Handbook of Soil Science, CRC Press Boca Raton NY Washington DC, pp. 73.

[23] Mbah, C.N., Idike, F.I. and Njoku, C. (2011). Accumulation of pollutants in an ultisol amended with burnt and unburnt rice mill wastes. J. Agric. Bul. Sci. 2(2):043 – 047.

[24] Mbah, C.N., Nwite .J.N., Njoku, C. and Nweke, I.A. (2010). Response of maize (Zea mays l.) to different rates of wood ash Application in acid ultisol in south east Nigeria. Afri. J. Agric. Res. 5(7) pp 580-583.

[25] Mbah, C.N., Nwite, J.N., Ogbodo, E.N., Okonkwo, C.I., Mbagwu, J.S.C. and Anikwe, M.A.N. (2006). Trace elements in maize (zea mays) as influenced by incorporation of animal wastes in dystric leptosol in south-eastern Nigeria. J.Sci. Agric. Food Tech. Environ. 6:33 – 39.

[26] Mbah, C.N., Orji, A. and Nweke, I.A. (2009). Effect of organic inputs on soil properties of heavy metal content and maize root yield on engine oil polluted soil. J. Agric. Rural. Dev. 11(2):94 – 99.

[27] Miller, D.M. and Miller, W.P. (2000). Land application of wastes, In: Summer M.E. (eds). Handbook of Soil Science CRC Books New York.

[28] Moolenar, S. W and Lexmond, T. M. (1999). General aspect of cadmium, copper, zinc and lead balance studies in agro-ecosystems. Heavy metal balances, part 1 J Indust. Ecol. 2: 4-8.

[29] Naidu, R., Kookana, R.S., Summer, M.E., Harter, K.D. and Tiller, K.G. (1997). Calcium sorption and transport in variation change in soils. A review. J. Environ. Qual. 26:608 – 617.

[30] Nwachukwu, O. I., Nyong, A. E. and Opara, U. D. (2012) . Effect of manures on soil properties, yield and nutrient uptake in an ultisol of southeast, Nigeria, Nig. J. Soil Sci. 22(2):70-78.

[31] Nweke, I. A. (2015). Effect of land use on organic matter concentration of aggregate fractions of fallow and cultivated soils. Indian J. Appl. Res. 5(3): 507- 511.

[32] Nweke, I. A., and Nnabude, P. C. (2014). Organic C, TN, and available P concentration in aggregate fraction of four soils under two land use systems. J. Res. Appl. Nat. Soci. Sci. 2(5): 273-288.

[33] Nweke, I. A., and Nnabude, P. C. (2015). Aggregates stability of four soils as evaluated by different indices. J. Expt. Biol. Agric. Sci. 3(3): 246-252.

[34] Nwite, J.N., Ekpe, I.I. and Ibeh, L.M. (2008). Assessment of selected heavy metals in spent lubricant oil contaminated and uncontaminated soil amended with organic wastes in Abakaliki: In Proceedings of 42nd Annual Conference, Agricultural Society of Nigeria (ASN), October 19th – 22nd 2000, Ebonyi State University, Abakaliki, Nigeria, 556 pp.

[35] Ojeniyi, S. O. Adekiya, A. O. and Amusan, O. A. (2012). Three year influence of tillage and poultry manure on soil physical properties and yield of cocoyam, Nig. J. Soil Sci. 22(2): 119-127.

[36] Okoronkwo, N.E., Igwe, J.C. and Onwuchekwa, E.C. (2005). Risk and health implication of polluted soils for crop production, Afr. J. Biotechnol. 4:1521 – 1524.

[37] Okpoku, G., Vyn, T.J. and Shanton, G. J. (1997). Modified no-till system for corn following wheat on clay soils, Agron. J. 85:549 – 556.

[38] Omoju, O. J. and Ojeniyi, S. O. (2012) Effect of tillage methods on soil properties and performance of

sweet potato (Ipomoea Batatas L) in Akure Nigeria, Nig. J. Soil Sci. 22(2): 128-131.

[39] Pierzynski, G M Sims, J T and George, F (2002) Soils and environmental quality, CRC Press, Boca, Raton.

[40] Rowland, K.R.J. (1993). Dry land farming in Africa. C.T.A, The Hague, Netherlands, 249 PP.

[41] Stassen, S. W. (2002). A study on how to prevent toxic effect of cadmium in the population at large, KUL, UL Gasthuisberg,Klinisch lab. Hypertensie, Inwendige, Geneeskunde-Cardio, Herestratt 49, 3000 Leuven.

[42] Strudley M.W., Green, T.R. and Ascough, J.C. (2008). Tillage effects on soil. Soil Till. Res. 99:4 – 98.

[43] Umeoguaju F U (2009) Conventional and new ways of remediating soils polluted with heavy metals, Scholars (http://scholars.ufumes.com) 1-4pp.

[44] Vousta, D.A. and Samara, C. (1996). Trace elements in vegetables grown in an industrial area in relation to soil and air particulate matter. Environ. Pollut. 94:125 – 145.

[45] Wildlife News (2000). Researchers work to reduce lead poisoning of children in Chicago's west town, Chicago USA.

[46] World Health Organisation (WHO) (1996). Guideline for drinking quality water, 2nd edition, Switzerland 1(3): 50-57.