FUPRE Journal of Scientific and Industrial Research
Vol.5, (1), 2021
ISSN: 2579-1184 (Print) ISSN: 2578-1129 (Online)

Synergistic Effect of Poultry Dropping and Poultry Dropping Biochar on Inorganic Contaminants in Soil

Ugbune, U[a]., Kpomah, B[a]., Idu, T.E[a]., Emakunu, S.O[a]
[a]Department of Chemistry,Delta State College of Education, Mosogar
Corresponding author (ugbuneufuoma@gmail.com, 08032711869)

Abstract
Inorganic contaminants of soil in dump sites are a major problem across the world especially in developing nation like Nigeriawhere good waste management are not practice. Inorganic contaminants such as cadmium, chromium, lead, and arsenicare commonly found in open dumpsites, this is due to industrial and medical waste. They pose a serious risk to soil and plant over time because metals are not biodegradable, they can remain in the soil for long time if not remediated. In this study soil sample from threedifferent dumpsites was investigated for physiochemical properties, inorganic contaminant concentration, metal fractionation, metal mobility and metal plant uptake. Poultry dropping and poultry dropping biochar were also assessfor physicochemical properties. Synergistic effect of poultry dropping and poultry dropping biochar combination on inorganic contaminant concentration,metal fractionation and metal mobility in soil were also investigated. Particle size distribution revealed that parent soil is mostly sand and clay. Poultry dropping and poultry biochar results revealed high amount of pH and nutrients Geochemical fractionation of selected inorganic contaminants (Cd,Cr, Mn, Pb and As) using sequential fractionation technique show that inorganic contaminantsincreases in the reduceable fraction (bioavailable) after incorporation of amender, poultrydropping, poultry dropping biochar and their combination. Poultry dropping, poultry biochar and their combination also decreases level of inorganic contaminant, metal mobility in soil and metal plant uptake. These suggested that inorganic contaminant become relatively immobile after treatment with poultry dropping, poultry dropping biochar and their combination. In overall, poultry dropping, and poultry biochar combination gave a better inorganic contaminant remediation.

Key words: Contaminant, Biochar, Poultry droppings, Soil.

1. Introduction

Soil is a variable mixture of minerals, organic matter, and water capable of supporting plant life on earth surface. One of the most important function of soil in supporting plant growth is to provide essential plant nutrients (Bahatial, 2002). These plants nutrients are classified as macro and micro-nutrients. Plant nutrient such as nitrogen, phosphorus, potassium etc. are regarded as macro-nutrient. Macro-nutrients are needed in large quantities for plant growth and productivity. Chromium, zinc, manganese are examples of micro-nutrients required in smaller concentration. Higher concentration is toxic to soil and plant. Micro-nutrients are also referred to as trace metals. A small portion of trace metals in soil is derived from natural process and may not cause pollution. A much higher proportion of trace metals in soil are from anthropogenic sources (Okieimen and llori, 2014), such as industrial waste, mining, domestic waste, and fertilizer application. Trace metal do not undergo microbial and/ or biogeochemical degradation and therefore total concentration and ecotoxicological effects may persists for a very long period after introduction to the environment (Okieiemen and Ilori, 2014). Adequate revitalization and remediation of polluted soil by trace metals may require treatment using organic manure or biochar. Biochar is created by heating organic feedstock under conditions of limited or no oxygen (Lehman, 2007., Ugbune and Okuo, 2019). Biochar depends on feedstock type and condition of pyrolysis consisting of different proportion of biochar and amorphous organic mobility matter (Lehman and Joseph, 2009). Ugbune and Okuo, (2019), reported that biochar contained higher nutrients and pH, various studies indicate that biochar has the potential to remediate soils contaminated with trace metals (inorganic contaminants) (Ugbune*et al.,* 2018;Medynska-Juraszek and Cwielag, 2020) as it decreases metal concentration in soil. Addition of organic manure (animal dump or poultry dropping) is also acknowledged to enhance soil nutrients,cation exchange capacity (CE), pH moisture and metal immobility when added to soil. Therefore, this study seeks to evaluate the synergistic effect of poultry dropping and poultry dropping biochar on soil physicochemical properties.

2. Material and Methods

2.1 Soil Sample Collection and Preparation

This study was conducted in Sapele metropolis which lies and located in (5°53' 59.99" N Longitude and 5° 39' 59.99"E Latitude)of Nigeria. Soil samples were obtained from three dumpsite in Sapele, namely New Road, (1), New Road 2, (2) and ReclamationRoad (3). Samples were collected in line with standard practices and as reported in previous studies (Okieimen and llori, 2014;Ugbune*et al.,* 2018;Medynska-Juraszek and Cwielag, 2020). At the laboratory, the soils were dried at ambient temperature (28°C), crushed in a porcelain mortar, and sieved through a 2 mm stainless sieve. Samples were stored in polythene bag and properly labelled for subsequent analysis.

2.2 Poultry Dropping Biochar (PDB) Production

Poultry dropping (PD) were obtained from Songhai integrated farm, Sapele, Delta State, Nigeria. PD production were done according to the method describe byTrakal*et al*., (2011);Ugbune and Okuo, (2017)

2.3 Soil Treatment and Design

Poultry dropping and poultry dropping biochar (PDB)was singly and co-applied to soil. The weight of soil to PD, PDB was 100g to 2000g of soil and that of the PD+PDB combination were also 100g to(50g of PD + 50g of PDB)2000g soil. The

amended soil was mixed thoroughly, watered with deionized water, and stirred twice a week for 10 weeks for stabilization to take place. These were kept in green house before planting and soil analysis.

2.4 Determination of Physical Properties of poultry dropping biochar (PDB)

The pH was determined following the method of Black, (1965), Anebge*et al* (2019), nutrient was determined using Ugbune and Okuo, (2019).

2.5 Determination of Physicochemical Properties of Soil

The hydrometer method described by Bouyoucos (1962) was used analyzed particle size distribution. Black method (Black 1965., Ugbune and Okuo, 2019) was used to determine pH. The Nelson and Sommer (1982) and Black (1965) were used to determine the Carbon content. Sodium, potassium, magnesium, nitrogen was determined following Ugbune and Okuo, 2019 method.

Heavy metal concentration was analyzed usingatomic absorption Spectrophotometer (AAS) VG210. Metal fractionation were determined using Tessier *et al*., (1979.

2.6 Fractionation of Trace Metals in Soil

In this study, fractionation of soil and treated soil was assessed using sequential extraction procedures according to Tessiers Scheme(Tessier *et al.,* 1979).

3. Results and Discussion

Particle size distribution of contaminated soil results is given in Table 1

Table 1: Particle Size Distribution of Contaminated Soil

Parameter Sand (%)	Sample 1	Sample 2	Sample 3
Sand (%)	72.15	72.12	71.10
Silt (%)	2.18	2.20	2.23
Clay	25.67	25.68	26.67

Soil texture is an important property of soil that determine nutrients, metal and water holding capacity in soil. Sandy soils are known to have poor water holding capacity, nutrient, and metals (Okieimen and Ilori, 2014). Textural assessment of the study soil revealed preproduce of sand fraction, followed by clay and silt, classifying the soil as sandy loam. The relative percentage of clay in the contaminated soil (Table 1) is an indication that the soil willbe retained nutrient and toxic metals.

The level of clay (Table 1)in the soil sample is relatively high suggesting that leachability and permeability of metal may below

Table 2: Physicochemical properties of Poultry Dropping (PD), Poultry Dropping Biochar PDB

Parameters	PD	PDB
pH	10.12	11.15
C (%)	20.16	82.68
N (%)	0.25	0.42

P (ppm)	0.23	0.22
K (meg)	0.21	0.29
Cr (ppm)	0.01	0.01
Cd (ppm)	BDL	BDL
Mn (ppm)	0.02	0.02
As (ppm)	BDL	BDL

BDL= below detection limit

Level of pH, Nutrient and Metal in PD and PDB

Level of pH and nutrients is very high and that of metal is low as shown in Table 2, indicating that PD and PDB is a good amender for inorganic contaminated soil remediation

Table 3: Effect of PD, PDB and PD+PDB in Soil and Amended Soil for Sample 1

Parameter	Control	PD	PDB	PD+ PDB
pH	7.02	7.09	7.20	7.19
C (%)	2.98	3.00	3.21	3.19
N(%)	0.25	0.27	0.26	0.26
P (ppm)	98.08	98.09	98.09	98.08
K (meg/100g)	0.22	0.24	0.35	034
Na(meg/100g)	0.98	1.08	1.96	1.93

Table 4: Effect of PD, PDB and PD+PDB in Soil and Amended Soil for Sample 2

Parameter	Control	PD	PDB	PD+ PDB
pH	7.05	7.98	8.26	8.42
C (%)	3.32	9.16	9.52	9.40
N (%)	0.25	0.32	0.45	0.44
P (ppm)	75.42	78.52	80.21	80.20
K (meg/100g)	0.38	0.46	0.53	0.57
Na(meg/100g)	01.32	1.35	1.36	133

Table 5: Effect of PD, PDB and PD+PDB in Soil and Amended Soil for Sample 3

Parameter	Control	PD	PDB	PD+ PDB
pH	8.09	8.92	9.52	9.41
C (%)	3.45	6.78	7.59	7.24
N(%)	0.42	0.52	0.51	0.52
P (ppm)	92.10	98.00	98.01	98.01
K (meg/100g)	0.42	0.45	0.58	0.56
Na(meg/100g)	0.152	0.155	1.00	0.99

Effect of PD, PDB and PD+PDB on Physico-chemical Properties of Soil

Soil pH is an important soil physical properties that controls the availability and mobility metal in soil.Italso determines heavy metal sorption as it controls the solubility and hydrolysis of metal hydroxides, carbonates, and phosphate (Okieimen and Ilori, 2014). According to Ugbune and Okuo, 2014, at high pH metals are adsorbed on the clay colloids and therefore not available for plant utilization. The pH of control sample soil (7.02-8.09) is within the range of dumpsite site soil (Ugbune and Okuo,2019), This pH range is an indication of domestic waste in the soil (Ugbune*et al*., 2018). In this study highest pH was observed in soil amended with PDB followed by PD+PDB and PD. The elevated pH levels notice is due to the release of sodium,potassium, and magnesium ion into the soil solution by ash in biochar (Okuo*et al*., 2014).

Table 6: Effect of PD, PDB, and PD + PDB of amendment on soilfor Sample 1

Parameter	Control	PD	PDB	PD+ PDB
Cr (ppm)	13.67	10.22	9.98	9.75
Cd (ppm)	12.52	9.10	7.78	7.62
Pb (ppm)	8.46	7.21	6.82	6.53
Mn (ppm)	10.22	8.92	7.52	7.42
As (ppm)	4.00	3.52	3.00	2.82

Table 7: Effect of PD, PDB, and PD + PDB of amendment on soilfor Sample 2

Parameter	Control	PD	PDB	PD+ PDB
Cr (ppm)	12.82	12.52	12.32	12.20
Cd (ppm)	12.48	12.20	12.10	12.00
Pb (ppm)	7.52	7.11	7.05	6.98
Mn (ppm)	9.82	9.20	9.06	9.06
As (ppm)	3.52	2.97	2.28	2.10

Table 8: Effect of PD, PDB, and PD + PDB of amendment on soilfor Sample 3

Parameter	Control	PD	PDB	PD+ PDB
Cr (ppm)	5.63	5.22	5.00	4.94
Cd (ppm)	1.72	1.22	1.02	1.00
Pb (ppm)	10.52	10.60	9.60	9.51
Mn (ppm)	9.22	8.92	8.21	8.00
As (ppm)	5.28	4.72	4.21	4.01

Effect of PD, PDBand PD+PDB on Inorganic contaminant of Soil

The result of soil amended with PD+PDB revealed low metal concentration (Table 6 – 8), PD sample having the lowest (PD+PDB>PDB>PD>control), this might be due to the synergistic effect ofPD and PDB combination that enhances metal adsorption to soil particle

Table 9: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil for Sample 1

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	2.65	2.72	2.60	2.42	3.19
PD	1.98	1.99	2.04	2.05	2.13
PDB	1.82	1.86	1.90	1.96	2.22
PD + PDB	1.72	1.90	1.92	1.93	2.19

Table 10: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil for Sample 2

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	3.08	2.23	2.25	2.44	3.19

PD	2.45	2.48	2.44	2.51	2.61
PDB	2.38	2.45	2.42	2.50	2.54
PD +PDB	2.40	2.41	2.47	2.47	2.52

Table 11: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil for Sample 3

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	1.20	1.32	1.10	1.06	1.17
PD	1.01	1.03	1.05	1.05	1.11
PDB	0.80	0.92	0.99	1.00	1.31
PD +PDB	0.80	0.85	1.08	1.09	1.17

Table 12: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil for Sample 1

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	2.40	2.49	2.50	2.51	2.61
PD	1.68	1.79	1.80	1.81	1.92
PDB	1.49	1.48	1.53	1.56	1.72
PD +PDB	1.40	1.42	1.53	1.65	1.65

Table 13: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil forSample 2

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	2.47	2.48	2.49	2.50	2.51
PD	2.31	2.42	2.43	2.54	2.44
PDB	2.30	2.35	2.44	2.51	2.40
PD +PDB	2.29	2.31	2.51	2.49	2.45

Table 14: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil for Sample 3

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	030	0.34	0.35	0.36	0.33
PD	0.20	0.23	0.23	0.24	0.34
PDB	0.15	0.16	0.13	0.24	0.23
PD +PDB	0.15	0.14	0.22	0.22	0.24

Table 15: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil for Sample 1

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	2.04	2.06	2.05	2.15	1.93
PD	1.75	1.77	1.74	1.75	1.90
PDB	1.45	1.47	1.50	1.50	1.59
PD +PDB	1.48	1.39	1.48	1.50	1.57

Table 16: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil forSample 2

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	1.97	1.95	1.96	1.90	2.05
PD	1.83	1.83	1.84	1.84	1.86
PDB	1.79	1.80	1.81	1.82	1.84
PD +PDB	1.80	1.81	1.82	1.83	1.84

Table 17: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil forSample 3

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	1.85	1.86	1.84	1.83	1.90
PD	1.77	1.77	1.78	1.79	1.80
PDB	1.64	1.62	1.61	1.65	1.70
PD +PDB	1.59	1.58	1.60	1.61	1.62

Table 18: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil for Sample 1

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	1.69	1.70	1.69	1.67	1.72
PD	1.43	1.43	1.44	1.45	1.45
PDB	1.33	1.36	1.36	1.34	1.46
PD +PDB	130	1.29	1.30	1.29	1.39

Table 19: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil forSample 2

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
PD	1.49	1.49	1.50	1.51	1.51
PDB	1.39	1.42	1.49	1.42	1.46
PDB	1.40	1.39	1.41	1.42	1.45
PD +PDB	1.40	1.42	1.39	1.39	1.42

Table 20: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil forSample 3

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	2.00	2.10	2.09	2.10	2.24
PD	1.85	1.90	1.96	1.98	2.20
PDB	1.80	1.82	1.91	2.03	207
PD +PDB	1.86	1.88	1.88	1.89	1.90

Table 21: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil for Sample 1

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	0.80	0.81	0.82	0.83	0.84
PD	0.70	0.69	0.70	0.69	0.74
PDB	0.60	0.61	0.62	0.62	0.66
PD +PDB	0.54	0.55	0.56	0.57	0.59

Table 22: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil forSample 2

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	0.69	0.73	0.70	0.71	0.69
PD	0.58	0.59	0.59	0.60	0.60
PDB	0.45	0.45	0.46	0.46	0.47
PD +PDB	0.30	0.32	0.40	0.41	0.57

Table 23: Chemical Fractionan of Cr (ppm) in Soil and Amended Soil for Sample 3

	Exch.	Carb.	Fe-mn oxide.	Org.	Res.
Control	1.05	1.05	1.06	10.7	1.06
PD	0.93	0.94	0.94	0.94	0.97
PDB	0.83	0.84	0.84	0.84	0.87
PD +PDB	0.78	0.80	0.79	0.80	0.84

Effect of PD, PDBand PD+PDB on fractionation of inorganic Contaminant in soil and amended soil

Geochemical fractionation of heavy metals (sequential extraction) provides information on the partitioning of metal into different soil fraction. The fractions are exchangeable, carbonate, Fe-Mn oxide, organic and residual. The fractions are useful tools in understanding the mobility and bioavailability of metal in soil.

Exchangeable fraction: Exchangeable fraction of soil sample after amendment (Table 9 - 23) show a decrease in metal concentration: control>PD>PDB>PD+PDB, suggesting that PD+PDB has a greater influence in reducing the exchangeable fraction in the contaminated soil.

Carbonate fraction: Results of carbonate fraction before and after amendment decreases. The decreased followed the order: control>PD>PDB>PDB, while metal concentration in this fraction is higher than exchangeable but lower than the reduceable for the amended and control soil.

Fe-Mn Oxide fraction: Fe-Mn Oxide minerals have relatively large area and surface density in comparison with carbonate mineral. Level of metal in Fe-Mn oxide phase of the control soil is below the concentration of organic and reduceable fraction (Table 9 - 23). The lowest concentration was notice in sample 2 of the study soil, 0.70, 0.59, 0.46. 0.40ppm for control, PD, PDB PD+ PDB respectively.

Organic fraction:

Organic matter plays an important role in the distribution and dispersions of metals by mechanisms of chelating and cation exchange (Kumar,2011). In this partitioning a reaction between metal ion an organic ligand to a species which either precipitate directly or adsorbed in soil surface (Kumar, 2011), Kumar, 2011 suggested that carboxyl, phenolic hydroxyl, and carbonyl functional group are primarily responsible for metal adsorption. The metal concentration of amended soil in this phase is quite high but lower than reduceable fraction. PD and PDB combination in the treated soil have the highest metal concentration in this phase.This might be attributed to the functional group of PDB(carbonyl, phenolic and hydroxyl) and the organic matter of PD. The organic fraction is not readily mobile or bioavailable (Ugbune*et al.,* 2018), it associates with higher molecular weight stable humic substance (Kumar, 2011).

Residualfraction: This fraction is concerned with the most stable and least bioavailable chemical fraction of soil (Kumar,2011), since metal is occluded with crystallized oxide. Residual fraction is a major carrier of metals in soil and sediment. The lower the concentration of metals present in this fraction the greater the pollution of the environment. In this study, level of metal in soil amended with PD+PDB is mostly found in residual phase (Table 9 - Table 23) followed by PDB,PD and control. Thrift of metals from exchangeable to residual fraction might be due to the synergistic effect PD+PDB combination.

Table 24: Mobility of Cadmium, Chromium, Manganese, Lead and Arsenic in Soil and Amended Soil

Cadmium	**Control**	**PD**	**PDB**	**PD+ PDB**
Sample 1	0.39	0.38	0.37	0.36
Sample 2	0.42	0.39	0.39	0.38
Sample 3	0.45	0.39	0.34	0.33

Chromium	**Control**	**PD**	**PDB**	**PD+ PDB**
Sample 1	0.39	0.38	0.38	0.36
Sample 2	0.39	0.38	0.38	0.37
Sample 3	0.36	0.35	0.31	0.30

Manganese	**Control**	**PD**	**PDB**	**PD+ PDB**
Sample 1	0.40	0.39	0.38	0.38
Sample 2	0.39	0.38	0.38	0.37
Sample 3	0.38	0.37	0.37	0.36

Lead	**Control**	**PD**	**PDB**	**PD+ PDB**
Sample 1	0.40	0.39	0.38	0.38
Sample 2	0.39	0.38	0.38	0.37
Sample 3	0.38	0.37	0.37	0.36

Arsenic	**Control**	**PD**	**PDB**	**PD+ PDB**
Sample 1	0.39	0.39	0.38	0.37
Sample 2	0.40	0.39	0.39	0.31
Sample 3	0.40	0.39	0.39	0.38

Mobility Factor

Total level of metal in soil is not a good indication of the potential risk of contaminated soil to human and environmental receptor (Okieimen and Ilori, 2014).Metal mobility is among the indices used evaluate the potential risk of metal in contaminated soil. Metal mobility is expressed as mobility factor (MF) (Kabala and Singh, 2001),

$$MF = \frac{exch.+carb.}{exch.+carb.+Fe-Mnoxide+org.+res.}$$

High mobility of results has been earlier reported and indices of relative high liability and bioavailability of metal in soil. Results of MF shown Table 24 indicates that amended soil of all the sample have lower Mf value.The lower value of PD+PDB may be due to the high pH of PDB and high organic matter of PD. Pooling the PD and PDB physicochemical properties together enhance the immobility of the metals. The MF result suggest that PD+PDB combination is the best amender for metal contaminated soil. Low mobility results have been earlier reported as an index of relative low reliability and bioavalability of metals in soil (Ugbune*et al*., 2018).

Table 25: Level of Cr, Cd, Pb, Mn and Asin Okra shoot after 6 weeks of Planting on Soil Amended with PD, PDB and PD+PDB for Sample 1

Parameter	Control	PD	PDB	PD+ PDB
Cr	1.05	0.98	0.94	0.84
Cd	1.07	0.97	0.95	0.82
Pb	05	0.2	0.09	0.03
Mn	1.04	0.84	0.74	0.70
As	0.05	0.03	0.02	BDL

Table 26: Level of Cr, Cd, Pb, Mn and As in Okra shoot after 6 weeks of Planting on Soil Amended with PD, PDB and PD+PDB for Sample 2

Parameter	Control	PD	PDB	PD+ PDB
Cr	1.06	0.94	0.79	0.70
Cd	1.04	0.98	0.95	0.92
Pb	0.92	0.42	0.40	0.38
Mn	0.94	0.52	0.46	0.40
As	0.82	0.62	0.41	0.36

Table 27: Level of Cr, Cd, Pb, Mn and Asin Okra shoot after 6 weeks of Planting on Soil Amended with PD, PDB and PD+PDB for Sample 3

Parameter	Control	PD	PDB	PD+ PDB
Cr	0.46	0.10	0.09	0.06
Cd	0.10	0.05	0.03	0.10
Pb	1.06	0.85	0.62	0.52
Mn	1.02	1.00	095	0.81
As	0.58	0.41	0.38	0.37

Concentration of Chromium, Cadmium, Lead, Manganese and Arsenic on Okra plant after Weeks of Planting on Soil AmendedPD, PDB and PD+PDB

The incorporation of biochar amendment to improve the phsico-chemical properties of soils (Ugbune and Okuo, 2019), uptake of plant (Okuo*et al*., 2014) and make it possible for vegetation to be established

(Sigua *et al.*, 2019). The analysis of okra plant after PD, PDB and PD+PDB application (Table 25 – 27) show a lower value of metal in plant when compared with control sample. PD+PDB amendment have lower concentration of metals in okra shoot of all the sample (PD+PDB<PDB<PD<control). The lower concentration of metal observed inokrashoot treated with PD+PDB may be due to the synergistic effect of PD and PDB combination. These properties may have aided the adsorption and the immobility of metal in soil solution;therefore, the metal will not be available for plant uptake(Lehman*et al.*, 2003).Okuo, 2014 earlier reported that addition of palm kernel shell biochar to soil have promoted the immobilization or decrease in bioavalability of metal in plant.

Conclusion

This study revealed that PD and PDB is rich in nutrients. Poultry dropping and poultry dropping biochar combination in soil treatment influences the physicochemical properties. It decreases the level inorganic contaminant and mobility in soil. It alsoincreases inorganic contaminant concentration in the reduceable fraction (bioavalable) of soil. The PD, PDB and its combination also reduces the concentration of metals in okra shoot (PD+PDB >PDB > PD). Therefore, this study revealed that PD+ PDB is more effective in the remediation of inorganic contaminant.

References

Anegbe, B., Okuo, J.M., Okieimen, F.E., Ugbune, U and Emina, R.A (2019). Levels of heavy metals in soil sample from active automobile workshops in Benin City. *International Journal of Environmental Chemistry, 3(1): 7-17.*

Asensio, V., Vega, F.A., Andrade, M.L., Covelo, E.F. (2013). Technosols made of wastes to improve physic-chemical characteristics of copper mining soils. *Pedosphere, 23: 1-9.*

Bhatta, S.C (2002). Environmental chemistry. CBS publisher and distributor, New Delhi.

Black, G.R. (1965). Particle Density Methods of soil analysis, part I. In: C. A. Black (ed) American Society of Agronomy monograph No. 9.

Bouyoucos, G.J. (1962). Hydrometer method improved for particle- size analysis of soil. *Agro. J.54: 464-5967*

Bray, R.M and Kurtz, L.T. (1945). Determination of total organic and available form of phosphorus in soil. *Soil science, 56: 39-45*.

Chan, K, Xu Z. (2009). Biochar: Nutrient Properties and Their Enhancement. In 'Biochar for Environmental Management: Science and Technology'. (Eds J Lehmann and S Joseph) pp. 53-66. (Earthscan: London, UK)

Day, P.R. (1965). Particle fractionation and particle size analysis. CA Black (Ed) method of soil Analysis part I. Soil Science America

Hazelton, P.A and Murphy, B.W (2007). Interpreting soil test results: what do all the numbers mean? CSIRO Publishing, Collingwood, 17.

Horsfall Jr, M and Ayebami, S.A (2005). European of sci res. 6(3): 20-36.

IITA (1979). Selected methods for soil and plant analysis manual series No. 1, 10.

Jackson, M.L. (1962). Soil chemical Analysis prentice-Hall, Englewood Cliff, NJ.

Kabala, C., and Singh, B.R. (2001). Fractionation and Mobility of Copper, Lead and Zinc in Soil profiles in the vicinity of a copper smelter, *J. environ. Qual, 30: 845-492.*

Kumar, B., Kumar, S., Misha, M., Singh, S.K., Dev, P., Sharma, C.S and Mukherjee (2011). Geochemical fractionation of some heavy metal in soil in the vicinity of Sukinda mining area, Orissa, 2(5): 263-272.

Lehman, J (2007). Handful of carbon, Nature, 447, 143-144

Lehmann, J. (2007). Bio-energy in the black, Frontiers in Ecology and the Environment, 5:381 – 387

Lehmann, J. and Joseph, S. (eds.). (2009). Biochar for Environmental Management: Science and

Technology. Earthscan, London & Sterling, VA. 416.

Lehmann, J. and Rondon, M. (2006). Bio-char soil management on highly weathered soils in the humid tropics. In Biological Approaches to Sustainable Soil Systems Ed. N. Uphoff. CRC Press, Boca Raton, FL, 517-530.

Lehmann, J. and Sohi, S. (2008). Comment on "Fire-derived charcoal causes loss of forest humus". Science. 321:1295c-. Lehman, J., Gaunt, J. Rondon, M. 2006. Biochar sequestration in terrestrial ecosystems – a review. Mitig. Adapt. Strat. Global Change 11: 403-4

Lehmann, J., Da Silva Jr., J.P, Stener, C., Nehls, T., Zech, W. and Glasser, B. (2003b). Nutrient availability and leaching in an archaelogificalanthrosol and a fertilizer in the central Amazon Basin: Fertilizer, Manure and Charcoal Amendments. Plant and Soil, 249: 343-357.

Lehmann, J., Gaunt, J. and Rondon, M. (2006). Bio-char Sequestration in Terrestrial Ecosystems –A Review. Mitigation and Adaptation Strategies for Global Change. 11:395-419.

Lehmann, J., Solomon, D., Kinyangi, J., Dathe L., Wirick, S. and Jacobsen, C. (2008). Spatial complexity of soil organic matter forms at nanometre scales. *Nature of Geoscience, 1: 238-242*.

Medynska-Juraszek, A and Cwielag-Piaske, C. (2020). Effect of biochar application on heavy metal mobility in soils impacted by Cu smelting process. *Pol. J. Environment*, 29:(29) 1749-1757.

Nelson, D. W. and Sommers, L.E. (1982). Total Carbon, Organic carbon, and organic matter. In-page, A.L., Miller, R.H and Kenergy D.R (Eds) method of soil Analysis. Part 2; America Society of Agronomy, Madison, Wisconsin, 539-579.

Okieimen, F.E and Ilori, E. (2014). Chelant extraction of heavy metals for the remediation of CCA contaminated soil.Geoenvironment& Climate change Adaptation, 3:1-34.

Okuo, J.M., Ewakey, E.O., Okieimen, F.E., Ogbeifun, D.E and Anegbe, B. (2014). Effect of biochar application on soil nutrient and heavy metal availability to okra plant. *Nigeria journal of applied science, 32: 162-173.*

Onder, S., Dursun, S., Gezgin, S. and Demirbas, A. (2007). Determination of heavy metal pollution is grass and soil of city centre green areas Kenya, Turkey. *Polish Journal of Environmental Studies 16 (1): 145-154.*

Sigua, G.C., Novak, J.M., Watts. D.W., Ippolito, J.A., Ducey,T.F (2019). Photostabilization of Zn and Cd in min soli using corn in combination with biochar and manure- base compost environment.

Tessier, A, Campbell, P.G.C, and Bisson, M. (1979). Sequential extraction procedure for the speciation of particulate trace metals. Anal. Chem. 51: 844-851.

Trakal, L., Komarek, M. SZakova, J., Zemanova, V. and Tlustos, P. (2011) Biochar application to metal contaminated soil. Evaluating Cd, Cu, Pb and Zn sorption behavior using single –and multi- element sorption experiment. *Plant Soil Env., 57*(8): 372-280.

Ugbune,U and Okuo, J.M. (2019). Effect of Carbonised sawdust briquette on the nutrient status of dumpsite soils. *Nigerian journal of Applied Science, 37: 1-11.*

Ugbune, U., Okuo, J.M and Idu,T.E (2018). Impact of carbonized briquette on the fractionation of trace metals in dumpsite soils. *Chemical Science International Journal, 25 (2):1-8.*

Wuana, R.A.,Okiemen, F.E, and Imoborvungu, J.A. (2010). Removal of heavy metals from a contaminated soil using organic chelating acids. *Int. Journal of Environmental Sc. Tech., 7(3): 485-496.*