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Research Article

Speciation of Some Heavy Metals as Influenced by Poultry Manure Application in Dumpsite Soils

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Abstract

Background and Objective: Dumpsites soils are known to contain high concentrations of heavy metals that could move through the food chain from consumption of vegetables and crops harvested from this site hence a study was conducted to determine the effect of poultry manure on fractions of some heavy metals (Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni) in six dumpsite soils. **Materials and Methods:** Soil: Manure mixture at 10:1 was incubated for 4 weeks in the laboratory. Soil pH, electrical conductivity (EC), organic manure (OM). Exchangeable Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni were extracted with 0.1 M $CaCl_2$, Fe-Mn oxide bound Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni were extracted with 1 M NH_4NO_3, carbonate bound Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni were extracted with 0.05 M EDTA solution and available Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni were extracted with distilled water, respectively. The soil suspension was centrifuged and Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni in the filtrate were determined with atomic absorption spectrophotometer. **Results:** Application of poultry manure increased pH by 1%, EC by more than 900% and OM. The order of abundance of the fractions was carbonate bound >Fe-Mn oxides bound >exchangeable >available. Application of organic manure resulted in reduction in the available Zn, carbonate bound Cu, Zn, Ni, Cr, exchangeable Zn, Fe and oxide-bound Zn, Pb, Cd. **Conclusion:** Application of amendment could mitigate the threat of food chain contamination by decreasing metal concentration in the soil.

Key words: Heavy metal fractions, soil contamination, dumpsites soils, organic manure, food chain contamination, poultry manure

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The problem and major environmental concerns associated with the disposal of industrial dumpsite and urban wastes generated by human activities is the contamination of the soil[1]. It is important to note that continuous disposal of municipal waste on soil may lead to increase in heavy metals in the soil and surface water[2]. Heavy metals such as manganese, iron, zinc, copper, cadmium, lead, chromium and nickel are of concern primarily because of their ability to harm soil organisms, plants, animals and human beings[3]. However, the fate and transport of a heavy metal in soil depends significantly on the chemical form and speciation of the metal. Elevated levels of heavy metals in soils depend not only on heavy metal contents in soils but on soil pH value, organic matter, clay contents and fertilization[4].

Insitu stabilization of heavy metals in the urban soil is considered a promising alternative remediation path used to reduce mobility of the heavy metals in the soil by adding immobilizing agents. Addition of organic matter amendments, such as compost, fertilizers and wastes, is a common practice for immobilization of heavy metals and soil amelioration of contaminated soils. Khan *et al.*[5] showed that amendment of contaminated soils with organic matter reduced bio-availability of heavy metals. The utilization of poultry manure as an organic fertilizer is essential for improving soil productivity and crop production. Poultry litter has been applied to agricultural soils for decades as an organic fertilizer, because it is a good source of plant nutrients. Addition of poultry manure to soils not only helps to overcome the disposal problems but also enhances the physical, chemical and biological fertility of soils[6].

Studies have shown that municipal refuse may increase heavy metal concentration in soil and underground water[7] which may have effects on the host soils, crops and human health. A major problem with land disposal system is the lack of appropriate waste management practices like proper waste handling, sorting and recycling thereby creating more unmanaged dumpsites. These dumpsites have high fertility status due to high organic matter, their use for cultivation of vegetables and arable crops have been essential since increased population caused advancement in food and fiber production for human consumption. However, municipal dumpsites are known to contain high concentrations of heavy metals that could move through the food chain from consumption of vegetables and foods harvested from this site. However, addition of poultry manure has been shown to improve the fertility of cultivated soil by increasing the organic matter content[8], metal chelation and hence reduce metal bio-availability. The ameliorative effects of poultry manure on Cd toxicity as been investigated by Azeez *et al.*[9]. Abdus-Salam[10] assessed the heavy metals pollution in Dumpsites in Ilorin Metropolis. Erinle *et al.*[11] investigated the effect of Manure Compost on chromium and nickel translocation and bio-availability in soils from an old municipal dumpsite. Shokalu *et al.*[12] evaluated the adsorption of cadmium as Influenced by Poultry Manure addition in Soils of south-western Nigeria. However, information on effect of poultry manure addition on speciation of heavy metals in various dumpsites soil is lacking, hence, the need for this study. The objectives of the study were therefore (a) To assess some chemical properties (pH, EC, OM) and heavy metal fractions (Fe, Mn, Zn, Pb, Cu, Cr, Ni and Cd) of six dumpsites soil (industrial dumpsite, small market, large market, municipal, auto-mechanic and abattoir dumpsites) and (b) To determine the effect of poultry manure on pH, EC, OM and heavy metal fractions (Fe, Mn, Zn, Pb, Cu, Cr, Ni and Cd) of the dumpsites soils (industrial dumpsite, small market, large market, municipal, auto-mechanic and abattoir dumpsites).

MATERIALS AND METHODS

Experimental site: The experiment was carried out at the laboratory of Soil Science and Land Management, Federal University of Agriculture, Abeokuta, Ogun state, Nigeria. The experiment commenced from June-October, 2016.

Study location: Six different dumpsites were selected within Ogun state based on human activities occurring around each dumpsite. The dumpsites included industrial dumpsite, small market, large market, municipal, auto-mechanic and abattoir dumpsites. The auto-mechanic dumpsite is located in a mechanic workshop, abattoir dumpsite contained waste from the slaughter slab, animal parts and other wastes and municipal dumpsite contained several household wastes. The industrial dumpsite is located at an industrial dumpsite estate and the market dumpsites contain waste from the various activities in the market.

Soil collection and analysis: Top soil samples at 0-20 cm depth were collected from the selected dumpsites using an auger in a zigzag pattern, collected samples were then bulked to make composite samples. The samples were air-dried and sieved with 2 mm mesh sieve. Sub-samples from the sieved soil samples were collected and analyzed for the following properties: Soil pH was estimated in 1:2 (soil: water) using glass electrode pH meter after which 20 mL of water was added into 10 g of soil shaken with mechanical shaker for 30 min[13]. Electrical conductivity was estimated in 1:5 (soil: water) with a calibrated EC meter after which 50 mL of water was added into 10 g of soil shaken with mechanical shaker for 30 min. Organic matter was determined according to Walker-Black[14].

Manure collection: Poultry manure was collected from the poultry farm of the College of Animal Science and Livestock production at the Federal University of Agriculture, Abeokuta. Collected manure was air dried to constant weight and homogenized with a hammer mill.

Incubation experiment: The experiment was laid in completely randomized design (CRD) with three replicates. Soils were incubated with poultry manure at a ratio of 10:1 soil: manure mixture. About 500 g of prepared soil sample were weighed into sample plastics with tight-fitting lids and 50 g of manure was added and mixed thoroughly with the soil sample. Distilled water was added to the soil: Manure mixture and the plastics were covered with perforated lids to allow for aeration. The soil: Manure mixtures were incubated for 4 weeks for mineralization to take place. At 4 weeks after incubation, soil samples were collected from the incubation mixture and analyzed for their soil exchangeable, Fe-Mn oxide bound, carbonate bound and available Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni contents. Exchangeable Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni were extracted with 0.1 M $CaCl_2$, Fe-Mn oxide bound Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni were extracted with 1 M NH_4NO_3, carbonate bound Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni were extracted with 0.05 M EDTA solution and available Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni were extracted with distilled water, respectively. This involved weighing 5 g of the incubated soil into a 100 mL centrifuge bottle after which 50 mL of the extracting solutions were added accordingly and shaken for 1 h using a mechanical shaker. The soil suspension was centrifuged and Fe, Mn, Cu, Pb, Zn, Cd, Cr and Ni in the filtrate were determined with atomic absorption spectrophotometer.

Statistical analysis: Data collected were subjected to analysis of variance (one way ANOVA) using[15] and means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

Characteristics of dumpsite soils: The characterization of dumpsites is shown on Table 1. The highest pH was recorded in auto-mechanic dumpsite although this was similar to the pH of Abattoir dumpsite. Municipal dumpsite, small market dumpsite and large market dumpsite had similar pH that was significantly lower than the other two sites. The electrical conductivity ranged from 0.572-0.635 dS m^{-1} in abattoir dumpsite and auto-mechanic dumpsite, respectively. Small market dumpsite had the highest organic matter content. Significantly, lower content of OM was found in the auto-mechanic dumpsite, large market dumpsite and industrial dumpsite.

Heavy metal fractions of dumpsite soils: Heavy metal fractions in dumpsites are shown in Table 2. Carbonate-bound fractions were higher in the dumpsites than the other heavy metal fractions. Auto-mechanic village and small market dumpsite had significantly higher carbonate-bound Mn than

Table 1: Some initial characteristics of dumpsite soil

Dumpsites	pH	EC (ds m^{-1})	OM (%)
Auto-mechanic	8.03^a	0.635^a	2.41^c
Municipal	7.43^c	0.573^a	5.69^b
Abattoir	7.97^{ab}	0.572^a	4.93^a
Small market	7.40^c	0.580^a	8.93^a
Large market	7.58^c	0.577^a	2.64^c
Industrial	7.80^b	0.632^a	1.93^c

Means with the same letter are not significantly different at $p \leq 0.05$

Table 2: Carbonate-bound and Fe-Mn bound heavy metals species in dumpsites

	Carbonate-bound (mg kg^{-1})								Fe-Mn bound (mg kg^{-1})							
Dumpsites	Mn	Fe	Cu	Pb	Zn	Cd	Cr	Ni	Mn	Fe	Cu	Pb	Zn	Cd	Cr	Ni
Auto-mechanic	232.19^a	501.85^c	16.44^b	241.08^a	47.17^b	0.25^c	0.01^b	0.88^{cd}	5.76^a	0.44^a	0.73^a	1.20^{ab}	0.52^{bc}	0.01^a	0.01^a	0.01^a
Municipal	106.98^d	508.27^c	5.49^c	13.08^c	51.42^b	0.13^d	0.01^b	0.76^d	2.30^b	0.82^a	0.28^a	1.55^{ab}	6.32^a	0.02^a	0.01^a	0.01^a
Abattoir	152.98^c	915.19^a	5.15^a	8.09^c	87.33^b	0.14^d	0.01^b	0.99^c	2.23^b	0.17^a	0.21^a	0.89^b	0.57^{bc}	0.01^a	0.01^a	0.01^a
Small market	233.55^a	552.12^c	32.34^a	40.03^c	130.96^a	0.45^a	0.01^b	1.98^a	1.92^b	0.69^a	0.81^a	0.16^{ab}	0.77^{bc}	0.01^a	0.01^a	0.01^a
Large market	181.16^b	766.86^{ab}	7.13^c	103.17^b	73.27^b	0.35^b	0.13^a	1.20^b	1.56^b	1.05^a	3.78^a	0.66^b	0.31^c	0.01^a	0.17^a	0.48^a
Industrial	50.38^e	651.91^{bc}	33.21^a	147.14^b	78.62^b	0.36^b	0.04^b	0.87^{cd}	1.03^b	0.29^a	0.84^a	2.16^a	2.50^{abc}	0.02^a	0.01^a	0.01^a

Means with the same letter are not significantly different at $p \leq 0.05$

Table 3: Exchangeable and available heavy metals fractions in dumpsites

	Exchangeable ($mg\ kg^{-1}$)								Available ($mg\ kg^{-1}$)							
Dumpsites	Mn	Fe	Cu	Pb	Zn	Cd	Cr	Ni	Mn	Fe	Cu	Pb	Zn	Cd	Cr	Ni
Auto-mechanic	2.318[a]	0.011	0.24[b]	0.12[a]	0.21[a]	0.01	0.01	0.01	0.116	2.346[ab]	0.43[a]	0.15[a]	0.41b	0.01	0.01	0.01
Municipal	0.188[b]	0.011	0.12[b]	0.10[a]	0.26[a]	0.01	0.01	0.01	0.003	0.665[ab]	0.15[a]	0.15[a]	0.33b	0.01	0.01	0.01
Abattoir	0.650[b]	0.017	0.16[ab]	0.13[a]	0.22[a]	0.01	0.01	0.01	0.106	6.822[a]	0.16[a]	0.15[a]	0.41b	0.01	0.01	0.01
Small market	0.059[b]	0.014	0.22[a]	0.10[a]	0.30[a]	0.01	0.01	0.01	0.167	2.063[ab]	0.48[a]	0.15[a]	0.72b	0.01	0.01	0.01
Large market	0.344[b]	0.017	0.12[a]	0.12[a]	0.12[b]	0.01	0.01	0.01	0.003	0.053[b]	0.19[a]	0.15[a]	0.46b	0.01	0.01	0.01
Industrial	0.120[b]	0.108	0.22[a]	0.13[a]	0.16[b]	0.01	0.01	0.01	0.003	0.458[b]	0.21[a]	0.15[a]	0.29b	0.01	0.01	0.01
		ns				ns	ns	ns	ns					ns	ns	ns

Means with the same letter are not significantly different at $p\leq0.05$, ns: Not significant

Table 4: Effect of poultry manure on selected chemical properties of dumpsite

Dumpsites	Treatments	pH	EC ($ds\ m^{-1}$)	OM (%)
Auto-mechanic	With poultry manure	8.00[a]	1.21[a]	3.30[cde]
Auto-mechanic	Without poultry manure	8.06[a]	0.06[e]	1.51[e]
Small market	With poultry manure	8.00[a]	1.05[c]	3.80[cde]
Small market	Without poultry manure	7.93[b]	0.09[de]	2.91[de]
Municipal	With poultry manure	7.36[b]	1.05[c]	5.34[cd]
Municipal	Without poultry manure	7.50[b]	0.09[de]	6.03[bc]
Large market	With poultry manure	7.60[b]	1.06[c]	2.84[de]
Large market	Without poultry manure	7.56[b]	0.09[de]	2.43[de]
Industrial	With poultry manure	7.56[b]	1.14[b]	2.22[e]
Industrial	Without poultry manure	8.00[a]	0.13[d]	1.22[e]
Abattoir	With poultry manure	7.36[b]	1.07[c]	9.52[a]
Abattoir	Without poultry manure	7.43[b]	0.10[d]	8.35[ab]

Means with the same letter are not significantly different at $p\leq0.05$

the other dumpsites, the least was recorded in industrial dumpsite with a value of 50.38 $mg\ kg^{-1}$. The order of carbonate-bound Pb was in the order of auto-mechanic dumpsite >industrial dumpsite: Large market dumpsite>small market dumpsite: Municipal dumpsite: Abattoir dumpsite. Significantly, higher amount of carbonate-bound Zn, Cd and Ni was found in small market dumpsite. There was no significant difference in the Fe-Mn oxide bound Fe, Cu, Cd, Cr and Ni (Table 2). Exchangeable Mn did not differ in all the dumpsites except auto-mechanic dumpsite (Table 3). The highest amount of exchangeable Mn was recorded in auto-mechanic dumpsite with value significantly higher than other dumpsites.

Effect of poultry manure on chemical characteristics of dumpsite soil: The data in Table 4 shows the effect of poultry manure on some chemical characteristics of the dumpsites. The pH of all the dumpsites except small market and industrial dumpsite did not differ after poultry manure addition. Although, the pH of most of the dumpsite slightly reduced after the addition of organic amendment. In small market and industrial dumpsite, the soil pH increased by 1% (8.00) and decreased by 5% (7.56), respectively after the addition of poultry manure. There was significant increase in the EC of all the dumpsites after amendment with poultry manure. The electrical conductivity of all the sites increased by more than 900% after amendment incorporation. Organic matter increased significantly in all the treated dumpsites except municipal dumpsite where a significant reduction of 11% (6.03-5.34%) was observed after poultry manure was applied. With the application of poultry manure, the organic matter significantly increased in auto-mechanic dumpsite (3.30%), small market dumpsite (3.80%) and abattoir dumpsite (9.52%), respectively.

Effect of poultry manure on heavy metal fractions of dumpsite soils: There was no significant difference in amount of available Mn, Pb and Fe before and after poultry manure additions in dumpsites as shown in Table 5. Available Cu was significantly increased in auto-mechanic dumpsite and small market dumpsite while in other dumpsites. In all the dumpsites except industrial dumpsite and large market dumpsite, application of poultry manure reduced Zn. In industrial dumpsite treated with poultry manure, exchangeable Fe reduced significantly by 99% when compared to untreated soil. For Cu, only the poultry manure treated dumpsite of auto-mechanic dumpsite and industrial dumpsite differed from their untreated dumpsite. The application of poultry manure to dumpsite of auto-mechanic dumpsite and industrial dumpsite significantly increased the amount of exchangeable Cu. Incorporation of poultry manure to dumpsite of auto-mechanic dumpsite, small market

Table 5: Effect of poultry manure on available and exchangeable forms of heavy metal in dumpsites

Dumpsites	Treatments	Available (mg kg^{-1})								Exchangeable (mg kg^{-1})							
		Mn	Fe	Cu	Pb	Zn	Cd	Cr	Ni	Mn	Fe	Cu	Pb	Zn	Cd	Cr	Ni
Auto-mechanic	With poultry manure	0.120	1.330	0.72^{a}	0.15	0.31^{c}	0.002	0.003	0.001	4.35^{a}	0.008^{ab}	0.32^{a}	0.12	0.18^{d}	0.002	0.003^{b}	0.001
Auto-mechanic	Without poultry manure	0.110	3.361	0.15^{b}	0.15	0.51^{bc}	0.002	0.003	0.001	0.28^{c}	0.015^{ab}	0.15^{cde}	0.11	0.23^{bcd}	0.002	0.003^{b}	0.001
Small market	With poultry manure	0.210	6.221	0.80^{a}	0.15	0.64^{ab}	0.002	0.003	0.001	1.23^{b}	0.021^{ab}	0.31^{a}	0.08	0.18^{d}	0.002	0.003^{b}	0.001
Small market	Without poultry manure	0.003	7.422	0.16^{b}	0.15	0.80^{a}	0.002	0.003	0.001	0.07^{c}	0.014^{ab}	0.31^{a}	0.12	0.42^{a}	0.002	0.003^{b}	0.001
Municipal	With poultry manure	0.003	1.020	0.19^{b}	0.15	0.22^{c}	0.002	0.003	0.001	0.28^{c}	0.015^{ab}	0.14^{cde}	0.07	0.21^{cd}	0.002	0.003^{b}	0.001
Municipal	Without poultry manure	0.003	0.310	0.11^{b}	0.15	0.44^{bc}	0.002	0.003	0.001	0.10^{c}	0.008^{ab}	0.10^{cde}	0.12	0.30^{bc}	0.002	0.003^{b}	0.001
Large market	With poultry manure	0.003	0.102	0.29^{b}	0.15	0.44^{bc}	0.002	0.003	0.001	0.65^{bc}	0.021^{ab}	0.14^{cde}	0.08	0.24^{bcd}	0.002	0.003^{b}	0.001
Large market	Without poultry manure	0.003	0.003	0.29^{b}	0.15	0.44^{bc}	0.002	0.003	0.001	0.04^{c}	0.014^{ab}	0.14^{cde}	0.08	0.24^{bcd}	0.002	0.035^{ab}	0.001
Industrial	With poultry manure	0.003	0.912	0.29^{b}	0.15	0.33^{bc}	0.002	0.003	0.001	0.10^{c}	0.002^{b}	0.25^{b}	0.15	0.18^{d}	0.002	0.101^{a}	0.001
Industrial	Without poultry manure	0.003	0.003	0.12^{b}	0.15	0.24^{c}	0.002	0.003	0.001	0.14^{c}	0.215^{a}	0.19^{c}	0.11	0.13^{d}	0.002	0.003^{b}	0.001
Abattoir	With poultry manure	0.221	4.122	0.19^{b}	0.15	0.36^{bc}	0.002	0.003	0.001	0.11^{c}	0.014^{ab}	0.15^{cde}	0.11	0.20^{cd}	0.002	0.003^{b}	0.001
Abattoir	Without poultry manure	0.112	0.003	0.13^{b}	0.15	0.46^{bc}	0.002	0.003	0.001	0.01^{d}	0.114^{a}	0.16^{cd}	0.15	0.23^{bcd}	0.002	0.005^{ab}	0.001
		ns	ns		ns		ns	ns	ns				ns		ns		ns

Means with the same letter are not significantly different at $p \leq 0.05$

dumpsite, municipal dumpsite and abattoir led to significant reduction in the amount of exchangeable Zn by 22, 57, 30 and 13%, respectively.

The results in Table 6 shows the effect of poultry manure on carbonate-bound and Fe-Mn oxide bound extractable heavy metals in the dumpsites. A significant increase of 560% and decrease of 17% in Fe-Mn oxide bound Mn was observed in large market dumpsite and industrial dumpsite, respectively after the application of organic manure. However, poultry manure was able to reduce Ni and Cr in large market dumpsite in comparison with the initial concentration in the dumpsite while it only encouraged an abrupt increase of more than 50 times the initial concentration of Cu in the treated dumpsite. Carbonate-bound Ni was significantly reduced with the application of poultry manure in small market dumpsite and industrial dumpsite. Carbonate-bound Zn did not differ in untreated and treated dumpsites except in small market dumpsite where a 62% reduction was observed following the application of organic manure. The Cd content of all the dumpsite was not affected with the incorporation of poultry manure, although significant increase and reduction was only recorded in the treated dumpsites of small market dumpsite and industrial dumpsite. A significant increase and decrease in Fe was recorded in auto-mechanic dumpsite and industrial dumpsite respectively after treatment with poultry manure.

DISCUSSION

The pH of the dumpsite ranged from slightly to moderately alkaline, organic matter ranged from moderately high to very high. Small market dumpsite and municipal dumpsite are popular markets and hence it is expected of their dumpsite to have high OM because of constant enrichment with highly carbonaceous plant and waste matter. Ayolagha and Onwugbata[16] demonstrated that high OM (>2.0%) in soils is conducive for heavy metal chelation formation. The order of mobility of the metals based on their abundance in the fractions is carbonate bound> Fe-Mn oxide bound >exchangeable >available. The distribution of metal among specific forms varies widely based on the metal's chemical properties and soil characteristics[17]. The reason for the high carbonate-bound heavy metals in the dumpsites could be attributed to the fact that most of the heavy metals were in association with carbonate salts. The non-significant difference in water available Cd, Cr, Ni, Cu Pb and Zn in all dumpsites could be attributed to the insolubility and immobility as a result high pH of the dumpsites. The mobility of heavy metals depend on soil organic matter and pH[18],

Table 6: Effect of poultry manure on carbonate bound and Fe-Mn bound forms of heavy metal in dumpsites

		Carbonate bound (mg kg^{-1})								Fe-Mn bound (mg kg^{-1})							
Dumpsites	Treatments	Mn	Fe	Cu	Pb	Zn	Cd	Cr	Ni	Mn	Fe	Cu	Pb	Zn	Cd	Cr	Ni
NiAuto-mechanic	With poultry manure	219.63^{a}	632.55^{bcd}	13.33^{d}	170.64^{b}	52.15^{b}	0.113^{e}	0.003^{c}	0.44^{fg}	6.61^{a}	0.76	0.92^{b}	1.50^{a}	0.51	0.002	0.003^{b}	0.001^{b}
Auto-mechanic	Without poultry manure	244.73^{a}	321.15^{f}	19.55^{c}	311.52^{a}	42.18^{b}	0.136^{de}	0.003^{c}	0.44^{fg}	4.90^{ab}	0.12	0.53^{b}	0.89^{a}	0.54	0.002	0.003^{b}	0.001^{b}
Small market	With poultry manure	149.41^{d}	994.98^{a}	29.42^{b}	33.33^{de}	71.79^{b}	0.243^{a}	0.003^{c}	0.91^{b}	3.21^{cd}	0.11	1.28^{b}	0.72^{a}	0.73	0.002	0.003^{b}	0.001^{b}
Small market	Without poultry manure	156.56^{cd}	835.40^{ab}	39.23^{a}	46.74^{de}	190.13^{a}	0.210^{b}	0.003^{c}	1.06^{a}	1.25^{cde}	0.22	0.35^{b}	0.63^{a}	0.81	0.002	0.003^{b}	0.001^{b}
Municipal	With poultry manure	109.69^{e}	521.13^{de}	5.56^{e}	11.61^{e}	55.44^{b}	0.060^{f}	0.003^{c}	0.39^{gh}	2.91^{cd}	0.71	0.19^{b}	1.17^{a}	5.93	0.004	0.003^{b}	0.001^{b}
Municipal	Without poultry manure	104.27^{e}	495.41^{e}	5.42^{e}	14.54^{e}	47.40^{b}	0.073^{f}	0.003^{c}	0.36^{h}	1.68^{cde}	0.94	0.20^{b}	1.93^{a}	6.71	0.011	0.003^{b}	0.001^{b}
Large market	With poultry manure	177.54^{bc}	815.85^{b}	4.66^{e}	87.25^{dc}	59.91^{b}	0.166^{c}	0.003^{c}	0.57^{cd}	2.71^{cd}	0.01	7.43^{a}	0.63^{a}	0.37	0.002	0.003^{b}	0.001^{b}
Large market	Without poultry manure	184.77^{b}	717.86^{bc}	4.66^{e}	87.25^{dc}	59.91^{b}	0.183^{bc}	0.123^{a}	0.63^{c}	0.41^{e}	2.08	0.13^{b}	0.70^{a}	0.25	0.008	0.162^{a}	0.476^{a}
Industrial	With poultry manure	55.73^{f}	461.24^{ef}	31.40^{b}	168.15^{b}	78.41^{b}	0.163^{cd}	0.003^{c}	0.40^{gh}	0.94d^{e}	0.57	1.00^{b}	2.13^{a}	2.65	0.008	0.003^{b}	0.001^{b}
Industrial	Without poultry manure	45.03^{f}	842.58^{ab}	35.03^{ab}	126.14^{bc}	78.84^{b}	0.200^{b}	0.041^{b}	0.47^{ef}	1.13^{cd}	0.01	0.69^{b}	2.20^{a}	2.34	0.014	0.003^{b}	0.001^{b}
Abattoir	With poultry manure	232.77^{a}	532.15^{de}	5.38^{e}	8.03^{e}	91.53^{b}	0.066^{f}	0.003^{c}	0.51^{de}	2.05^{cd}	0.05	0.23^{b}	0.69^{a}	3.55	0.002	0.003^{b}	0.001^{b}
Abattoir	Without poultry manure	234.33^{a}	572.09^{cde}	4.93^{e}	8.15^{e}	83.13^{b}	0.073^{f}	0.001^{c}	0.47^{ef}	1.79^{cde}	0.87	0.19^{b}	1.09^{a}	7.85	0.002	0.003^{b}	0.001^{b}
											ns			ns	ns		

Means with the same letter are not significantly different at $p \leq 0.05$

increase in these soil properties with the application of manure could have consequently caused a decrease in heavy metal mobility.

Application of poultry manure enhanced a reduction in pH, this could be attributed to the production of organic acids like humic acid during mineralization of organic matter. This is similar to the findings of Pattanayak *et al.*[19] and Yaduvanshi[20], who also observed a decrease in soil pH after the use of organic materials. An increase in electrical conductivity was observed after incorporation of manures in the dumpsites. This is in agreement with the results of Azeez and van Averbeke[21], who found that electrical conductivity of soil significantly increases with the application of poultry manure. An increase in organic matter of the dumpsite is expected since organic manure such as poultry manure is known to increase organic matter of soils. This conforms to the result of Ojeniyi[22], who reported that increase in the levels of soil organic C and organic matter was expected since organic manures have the ability of increasing soil organic matter content.

Application of organic manure enabled a reduction in the levels of metals in the dumpsite. This is because organic amendments are able to immobilize metals in the soil, i.e., the transformation of the metals in the potentially available pools into forms in which they are less bio-available. Application of poultry manure increased the amount of water available and exchangeable Cu in auto-mechanic dumpsite and small market dumpsite. Cu is strongly bound to organic matter and the land application of organic matter-rich poultry manure is likely to result in the accumulation of such metals in soils[23]. Water available Zn content was greatly reduced in all the dumpsites. The main reason of deficiency of plant-available Zn in soil is the sediment or adsorption of Zn with various soil components, depending on the pH and redox potential[24]. The reduction in exchangeable Fe in industrial dumpsite treated with poultry manure is similar to the findings of Rostami and Ahangar[25] that found an increased Fe concentration significantly relative to the control in the exchangeable fraction and decrease in the carbonate-bound fraction following cattle manure application. The solubilization of organic matter could increase the Mn availability by providing a strong buffer for free Mn[26] this could have been the rationale for the abrupt increase in exchangeable Mn of auto-mechanic dumpsite, small market dumpsite and abattoir dumpsite. This is similar to the findings of Rostami and Ahangar[25], who observed an increase in the amount of exchangeable Mn after cattle manure application to soil.

The increase in Fe-Mn oxides fractions of Mn in industrial dumpsite agrees with Ehsan *et al.*[27], who showed that Mn has high contiguity for Fe-Mn oxides. In incubation studies, Sabir *et al*.[28] reported reduction of Mn with addition of activated carbon but DTPA extractable Mn increased with farmyard manure and poultry manure. The ameliorating ability of poultry manure to removal of Fe-Mn oxide bound Ni and Cr in large market dumpsite was 100%, carbonate bound Ni and Cr was reduced in small market dumpsite and industrial dumpsite. This is in contrast with the study of Barakat *et al*.[29], who found an increase in carbonate bound Ni after cow manure application in an incubation experiment. An increase in all fractions of Cu except carbonate bound was observed after poultry manure addition. Of Cu from poultry manure to the treated dumpsite thereby increasing Cu content. This is similar to the findings of Zheljazkov and Warman[30], who observed an increase in all fractions of Cu in soils amended with source separated municipal solid waste compost.

A reduction was observed for carbonate bound Zn, this may be because calcium carbonate acts as a strong absorbent for heavy metals and could complex as double salts like $CaCO_3$ and MCO_3. This is similar to the findings of Rostami and Ahangar[25], who observed reductions in the percentage of exchangeable Zn/amount of Zn bond to carbonates fractions following additions of cow manure. Soil characteristics also play a major role in the ameliorative capacity of poultry manure in Fe-polluted soil. This is deduced from the result of this study as an increase in carbonate bounded Fe content was observed in soils with lower pH while in soils with higher pH, poultry manure incorporation caused a reduction in carbonate bound Fe. The decrease in carbonate bound Cd content after poultry manure addition could be explained by the high cation exchange capacity of organic matter and its ability to form chelate complexes with Cd. Many authors have found that soils with high organic carbon content as well as addition of organic fertilizer decreases the Cd content of soil. Brown *et al*.[31] showed that extractable metals (Pb and Cd) concentrations were declined by amendment application. Ahmad *et al*.[32] reported increased Cd and Pb concentrations in all the fractions following application of farm manure at 15 g kg^{-1} in both sandy loam and sandy clay loam soils.

CONCLUSION

The order of abundance of the metal fractions were carbonate bound >Fe-Mn oxide >exchangeable >available for all the heavy metals except Fe, Cd, Cr and Ni. Cd, Ni and Cr existed in the dumpsites as carbonate bounded >Fe-Mn oxide bounded >exchangeable = available. The application of poultry manure increased soil conductivity and organic matter. The use of poultry manure is a pertinent option in the total cleanup of Ni and Cr polluted dumpsite. Heavy metal metals fractions were reduced with the incorporation of poultry manure thus the application of organic amendment could mitigate the threat of food chain contamination by decreasing metal concentration in the soil.

SIGNIFICANCE STATEMENT

This study discovered that application of poultry manure enhanced a reduction in pH and concentration of heavy metal fractions. It also increased electrical conductivity and organic matter of the dumpsites soils. The use of poultry manure is a pertinent option in total cleanup of nickel and chromium polluted dumpsite. Soil characteristics affect the amelioration of heavy metal polluted dumpsite. The above can be beneficial for restoration of dumpsite for agricultural purpose like Vegetable or arable farming and mitigating the threat of food chain contamination becomes inevitable. This study will help the researchers to uncover the critical areas of heavy metal speciation in dumpsite soils that many researchers were not able to explore. Thus, a new theory on ameliorative effect of poultry manure on heavy metal speciation may be arrived at.

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