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Research article

BIOACCUMULATION OF HEAVY METALS BY EARTHWORM (LUMBRICUS TERRESTRIS) AND ASSOCIATED SOILS IN DOMESTIC DUMPSITE IN ABRAKA, DELTA STATE, NIGERIA

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ABSTRACT: Metal concentrations in (earthworm) *lumbricus Terrestris* and soil samples from six domestic dumpsites located in Abraka Delta State, Nigeria were measure spectrophotometrically after sample digestion. Mean metal content in dumpsite soils were, 14.45-63.12, 1613.83-1967.70, 35.41-53.70, 10.81-73.10, 9.73-47.92, 80.17-112.13ug/g for Cr, Fe, Mn, Ni, Pb and Zn respectively. While the concentration ranges recorded in *L. Terrestris* samples were: 7.18-9.65, 347.22-355.76, 19.31-43.59, 3.12-12.64, 4.57-12.62, 53.57-74.52ug/g for Cr, Fe, Mn, Ni, Pb and Zn respectively. The biota–to-soil accumulation factors were all less than unity for all metals. The order of bioaccumulation of the metals followed the trend: Mn >Zn >Pb> Cr>Fe>Ni. The availability of metals in soil was also co-determined by the pH and soil organic matter which accounted for the trend of metal concentration at the various dumpsites. The pH of the soil samples ranged from 4.5-5.7 while organic matter ranged between 1.97-4.22% Since birds and domestic fowls fed on insects and *L. Terrestris,* transfer of these metals across the food chain are most probable.

Keywords: Earthworms, heavy metals, dumpsites, soil organic matter, pH, Abraka, Nigeria

INTRODUCTION

Heavy metal can be defined as any metal with specific gravity higher than 4.00 and is toxic and poisonous even at low concentration [1,2]. Heavy metal concentrations in soil are associated with biological and geochemical activities and are influenced by anthropogenic activities [3, 4, 5, 6, 7]. Dumpsites contain various kinds and concentration of heavy metals, which is dependent on the age, location and type of waste [6,8, 9,]. Heavy metals are considered serious pollutants because they are toxic and non-degradable [10, 11, 12, 13, 14].The accumulation of heavy metals in soil poses many risk to human and the ecosystem [15]. Earthworm constitute a major component in soil functioning and they play an important role in chemical element transformation [16]. They utilize a significant amount of soil organic matter for feeding, produce huge amount of biogenic structures and determine the activities of micro-organisms and other smaller invertebrates [17]. The influence of heavy metals in soils on earthworms and their bioaccumulation has been subject of many studies [18, 19, 20]. According to Ireland 1983[21] and Bamgbose, Odukoya and Arowolo 2000[22], earthworms can accumulate in their tissues, heavy metals from the environment. The use of earthworm as a bio-indicator for soil pollution was shown by Morgan and Morgan [23,24]. Stafford and Mc Grath 1986[25] also reported positive correlation between earthworm and total soil Cu, Pb and Zn concentration from various metal contaminated sites. Metal bioavailability to earthworm can be evaluated both in terms of relative toxicity and through bioaccumulation determination yielding a Biota-to-soil accumulation factor (BSAF)[26]. Abraka, like many cities in Nigeria faces problems of environmental sanitation such as indiscrimate dumping of refuse along major roads and market places. The aim of this work is to determine the relationship between contents if some heavy metals (Cr, Fe, Mn, Ni, Pb and Zn) in earthworm with the total contents in the soils. It will also determine some physio-chemical properties of the soils of various dumpsites in Abraka, Delta State, Nigeria.

MATERIALS AND METHODS

The study area is located between latitude 5^0 15'E. According to UNDP 2006[27], the rain pattern is characteristic of the rainforest zone with mean annual rainfall of 3000mm. Temperatures are high and fairly constant throughout the year. Average monthly temperature for the warmest months (February to April) range from 28^0C to 33^0c while the average monthly temperature for the coolest month (June-September) ranged from 20^0C to 23^0C.

The soils from six domestic dumpsites namely: site II of the Delta State University, Abraka, Agbarah, Ekrejeta, main market, Umono and Urhuoka. At each sampling site the surface debris was removed and the subsurface soil dug to a depth of between 1-15cm with a hand soil anger. About 50g of soil sample from each site was taken into a polyethene bag and labeled. The areas used for sampling in each site were divided into four quadrants [28]. Earthworms were collected by digging into the soil within the quadrant and then placed in sample bottles and labeled. The earthworm samples were placed in petri dishes, then refrigerated for 24hrs in order to purge the soil in the gut; thereafter were removed, rinsed slightly with deionised water and then fozen pending analysis [22].The earthworm sample was identified by the department of Animal and Environment Biology, Delta State, University, Abraka.

3g of the thawed earthworm sample was digested with 2ml concentrated nitric acid and heated to dryness on a hotplate. The digest was then redissolved in 1ml concentrated nitric acid, after which it was made up to 50ml with distilled water. The soil samples were allowed to dry at room temperature and passed through a 2mm sieve. 5g of the sieved soil sample were weighed and 10ml concentrated nitric acid was added. The mixture in the beaker was covered with a watch glass and refluxed for 45 min. the watch glass was then removed and the content in the beaker evaporated to dryness. 5ml aqua regia was added and evaporated to dryness after which 10ml 1M nitric acid was added and the suspension filtered. The filtrate was then diluted to volume with distilled water in a 50ml volumetric flask. Triplicate digestion of both soil and earthworm sample was carried out.

20g of the air dried soil sample was weighed into a 50ml beaker and 20ml of distilled water added. The mixture was allowed to stand for 30min with occasional stirring with a glass rod. The electrodes of the calibrated pH meter were then inserted into the partly settled suspension.

The soil samples were ground using 0.5mm sieve after which they were weighed in duplicate and transferred to a 250ml Erlenmeyer flask. Exactly 10ml of 1M potassium dichromate was pipette into each flask and swirled gently to disperse the soil followed by addition of 20ml concentrated sulphuric acid. The flask was swirled gently until soil and reagents were thoroughly mixed. The mixture was then allowed to stand for 30minutes on a glass plate. 100ml distilled water was then added, followed by addition of 3-4 drops of ferroin indicator; after which it was titrated with 0.5N ferrous sulphate solution. A blank titration was similarly carried out.

The percentage organic carbon is given by the equation;

$$\frac{MeK_2Cr_2O_7\text{-}MeFeSO_4 \times 0.0031 \times 100 \times F}{\text{Mass (g) of air dried soil}}$$

F = correction factor (1.33)

Me = Normality of solution x ml of solution used % organic matter in soil = % organic carbon x 1.729

Quantitative Analysis

The sample digests were analysed for heavy metals using model A analyst 200 Perkin – Elmer AAS.

RESULTS AND DISCUSSION

Table 1: Physio-chemical properties of the soil (mean ± standard deviation, n=3)

Sampling site	pH	Organic matter %
Site II	5.1±0.06	3.27±0.01
Agbarha	4.5±0.05	4.22±0.02
Ekrejeta	5.7±0.06	1.97±0.01
Market	4.8±0.06	4.04±0.01
Umono	5.3±0.12	4.04±0.01
Urhuoka	4.9±0.06	2.98±0.01

Table 2: Heavy metal content of soil (Mean± standard deviation n=3 (ug/g).

Sampling site	Cr	Fe	Mn	Ni	Pb	Zn
Site II	14.45±0.06	1967.70±0.56	41.67±0.02	46.10±0.01	24.02±0.01	112.13±0.03
Agbarha	25.22±0.03	1725.89±0.57	53.70±0.01	10.81±0.01	13.51±0.01	80.17±0.02
Ekrejeta	63.12±0.03	2916.10±0.61	50.20±0.01	73.10±0.01	14.92±0.02	96.17±0.01
Market	16.31±0.01	1613.83±0.37	36.12±0.01	73.51±0.01	40.11±0.01	106.73±0.03
Umono	39.25±0.01	1814.00±0.01	37.45±0.03	33.33±0.03	47.92±0.02	102.24±0.01
Urhuoka	44.30±0.07	1818.63±0.06	35.41±0.02	18.53±0.03	9.73±0.03	83.14±0.01

Table 3: Heavy metals in Earthworm sampling site (Mean± standard deviation n=3 (ug/g).

Sampling site	Cr	Fe	Mn	Ni	Pb	Zn
Site II	7.73±0.01	355.75±0.01	32.31±0.01	3.27±0.01	5.02±0.01	67.31±0.02
Agbarha	7.70±0.01	353.74±0.01	43.59±0.01	3.47±0.01	6.52±0.01	68.69±0.01
Ekrejeta	9.65±0.01	349.33±0.50	38.21±0.02	7.27±0.01	7.27±0.01	53.57±0.01
Market	8.14±0.01	357.66±0.11	29.01±0.02	12.64±0.01	12.62±0.03	71.61±0.01
Umono	7.18±0.01	348.23±0.02	32.29±0.01	6.17±0.01	6.17±0.01	74.52±0.01
Urhuoka	7.24±0.01	347.22±0.03	19.31±0.01	3.12±0.01	4.57±0.01	63.62±0.01

Table 4: Biota-to-soil Accumulation Factor (BSAF)

Sampling site	Cr	Fe	Mn	Ni	Pb	Zn
Site II	0.53	0.18	0.78	0.07	0.21	0.56
Agbarha	0.31	0.20	0.81	0.32	0.48	0.87
Ekrejeta	0.13	0.12	0.76	0.10	0.49	0.56
Market	0.50	0.22	0.80	0.17	0.31	0.67
Umono	0.18	0.19	0.86	0.19	0.13	0.73
Urhuoka	0.16	0.19	0.54	0.17	0.47	0.77

Table 5: Environmental quality criteria in Canada. Interim environmental quality criteria for contaminated sites recommended to sub-national authorities (CCME 1991)

Soils (mg/kg)

Element	Agriculture	Residential	Commercial/industrial
Cd	3	5	20
Cr	750	250	800
Cu	150	100	500
Pb	375	500	1000
Ni	150	100	500

The results of the analysis are as shown in tables 1-4 above. Soil pH has been regarded as the parameter most widely accepted as exerting a controlling influence on the availability of micronutrient to plants [30, 31, 32]. The pH values of the soil sample ranged from 4.5-5.7 which is acidic. Heavy metal cations are said to be more mobile under acid conditions [33]. Since these soil samples were acidic, it therefore may favour mobility of these cations. Banjoko and Sobulo 1990[34] reported similar figures as normal for some Nigeria soils especially from the forest region. Correlation between soil pH and micronutrients availability has been reported [35, 36, 37, 38, 39, 40]. pH within this range had previously been reported for Abraka farmland soils [40].

The soil organic matter acts as a "storehouse" for many of these metals. It therefore influences micronutrient availability through chelation. Positive correlation between some micronutrients availability and organic matter had been reported [36, 37, 38, 39, 40,41]. The organic matter of the soil under investigation ranged from 1.97-4.24%. For West African soil, Alm 1970[42] had reported that a good forest top soil should contain between 5-7% organic matter. The results obtained from this work is low as compared with Alm's figures but compares favourable with the result obtained by Bamgbose et . al. 2000[22] for uncontaminated soils. The low values obtained may be due to the age of the dumpsites.

Table 2 showed the concentration of six heavy metals in soils collected from the selected dumpsites. Chromium, iron and manganese ranged from 14.45-63.12ug/g, 1725-2916ug/g, 35.41-53.70ug/g respectively. Others are Ni 10.81-73.10ug/g, Pb 9.73-47.92ug/g and Zn 80.17-112.13ug/g. The profile of average metals contents in the study areas are Fe>Zn>Ni>Mn> Cr>Pb. Comparing results obtained with recommended standards, the concentration of all metals from the dumpsites soil were found to be lower than the threshold values for agricultural residential and commercial/industrial application (Table 5). We can therefore say that these soils were not yet polluted.

Table 3 showed the values for metals content recorded in the earthworm (*L. Terrestries*). The values ranged from 7.18-9.65ug/g for Cr, 347.22-357.66ug/g, for Fe and 19.31-43.59ug/g for Mn. Others are 3.12-12.64ug/g for Ni, 4.57-12.62ug/g for Pb and 53.57-74.52ug/g. The transfer factor is shown in table 4. The transfer factors were all less than unity in all the dumpsites studied. Generally levels of all the metals analysed in dumpsite samples were higher than those in *L. Terrestries* samples; this was not unexpected since soil has been described as reservoir of pollutants [43]. Mineralization of dead earthworms releases accumulated heavy metals back to the soil [24]. The amount of metals accumulated within earthworm tissues is partly dependent on the absolute concentration of metal within a given soil and physiochemical interactions [44]. The general trend of metal concentration either in the soil or in the earthworm followed similar trend.

CONCLUSION AND RECOMMENDATION

In conclusion, this study confirms that earthworms accumulated some amount of heavy metals from domestic dumpsite soils and so can be used as a bio-indicator for pollution. The study also showed that the levels of these metals accumulated in the earthworm tissue were less than unity. Furthermore, the availability of metals in soils was influenced by the soil pH and the soil organic matter accounting for the variation in metal concentrations from one site to the other. The result further showed that possible contamination by metals is possible as a result of indiscriminate deposition of used metals. It is therefore recommended that the use of dumpsite soil as manure be discourage to prevent possible transfer of toxic metals into the food chain.

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