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Assessment of Soil and Earthworm (As Bio-Indicator) of Heavy Metals around the Cattle Market, Isheri, Along Lagos-Ibadan Express Road.

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ABSTRACT
Heavy metal released by traffic activities on the road sides are important sources of soil pollution in developed and developing countries for decades. Earthworms have been used as bio indicator of soil pollution (heavy metals) by many researchers over the years. Vehicular emission is a major source of heavy metal in this site. This research work aimed at examining the level of heavy metals concentration in the soil and in the earthworm at the Isheri Cattle Market along Ibadan-Lagos Express road in Lagos State, Nigeria.
The soil samples were collected at the surface and subsurface levels from different sections of the market (upstream, downstream and around the market) Earthworms were also collected at the three different sections of the market. The concentration of heavy metals at the site is higher than that of the control site collected from Botanical garden, University of Ibadan. The heavy metals were digested using aqua regia (Conc. HNO_3 and Conc. HCl in 1:3 ratios) and analyzed by atomic absorption spectrophotometer (AAS).
This result showed that the concentration of heavy metals in all the sites ranged from 0.14 – 15.4mg/kg for Cr , 0.012 – 1.072mg/kg for Cd while that of Ni, Cu, Zn and Pb are (0.025 – 4.69, 0.33-9.35; 2.42-41.0 and 0.19-15.82 mg/kg). The concentration of heavy metals in earthworm in the three major sections of the market ranged from 18.0 – 909mg/kg for Cr, 0.0014 – 0.056mg/kg for Cd, 0.32 – 1.39 mg/kg for Pb, 1.76 – 66.0mg/kg for Ni, Cu is 9.12 – 489mg/kg and Zn is 3.18 – 12.9mg/kg. The earthworm present in the market is a good bio-indicator of heavy metals. This implies that vehicular emission and various burning activities are sources of environmental pollution which possesses a serious risk to human health and animals. There is need for a continuous research in this site to monitor the increase in the concentration of heavy metals because of their toxic and carcinogenic effect in the environment.
Key words Earthworm, Heavy metals, Bio- indicator

Introduction:

Pollution in recent years has increased considerably as a result of increasing human activities, such as burning of fossil fuels industrial and automobile exhaust emissions (Amusan et al.,2003). It is now well established that a variety of motor vehicles introduce a number of toxic metals into the environment most of which are released adjacent to roadsides, LargerWerft and Specht (1990) reported the release of Lead (Pb), Cadmium (Cd), Nickel (Ni) and Zinc (Zn) into areas adjacent to road sides(Molton et al; 1970) observed that Pb emission from vehicles produced elevated concentrations of the elements on roadside vegetation. Additional sources of heavy metals include rainfall in atmospheric polluted areas, use of oil or fossil fuels and fertilizers(Atrouse et al,.2004,Subukola et al,. 2008).
Heavy Metals in the soil may be important trace elements in nutrition of plants, animal and human beings (e.g Zn, Ni, Cr ,V, Cu, Mn).While others are not known to have positive nutritional effects (e.g Hg, Pb and Cd) and they may cause toxic effect even at a low level if they occur extensively(Spieget,2002). Heavy metals have been reported to have positive and negative roles on human life(Divrikli et al,.2003,Dunder and Saglam,2004). The level of heavy metals (Cd and Pb in the environment has increased tremendously in the past decades as a result of human activities(Awofolu,2005). Heavy Metals contaminated soils constitute a huge problem as it affects human health and environmental quality (Otitoloju, 2009).
Earthworms contribute to the aeration of the soil, hence the need for its study in earthworm toxicity testing, the organisms are in close contact with soil and can be used to evaluate bioavailability (Connor, 1988). In addition, the earthworm is a representative of soil fauna and recognized to be relatively sensitive indicator (Connor, 1988). For more than 200 decades, earthworms have played the major role in soil toxicity testing, this group has specially been studied concerning the problem of bio-accumulator of heavy metals (Gobalt et al; 2004). Earthworm is found in every type of soil except very dry and acidic soil(Elaigwu et al.,2007). Earthworm may be exposed to heavy metals in pore water , food,(including plant leaves and ingested soil particles (Saxe et al.,2001). Pore water is the major route of exposure of heavy metals to organism like earthworm(Viguor,et al.2003).

Monitoring of the toxic substance in the environment using biological indicators have been well established (Bamigbose, 2000). Earthworm are found in every type of soil except very dirty or very acidic soil and plays an important role in processing organic material derived from natural and anthropogenic substances such as sewage sludge (Yoloye, 1988). The best bio-indicators or bio-accumulator of heavy metals are the invertebrates that store substances taken from soil water. (Vanstralen, 2004). Bioindicators are organisms that provide information on conditions from its environment by its presence or absence and by its behavior (Gestel and brummelen ,2004).

Site Description

The site under study is the cattle market located along the Lagos-Ibadan Express Road. It is popularly known as Isheri Cattle Market. Major practices or activities in the market include selling and buying of cows and other livestock like sheep and goats. It must be stated that 95% of the livestock there is cattle. Slaughtering of cows, selling of beef, burning of bones and horns of cattle are also common activities in the market. The site also receives contaminants like heavy metals from the vehicular emission since it is close to a busy express road (Lagos-Ibadan Express road). There is a river behind the market which receives most of the waste from the market. In fact, there are several dumpsites at different points along the river. The market has been seen by many researchers as a source of pollution to the river. Fig 1 shows the map of the market and the sampling points

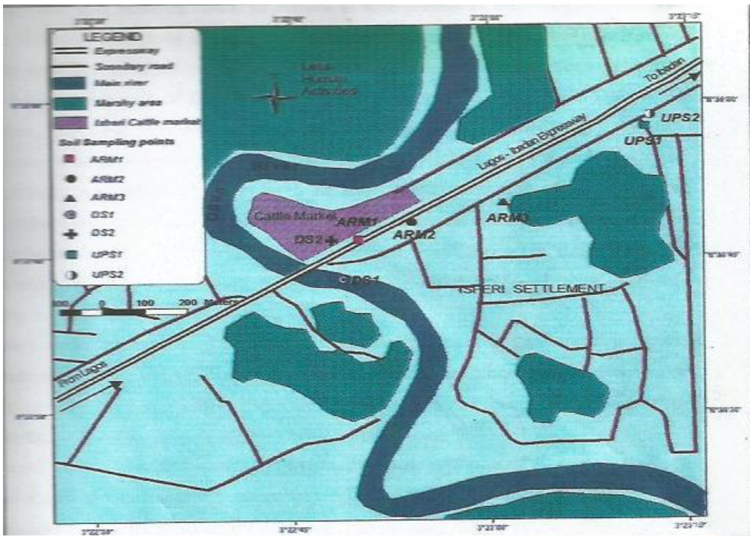

Fig 1: Map of the Isheri cattle market showing the sampling point.

Materials and Methods

The environmental investigation of pollution stress arising from specified location basically involves the measurement of pollution indicating parameters at upstream around the market and downstream. Upstream is the location from localized source of pollution, around the market would be a location right inside the market where major activities take place. Downstream is the location far from around the market. The assessment of the soil at this market for pollutant stress in the soil will involve. The pH, Total Organic Matter or Total Organic Carbon (TOC). The soil will be analyzed for heavy metals and earthworm will be used as bio indicators.

Sampling method

Soil samples were obtained at the market using polythene bags. The soil samples were collected at five points at each depth of 0-15cm and 15-30cm at different locations of upstream, downstream and around the market. At upstream area, the area was divided into two i.e. upsI and upsII, the same with downstream which gave rise to DsI and DsII. At around the market, the area was divided in three:, around the market area of major activities(place of large number of cows where most activities of buying and selling of cows take place).

Around the market, area of minor activities (the place with few number of cows and less activities of buying and selling of cows take place). Around the market, area of selling point where selling of beef, food and other daily needs of people are being sold. These are coded ARM – major activities, ARM – Selling point respectively. Earthworms were also collected only at the upstream, downstream and around at the market only (3 points) since they are not easily found at the subdivisions of those areas. They were also found at the surface level 0-15cm not at the subsurface, 15-30cm. They were then coded thus UPSE, DSE and ARME. The soil sample were kept in the polythene bag while the earthworms were kept in plastic bottles and placed in a cooler of ice block.

Table 1. Sample Code and Location

Code	Location	Co-ordinates
UPSI	Soil sample at the upstream point 1 0-15 cm and 15-30 cm	Lat. .06^0 64 .8^{11} N Long.003^0 38^1 66.0^{11}E
UPS11	Soil sample at the upstream point 11 0-15 cm and 15-30 cm	Lat. 06^0 64^1 95.9^{11} N Long. 003^0 38^1 67.1^{11} E
DSI	Soil sample at downstream point 1 0-15 cm and 15-30 cm	Lat. 06^0 64^1 52.1^{11}N Long. 003^0 38^1 02.1^{11} E
DS11	Soil sample at downstream point 11 0-15 cm and 15-30 cm	Lat. 06^0 64^1 52.5^{11} N Long. 003^0 37^1 99.7^{11} E
ARM (selling point area)	Soil sample around the market selling point area 0-15 cm and 15-30 cm	Lat. 06^0 64^1 62.7^{11} N Long. 003^0 38^1 05.6^{11} E
ARM (major activity)	Soil sample around the market area of major activity 0-15 cm and 15-30 cm	Lat. 06^0 64^1 67.4^{11} N Long.003^0 38^1 16.6^{11} E
ARM (area of minor activity)	Soil sample around the market area of minor activity 0-15 cm and 15-30 cm	Lat. 06^0 64^1 72.8^{11} N Long. 003^0 38^1 36.2^{11} E
Control Sample	Sample at the control site	
UPS_E	Earthworm at upstream	
DS_E	Earthworm at down stream	
ARM_E	Earth around the market.	

Soil Digestion (Aqua regia method)

5g of each of the air dried and sieved soil sample was weighed into a digestion tube 7.5ml Conc. HCl and 2.5ml Conc. HNO_3 (ratio 3:1) was added i.e. (10ml aqua regia). The tube was covered and heated in a water bath to 100^{o}c for 2 hours with intermittent shaking every 20 minutes. The digest was allowed to cool to room temperature and then filtered into 25ml standard volumetric flask through Whatman filtered paper. The filtrate was made up to mark and transferred into plastic container for AAS analysis for Cr, Cd, Pb, Ni, Zn and Cu using Buck Scientific AAS incorporated model 205A.

Digestion of Earthworm

5g of the thawed earthworm were digested with 3ml concentrated citric acid (HNO_3) and heated to dryness on the hot place. The digest was re-dissolved in 2ml Conc. HNO_3 after which it was made up to 25ml mark with distilled water and stored ready for analysis.

$$\text{Con (mg/kg)} = \frac{\text{Con(mg/L) x Volume of Sample x (0.025L)}}{\text{Weight of Sample (kg)}}$$

Determination of Soil pH

Electrometric Methods AOAC, 1975)

The procedure adopted for this determination is water method in ratio 1:1 (W/V) using pH meter Jenway 3310. The pH meter electrode was calibrated with buffer solutions pH4 and 7. 20.0g of air-dried and served soil sample was weighed accurately into a 50ml beaker, 20ml distilled water was added and stirred thoroughly with a glass rod for about 10minutes. The mixture was allowed to stand for 30minutes and suspension stirred every 10minutes during this period. The suspension was allowed to settle for another 30minutes. The electrode was dipped into the partly settled suspension and the pH reading taken for each sample when the reading of the pH meter stabilized. The electrode of the pH meter was rinsed with distilled water and wiped clean with tissue after each reading of the sample.

Determination of Soil Total Organic Carbon using the Walkley-Black method (Nelson and Summer 1974)

The principle of the method involved the oxidation of organic carbon in the soil with an oxidizing agent in acidic medium. Excess oxidizing agent is then back-titrated using ferroin as indicator to determine its end point.

0.5g of the sieved sample was weighed into a 250ml conical flask.10ml of standard $K_2Cr_2O_7$ solution was added and swirled to mix. 15ml of Conc. H_2SO_4 was added gently and swirled to mix, the flask was then left to stand for 30minutes. 5 drops of ferroin indicator were added and the resulting mixture was titrated against 0.5N

Ferrous Ammonium Sulphate (FAS) until colour changes. The solution initially took a greenish cast and latter changed to dark green, at this point FAS was added drop by drop until the colour finally change from blue to red which marked the end point. A blank solution contained the entire reagent without the soil sample was also titrated and the value obtained was recorded.

Calculation:

$$\% \text{ Organic Carbon} = \frac{(\text{Meq}K_2Cr_2O_7 - \text{Meq (AS)}) \times 0.003 \times 100}{\text{Weight in (g) of soil sample}}$$

%Total organic carbon = f x % organic carbon

% Total organic matter = % Total organic carbon x 1.729

Where f = 1.33 – empirical figure to account for in complete oxidation of the organic carbon

Milligram equivalent (Meq) = Normality of Solution x oil of solution used.

Results and Discussions

Soil pH: Looking at the soil samples, pH values in all the samples were higher that which was obtained from the control sample. (Botanical Garden, UI).

This result is accordance that which was obtained by Eliagu in 2007. We can also see from the result of the research that pb, zn, cr, pb and Zn show high concentration at the points where the pH is higher.

This is similar to what was obtained by Awofolu (2005). Zn also showed a high concentration.

Soil pH has been defined as the parameters most widely accepted as exerting a controlling influence on the availability of micro-nutrients in plants. The pH value of the test area (Isheri Cattle Market) ranges from 5.60 – 8.9). It is shown that pH of the site is relatively high, especially at the upstream and downstream areas. A close observation from the table shows that the soil at the upstream is alkaline, the pH ranges from 8.30 to 8.90. The pH value at the downstream ranges from 6.30 to 6.90 showing slight acidity. The pH of the soil decreases with depth. This observation is in accordance with the report of a research carried out by Rama Krishanavah and Somaenekar in 2002.

The pH values of the samples is higher than which was obtained from the control sample. Elaigu and Ajibola also had this experience in 2007.

A careful look at the result of the research work shows that Cr, Pb and Zn showed a high concentration at high pH values which is similar to that which was obtained by Awofolu in 2005.This looks contrary to the experience of jarup in 2003 where he discovered a high uptake of cadmium by plants at a low $P^{H.}$

Soil Organic Matter

The soil organic matter at the upstream was found to range from 0.36 – 0.73% while that of soil pH at around the market has a high value of organic matter. There is decrease in the organic matter with depth. This is in accordance with the report of Ramakrisha and Somachekar in 2002. A careful observation of the table of result shows that at the deeper level of the soil, where the organic content is lower compared to the top soil has higher concentration of heavy metals. Zn shows a high concentration (27.1, 26.6, 39.3, 27.5 and 27.3)mg/kg at ARM areas of major and minor activities. This is in accordance with the result of research carried out by Elaigwu 2007 where Zn contamination in earthworm was high in area with high percentage of organic matter.

Table .2. : physico-chemical properties of the soil samples around the cattle market

Sampling point codes	Depth (cm)	P^H	Total Organic Matter (%)
UPS I	0-15	8.30	0.73
	15-30	8.40	0.54
UPS II	0-15	8.80	0.44
	15-30	8.90	0.36
DS I	0-15	6.30	1.70
	15-30	6.50	1.42
ARM(selling point)	0-15	5.60	6.57
	15-30	5.70	6.40
ARM(major activity)	0-15	5.70	6.74
	15-30	5.80	6.22
ARM(minor activity)	0-15	5.80	8.65
	15-30	5.90	6.92
CONTROL	0-15	6.89	1.56
	15-30	7.20	0.29

NOTE

UPS I – Upstream I
UPS II – Upstream II
DS I – Downstream I
DS II – Downstream II
ARM – Around the market

Table 3. Mean and standard deviations of heavy metals (mg/kg) in soil around the cattle market

Simpling Point	Depth (cm)	Cr	Cd	Pb	Ni	Cu	Zn
Ups I	0-15	1.24+0.04	0.16+0.004	1.21+0.004	1.21+0.004	0.87+0.009	4.08+0.004
	15-30	0.83+0.004	0.27+0.004	12.01+0.004	2.13+0.004	3.97+0.003	39.1+0.004
Ups II	0-15	14.8+0.09	0.41+0.2	15.82+0.2	4.69+0.2	9.35+0.1	30.4+3.3
	15-30	12.82+0.1	0.42+0.03	14.4+0.03	3.32+078	8.031+0.01	27.1+8.7
DS I	0-15	5.31+0.004	0.08+0.004	7.10+0.4	0.711+0.004	1.78+0.004	41.0+0.004
	15-30	8.75+0.4	0.13+0.004	10.4+0.07	2.16+0.09	3.25+0.06	26.2+0.04
DS II	0-15	10.12+0.01	0.012+0.004	9.14+0.2	3.17+0.4	7.37+0.07	30.1+8.6
	15-30	15.52+0.5	1.07+0.01	9.14+0.1	3.17+0.4	7.37+0.07	30.2+8.6
ARM selling point area	0-15	4.14+0.01	0.33+0.004	6.012+10	2.89+0.003	7.49+0.2	27.3+7.7
	15-30	3.31+0.06	0.28+0.01	4.87+0.007	2.23+0.004	6.22+0.03	27.5+8.3
ARM major activity area	0-15	1.64+0.004	0.30+0.004	1.31+0.5	1.12+0.004	2.84+0.004	39.3+0.004
	15-30	0.014+0.004	0.08+0.004	0.70+0.004	0.0025+0.004	0.33+0.004	2.42+0.004
ARM area of minor activity	0-15	2.98+0.05	0.05+01	7.11+0.06	1.41+0.004	3.62+0.006	26.6+8.7
	15-30	5.071+0.01	0.32+0.0071	7.13+0.06	2.30+0.007	5.72+0.02	27.1+7.9
Control Sample	0-15	0.17+0.01	0.012+0.01	0.19+0.02	0.111+0.031	0.211+0.007	2.82+0.1
	15-30	0.13+0.01	0.072+0.12	0.21+0.1	0.130+0.14	0.230+0.2	2.83+0.1

Note:
Ups - Upstre
DS - Downstream
ARM – Around the market

Concentration of heavy metals in soil around the cattle market

Concentration of heavy metals in soil around the cattle market is presented in the table of result, it can be seen that the concentration of zinc (Zn) is very high. The trend is mostly shown as we go from 0-15cm to 15-30cm especially at UPS II, DS I ARM (area of major activity). This trend is also shown in cadmium concentration in some points. This result agrees with the observation made by Amusan and Bada 2003 who reported that the top soil has significant higher metal concentration than the sub soil (15-30cm) while working on the effect of traffic density on heavy metal content of the soil along roadsides in Osun State The concentration Cr, Cd, Pb, Ni and Cu is higher than what is obtained in uncontaminated soil. This is in accordance to the result obtained by Eliagwu et al.,(2007).

The concentration of lead (Pb) is also a little bit higher at upstreams I and II, downstream. These sampling points are far apart in distance but not far from the busy express road. The concentrations of these two metals may be a function of high traffic density (Fatoki and Ayodele 1991). Ademoroti (1986) noted that organometallics such as tetra ethyl lead ($\{C_2H_5\}_4Pb$), an additive to gasoline (Petrol), is an important source of Pb in automobile exhaust emission.

The exceptions (as it can be seen from the table) to the trend that top soil contains higher metal concentration could be caused by the fact that the sampling was carried two times. The first set was done during dry season while the second one was done during the flood at Lagos which might have caused the metals to percolate to deeper sub soil.

The result also shows that cadmium is least present in the test area (the market). The high concentration of Zn could be as a result of parent materials of the soil and the Zn based soil and rubber additive from tire (Largerwerff, 1971). Concentrations of the heavy metals in the test area are higher than those at the control site (Bamigbose et al., 2000)..

Concentration of heavy metals in earthworm around the cattle market

The concentrations of heavy metals in earthworm as presented in table 4 shows that the species of earthworm in the market (not identified) is a good bioindicator of heavy metals most especially Chromium (Cr), Nickel (Ni), Copper (Cu). The result is in excellent agreement with the Statement of Bamigbose (2000) that earthworm is a good accumulator of heavy metals.

The results also show that the species of earthworm in the test areas are poor bioindicators of Zn. This observation is in excellent agreement with the repot of Ireland, (1983) who recorded a low concentration of 0.34mg/g of Zn compare to other metals.
The species in the market cannot also accumulate Pb. The concentration of Pb in the test area shows the following values (1.39, 1.79 and 0.32)mg/kg at Upstream, Downstream and around the market respectively.
There are many reasons while the earthworm in the market could not uptake or accumulate some metals. Earthworms are able to avoid unfavourable surroundings because of the high number of chemo-receptors located in their prostomium which make them react sensitively toward chemical influences. A species of earthworm called Lumbricus rubellus showed intermediate reaction at 730mg/kg of Zn in tested soil while copper content are tolerated up to 200mg/kg by another species called Aporrectodea caliginosa (Paoletti, 2001). The type of soil at the tested area also determines the accumulation of the heavy metals.
The epigeic species of earthworm prefer the humus soils . (Sabine T, 2001). Some earthworms are also tolerant and a good example is epigeic species which was found to contain a higher proportion of heavy metals in a research carried out by Sabine Tischer in 2001 where the species accumulated 231mg/kg of Zn.

Table .4. Mean and Standard deviation of heavy metals (mg/kg) in the earthworm around the cattle market.

	Location		
Metals	Upstream	Downstream	Around the market.
Cr	909 ±3.5	17.95±0.07	105±0.7
Cd	0.014±0.02	0.0561±0.01	0.14±0.2
Pb	1.39±0.01	1.79±0.2	0.32±0.007
Ni	48.2±0.7	1.76±0.09	66.0±0.4
Cu	43.5±0.5	9.12±0.2	48.9±0.6
Zn	3.18±0.1	6.91±0.2	1.92±0.04

The result shows that earthworm were able to accumulate lower concentration of Pb (Lead) in their bodies.

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