CONCENTRATION AND DISTRIBUTION OF HEAVY METALS IN SOIL AND EARTHWORM *(Aporrectodea longa)* FROM SELECTED NURSERY AND PRIMARY SCHOOLS IN BENIN CITY

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(A CASE STUDY OF SELECTED SCHOOLS IN BENIN CITY, EDO STATE, NIGERIA)

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF ANIMAL AND ENVIRONMENTAL BIOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY

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CERTIFICATION

We the undersigned hereby certify that this research work was carried out by **Ethel Ewoma ONODUA** with matriculation number **LSC1704987**

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EXTERNAL SUPERVISOR	**DATE**

DEDICATION

This project is dedicated to my Heavenly Father, for the strength, guidance, provision and ability to successfully put together this project. I also dedicate this report to my parents for their love, moral and financial support.

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I am grateful to God Almighty for the grace to complete my research project. My sincere appreciation goes to my family for their financial and emotional support towards my academics.

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ABSTRACT

This study was carried out to determine heavy metal levels and distribution in soils and earthworm in selected primary and nursery schools namely, Owina school, Olua school, Ubth staff school, Calvary crown and Impact academy, located in Benin City, Nigeria. A total of ten (10) soil sample and thirty (30) earthworms were collected from five school; particularly the playground area in Benin City, Nigeria. Seven (7) heavy metals were examined in this study namely: Iron, Zinc, Chromium, Copper, Lead, Nickel and Cadmium. The mean concentration of metals in soils ranged from 14.56-121.3 mg/kg for Fe, 5.98-43.22 mg/kg for Zn, 1.56 -15.44 mg/kg for Cr, 0.73 - 19.26 mg/kg for Cu, 0.38 - 1.44 mg/kg for Pb, 2.16 - 4.28 mg/kg for Ni and 0.012 - 0.04 mg/kg for Cd. While the mean concentration of metals in earthworm ranged from 49.45-95.73 mg/kg for Fe, 18.93 - 108.7 mg/kg for Zn, 1.86 - 5.74 mg/kg for Cr, 6.47 - 50.27 mg/kg for Cu, 0.23 - 0.63 mg/kg for Pb, 0.22 - 0.62 mg/kg for Ni and 0.04 - 0.14 mg/kg for Cd. The value recorded in soils were observed to be higher in comparison to the values in earthworms. The highest mean value in soils was recorded in Owina school and the lowest was recorded in Ubth staff school while the highest mean value in earthworm was recorded in Olua school and the lowest in Impact academy. Much attention should be given to heavy metals because of their high toxicity potential in children, their widespread use and their prevalence.

CHAPTER ONE

INTRODUCTION

1.1 background to the study

Heavy metals are toxic environmental pollutants that enters the environment from natural or anthropogenic activities. These metals can be naturally occurring in the environment or introduced by human activities. Examples of heavy metals found at contaminated sites includes Lead (Pb), chromium (Cr), zinc (Zn), cadmium (Cd), iron (Fe), copper (Cu), and nickel (Ni).

The concentration of heavy metals in the environment has risen dramatically in recent decades as a result of human activity (Awofolu, 2005).These human/anthropogenic activities that increases the level of heavy metals in the environment include the use of pesticide and fertilizers, inappropriate disposal of toxic metal waste, paint pigments, battery manufacturing, etc. and when introduced to soils, they contribute to the increase in heavy metal levels in the environment, making these metals a threat to the environment.

Heavy metals can persist in the soil for a long time and have negative impact to the environment and soil; it decreases the total number of soil organisms by affecting their growth, morphology and metabolism, it causes retardation of plant growth, it reduces soil productivity, even at very low concentration. These metals cannot be biodegraded or destroyed in the soil so they have the potential to cause harm to soils and the environment for a prolonged period of time.

One of the soil organisms that can be affected by heavy metal is the earthworm. They can also be used as bio indicators in soil. Bio-indicators are organisms that provide information about environmental conditions through their presence or absence as well as their behavior (Gestel and brummelen, 2004). Earthworms are uniquely suited to be bio indicators of heavy metals in the soil ecosystem due to their limited mobility (Suthar et al., 2008). Since heavy metals are non-biodegradable, they tend to accumulate in living organisms like the earthworms. These earthworms accumulate heavy metals in their body tissues from contaminated substrates (Gupta et al., 2005; Suthar, 2008) and the concentration of metals in earthworm tissues has been shown to be directly related to the level of contamination in the soil (Hobbelen et al., 2008). These organisms are in close contact with the soil and can be used to assess bioavailability of heavy metals (Connor, 1988).

Several researchers have discovered heavy metals in school soils specifically in the areas where these children play. The primary source of these pollutants in children is the playground equipment such as swings, seesaws, slides, and carousels. The majority of these items are made of metals, which when released into the environment are the leading cause of heavy metal poisoning in children. Furthermore, when children play in the dirt, they are more exposed to these toxic metals.

The primary routes of exposure in children are accidental ingestion, inhalation, and dermal absorption, which results in some negative health effects (Osman et al., 2019). Children become mildly or severely infected by ingesting contaminated soil and coming into contact with it through their skin and these potentially contaminated soils are known to be more toxic to children due to their small body mass. Although germs found in soil may help strengthen a child's immune system and increase the diversity of friendly bacteria in the body (Iftikhar et al., 2020), toxic metals found in soil pose a serious threat to humans, particularly children, through direct ingestion or contact with contaminated soil in their various schools.

Heavy metal contaminated soils are a major issue because they harm both children's health and the environment (Otitoloju, 2009). Its effects on children's health have been found to be more severe than those on adults. This is due to children's weakened immunity (Muwaffak et al., 2019).

When children consume these pollutants, they may accumulate in their body tissues, resulting in either mildly effects or chronic life-threatening diseases.

High levels of Copper in soil can cause mental illnesses such as Alzheimer's and manganism, which primarily affects children's intellectual functions (Bayer, 2005). Lead is a very dangerous and cancer-causing metal that can cause long-term health issues such as migraine, agitation, stomach pain, nerve harm, kidney harm, circulatory strain, lung tumor, stomach growth, and gliomas (Ogwuegbu, 2005). Because children are the most vulnerable to lead toxicity, long-term exposure to high levels of lead causes serious health complications such as behavioral disturbances, memory disintegration, and decreased comprehension capacity, as well as anemia (Ogwuegbu, 2005). Lead also causes renal tumors and interferes with the normal functioning of the kidneys, joints, reproductive, and nervous systems (Banerjee, 2003). Other effects include; mental retardation (autism), neurocognitive disorders, behavioral disorders, respiratory problems, cancer, and cardiovascular diseases are among the harmful effects of the element on children's health (Iftikhar et al., 2020). Heavy metal exposure is typically chronic (exposure over a long period of time) or immediate, such as poisoning from ingestion or dermal contact.

1.2 Justification of the study

Heavy metals are non-biodegradable, toxic, and can accumulate in humans, causing a variety of health problems. Children are more vulnerable to environmental hazards due to a variety of factors such as smaller body sizes, closer organ proximity, and shorter stature (De-Mingeul et al., 2007). Currently, there is a very low level of awareness in Nigeria of the harmful effects of heavy metals that children are exposed to in contaminated soils of playgrounds, resulting in a knowledge gap in this area. It is in this regard that this study focuses on the attempts to quantify heavy metals concentrations in kindergarten schools across Benin City and the effect of heavy metal on the activities of *Aporrectodea longa*. The study focused at how much heavy metal pollution had polluted the soil and earthworms, making it unsafe for children.

1.3 Aim and Objectives

The aim of this study is to assess the concentrations of heavy metals in Kindergarten soils in Benin City and the health risk of these metals to children.

The objectives of the study are to:

1. Ascertain the levels of heavy metals in soil samples collected from different kindergarten schools in Benin City.
2. Assess the bioaccumulation of heavy metals in *Aporrectodea longa* from the soil as a measure of heavy metal pollution.
3. Propose general recommendations to the government and environmental management officials.

CHAPTER TWO

LITERATURE REVIEW

2.1. Heavy metals contamination in soil

Toxic metals in soil can significantly impede the soil productivity and richness in a particular area. Several studies have been conducted on the heavy metal content of Nigerian soils in Nursery and Primary schools. Some researchers have recently studied soils in schools in order to ascertain whether or not the concentrations of heavy metals in these schools are within permissible limits.

Biose et al (2021) conducted a study a study on the heavy metal content in soils of public primary schools in Benin, Nigeria. The result showed that iron had the largest concentration across all schools; manganese and zinc were also significantly high with the lowest concentrated metals being lead and nickel across all selected schools. This study suggests that heavy metal accummulation in these children might be from their school playground and other sources in the school.

Ugwu and Ofomatah (2021) assessed the concentration of toxic metals in selected schools in Southeast Nigeria. The findings indicated that all the classrooms observed were contaminated at different levels with heavy metals. The degree of pollution in the classroom ranged from low contamination due to Copper and high contamination due to Iron. Dermal contact was the highest route for heavy metals at the schools selected due to social interactions by the pupils.

Popoola et al., (2012) investigated the heavy metal content in playground soil of some public primary schools in Lagos, Nigeria. The results shows that lead concentarion in the soil showed a wide range of high concentration. This is due to the great influx of people in these school and the industrialization of the state. Chromium, cadmium and manganese were also tested for but they were at a lower concentration than lead.

Wirnkor et al., (2000) conducted a study on the assemesnt of heavy metals in schools in Owerri, Nigeria. Nine (9) schools were selected for this study and the findings indicated that zinc showed a higher value and manganese had the lowest value out of five total metals investigated. He concluded that children are at risk at some of the heavy metal due to their exposure to these metals for a long period of time.

Akinwumi et al., (2017) researched on heavy metal burdens of primary school children in Ibadan, Northwest local government area, Nigeria. The research was focused more on the areas children in these schools play. Five (5) heavy metals were analyzed namely; lead, copper, zinc, iron and manganese. Iron and zinc was more abundant and showed the highest concentration in the schools. The lowest concentration of metal was lead and copper.

In order of abundance, the highest concentrations of heavy metals found in schools are Iron, Zinc, Manganese, Copper, Cadmium, Lead, Chromium and Nickel.

2.2. Heavy metal contamination in Earthworms

For more than 200 years, earthworms have played a crucial role in soil toxicity testing; this group has been particularly studied in relation to the problem of heavy metal bio-accumulators (Gobalt et al., 2004). Except for very dry and acidic soil, earthworms can be found in all types of soil (Elaigwu et al., 2007). They accumulate the most heavy metals, particularly Cadmium and Zinc (Hobbelen et al., 2006). Because earthworms absorb heavy metals, they pose a potential pollution risk. Heavy metal accumulation in Aporrectodea longa raises the concentration of these pollutants in the soil. The use of biological indicators to monitor toxic substances in the environment is well established (Bamigbose, 2000).

Owagboriaye et al., (2015) examined heavy metal bioaccumulation in earthworms obtained from abattoir soils in Abeokuta, Nigeria. The study found that the concentrations of all metals tested were higher in L. violaceous tissue than in *A. milsoni* and *E. eugeniae* tissue. The concentrations of Cu, Zn, Pb, Cd, and Ni in earthworm tissues were discovered to be directly dependent on the metal concentrations in their respective abattoir soil, as evidenced by the positive correlation between metal accumulation and metal concentrations in the abattoir soil. This study clearly shows that earthworms bioaccumulate heavy metals from their soil substrates in their body tissues. This study showed that earthworms accumulated some heavy metals from abattoir soils and can thus be used as a bioindicator for heavy metal pollution.

Oketola et al., (2015) analyzed the assessment of heavy metals in soil and earthworm (as a bio-indicator) near the Isheri Cattle Market on the Lagos-Ibadan Express Road. The results show that the market earthworm species is a good bioindicator of heavy metals, particularly chromium (Cr), nickel (Ni), and copper (Cu). The findings are consistent with Bamigbose's (2000) assertion that earthworms are excellent heavy metal accumulators. The findings also show that the earthworm species in the test areas are poor bioindicators of Zn. This observation is consistent with Ireland's (1983) report, which found a low concentration of 0.34mg/g of Zn in comparison to other metals. The species present in the market were unable to also accumulate Pb. There are numerous reasons why the earthworm in the market is unable to absorb or accumulate certain metals. Earthworms can avoid unfavorable environments due to a high number of chemo-receptors in their prostomium, which causes them to react sensitively to chemical influences.

Bamidele et al., (2015) investigated the heavy metal accumulation and biochemical evaluation of earthworms from sawmills in Abeokuta, Nigeria. The concentrations of these heavy metals (Pb and Cd) were significantly higher in Sapon sawmill soil and earthworm samples than in the other locations. Sapon Sawmill is located in the commercial heart of Abeokuta, with heavy vehicular traffic passing through two major roads very close to the sawmill. It is possible that the high levels of Pb found in Sapon sawmill earthworm and plant samples are a result of soil contamination from vehicular emissions on busy roads, combined with several other inputs from nearby commercial activities. Heavy metal contamination of sawmill soils was discovered to have affected the body protein banding pattern of sawmill earthworms. *Eudrilus eugeniae* found in the sawmill showed more protein bands than the control site.

Agbaire et al., (2012) investigated heavy metal bioaccumulation by earthworm (*Lumbricus terrestris*) and associated soils in a domestic dumpsite in Abraka, Delta State, Nigeria. This study confirms that earthworms accumulated heavy metals from domestic dumpsite soils and can thus be used as a bio-indicator of pollution. The study also revealed that the concentrations of these metals accumulated in earthworm tissue were less than one. Furthermore, the availability of metals in soils was influenced by soil pH and organic matter, which accounted for the variation in metal concentrations between sites. The results also revealed that metal contamination is possible as a result of indiscriminate deposition of used metals.

Elaigwu et al. (2007) researched on the earthworm (Eudrilus eugenia kinberg) as a bio-indicator of heavy metal pollution in two municipal dump sites in two northern Nigerian cities. The findings of this study indicate that, while the concentration of metals found in earthworms is dependent on the concentration in dumpsites, the levels in earthworms do not consistently reflect the metal contamination levels present in dumpsites. This may be due to the maturity of the individual earthworm, as accumulations of Cd, Pb, and Zn in earthworms can significantly increase with developmental stage (Ma et al., 1983). Furthermore, the differences found between this study and previous studies conducted in the southern part of the country suggest that earthworm habitat may influence bioaccumulation of these metals.

2.3. Heavy metals Effect on Children

Although the body requires minimal quantities of heavy metal ions such as Zn2+, Mn2+, Fe2+, and Cu2+ for growth and health, excessive amounts are toxic (Valko et al., 2005). However, some of them, such as (Pb2+, Hg2+, As3+, Cd2+), have been identified as contaminants and toxic substances even at very low concentrations, posing a serious risk to human health and the environment (Bagal-Kestwal et al., 2008; Patrick, 2006). These pollutants can cause anemia, liver and kidney damage, and stomach irritation (Wuana and Okieimen, 2011), while Cadmium and Lead at extremely low concentrations can cause toxicity and lead to cancer (Willers et al., 2001).

Durowoju et al. (2018) accessed the Health Risk Assessment of Heavy Metals on Primary School Learners from Dust and Soil within School Premises in Lagos State, Nigeria. Heavy metal concentrations (Pb, Cr, Cd, and Mn) were measured in the playgrounds and classrooms of selected primary schools in Lagos State. Except for Mn, the concentrations of metals detected in classroom dust and playground soils exceeded the DPR, FEPA, and WHO permissible limits. The high concentrations of heavy metals could be due to the schools' proximity to bus stops, auto workshops, nearby industries, gas stations, and paint chippings. According to the findings, the primary route of exposure for children to playground soil and classroom dust is ingestion, followed by dermal exposure. The high concentrations of heavy metal pollution indicated may pose a non-cancer health risk to children attending such schools. This could be attributed to the

6-year short-term exposure duration (ED). The USEPA health assessment model used in the study was recommended. The findings also suggest that children may be exposed to non-carcinogenic risk via the ingestion pathway, followed by the inhalation pathway if long-term exposure is considered.

The following are adverse health effects on children associated with some of the heavy metal:

Lead accumulates in body organs (such as the brain), causing poisoning or even death. The presence of lead also has an effect on the gastrointestinal tract, kidneys, and central nervous system. Various effects occur over a broad range of doses, with developing children and infants being more sensitive than adults. Lead poisoning is common, and the majority of poisoned children show no symptoms (CDC, 1991). Children who are exposed to lead have a lower IQ, a shorter attention span, hyperactivity, and mental deterioration, with children under the age of six being at a higher risk (NSC, 2009).

Cadmium- The tobacco plant naturally accumulates high levels of cadmium in its leaves. Thus, smoking tobacco is a significant source of exposure, and in the case of heavy smokers, daily intake may exceed that from food. Tobacco inhalation can result in significant increases in cadmium concentrations in children's kidneys, the primary target organ for cadmium toxicity (WHO, 2011). Cadmium has been linked to behavioral and cognitive dysfunction, including poor learning memory in children.

Copper- Copper exposure can cause mental illnesses such as Alzheimer's and manganism, which frequently affects children's intellectual functioning. Other side effects include hemolysis, genetic disorders, and kidney failure. Excessive copper has a negative impact on the nervous system, including movement disorders.

Nickel is the leading cause of allergic contact dermatitis (ACD) in children. Nickel ACD is a major cause of cutaneous disease in children. When taken in large quantities, it generally causes skin irritation in children.

Zinc- Acute zinc toxicity due to heavy metal contamination can lead to gastrointestinal problems in children.

Iron- It causes a decrease in height and weight, as well as an increase in illness. When the liver stores too much iron, it can be damaged, resulting in hepatitis, a viral liver infection. Excess iron is also deposited in other organs and tissues, particularly the heart and pancreas, causing damage to these organs as well. Excessive iron consumption in children can lead to early death from heart failure if not detected and treated.

Chromium- In children, too much chromium can cause stomach problems and low blood sugar (hypoglycemia). Too much chromium can also cause liver, kidney, and nerve damage, as well as irregular heart rhythm.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

Edo state is one of the 36 states located in Nigeria's southern region. It is an urbanized state with an estimated amount of 50 industries, the majority of which are pharmaceutical industries, rubber industries, plywood manufacturing industries, and oil palm institute. Five schools in total were carefully selected for this research in two different Local Government Area; Egor Local Government Area (Olua primary school and Calvary Crown School) and Ovia North-East Local Government Area (Owina Primary School, University of Benin Teaching Hospital Staff School and Impact Academy). These schools were randomly selected based on their proximity to major city roads as well as their proximity to industrial activities or metal manufactured product (metal swings, slides etc.).

Plate 1: UBTH staff school

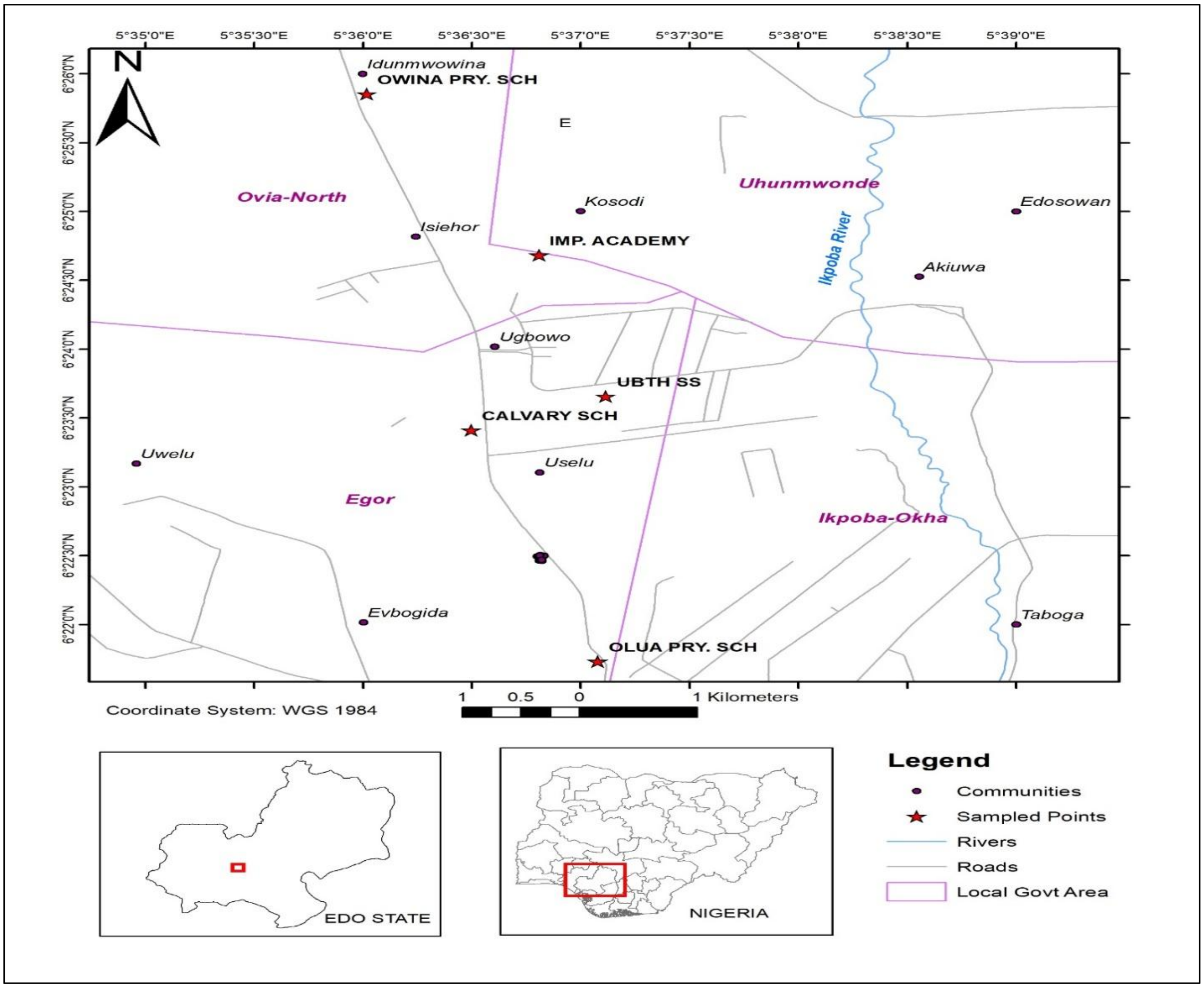

Fig 1: Map depicting the sampled kindergarten location in Benin-City

3.2 Sampling of Soil and Earthworm

Samples of soil were collected in groups of twos from different points in the schools. A point was picked in the play area of each school i.e. spots where the children frequently play during recess or the playground of the schools. A total of 10 soil samples were obtained and stored in a black polythene bag. The earthworms were obtained mostly from dumpsites or moist locations within the schools and were placed in a petri dish. In each location, a total of 4-7 earthworms were collected and stored. After obtaining both the soil and earthworm samples, they were kept in the refrigerator awaiting analysis.

3.3 Preparation and Digestion of Samples

The soil samples were air-dried in the laboratory for 24 hours. 0.5-1.0g of soil was weighed and 10ml of mixed acid was added to the weighed sand. It takes about 30mins-1 hour for clear digestion of the sample. The earthworms were brought out from the refrigerator where they were weighed. All the five samples gotten from the five different schools were weighed before being placed in a beaker. 10ml of nitric acid was then added to each sample and was stirred for proper mixture and dissolution.

The following apparatus were used for the digestion procedure;

- 250ml digestion tubes
- Heater
- Funnels
- 25ml volumetric flasks
- Beaker
- Filter paper
- While the reagent used was Perchloric Acid.

After adding the acid, the solution was then filtered using filter paper and funnel into 250ml digestion tubes. The digestion tubes were brought to the heater and heat was applied until a clean clear solution was gotten. After a clear solution is gotten, the heat was removed and the solution left to cool. Then a little amount of deionized water was added to the solution to prevent burning of the filter paper when filtering. The solution was filtered using a filter paper whitemann into a 25 ml volumetric flask. Then deionized water was added to make it up to the 25ml mark. Each flask was labeled appropriately. A reagent blank was prepared without deionized water before determination of choice metals was carried out using the Atomic Absorption Spectrophotometer (A.A.S.) machine.

3.4 Determination of Heavy Metals

To obtain a calibration curve, the equipment (A.A.S.) was first calibrated using Buck certified atomic absorption standards for the respective metals of choice. The following procedure was used to prepare standard solutions for machine calibration for each metal of interest;

10 ml stock solution (1000 ppm) is introduced into a 100 ml volumetric flask and diluted to volume with deionized water. This solution contains 100 ppm of the metal. From the diluted stock solution 10 ml of it was taken and introduced into a 100 ml volumetric flask and was made up to mark. These solutions contain 10 ppm of the metal. 1, 2, 4, 6, 8, and 10 ml was taken from the second diluted stock solution in 50 ml numbered flask and then made to mark with deionized water. These solutions contain 0.2, 0.4, 0.8, 1.2, 1.6, and 2.0 ppm of metal of interest. They were then used to calibrate the machine.

The element's lamp was inserted into the A.A.S. machine to determine the metal. To eliminate equipment drift, the solutions of each sample were run through the A.A.S. machine while blanking with deionized water (reagent blank) at intervals of each sample analysis. Each metal's value was then precisely recorded. All samples were tested in duplicate to ensure reproducibility, accuracy, and precision.

3.5 Data Analysis

The collected data was analyzed using the computer software EXCEL and SPSS (Statistical Package for Social Sciences) v.20. The heavy metal levels in the soil and earthworm were characterized using basic statistical measurements. The heavy metal concentrations were compared using one way ANOVA at the 0.05 level of significance. Post Hoc tests were done using Duncan Multiple Range (DMR) test.

CHAPTER FOUR

RESULT

4.1 Heavy metal content in soils in schools

The results of the concentration of metals across all schools are given in Table 4.1. Result from this study which was restricted to soil of selected school in Benin shows that the playgrounds are polluted with Cr, Cd, Pb, Fe, Zn, Ni and Cu which arises from anthropogenic deposition.

4.1.1 Concentration of iron in the soil of selected school

Mean concentration of iron in the soil is shown in Table 4.1. The total iron concentration recorded ranged between 14.56 to 121.3 mg/kg with Ubth being the lowest and Calvary Crown being the highest. There was a significant difference ($p < 0.005$) in the concentration of iron between the schools. Duncan multiple range (DMR) post-hoc test showed three grouping. Two schools (calvary and owina) were in homogeneous subsets and were found to be significantly different from other subsets, impact and olua schools were in the same homogenous subset and ubth being alone in a subset. The highest mean concentration (106±8.37) was in owina school and the lowest (15.46±0.89) was in ubth school.

4.1.2 Concentration of zinc in the soil of selected school

Mean concentration of zinc in the soil is shown in Table 4.1. The total zinc concentration recorded ranged between 5.98 to 43.22 mg/kg with Ubth being the lowest and Owina School being the highest. There was a highly significant difference ($p<0.001$) in the concentration of zinc between the schools. Duncan multiple range (DMR) post-hoc test showed three groupings. Owina school was in the last subset and was significantly different from other subsets. Olua and calvary school were in the same homogeneous subsets and, impact academy and ubth schools were also in the same homogenous subset having the lowest values. The highest mean concentration (41.55±1.67) was in owina school and the lowest (6.21±0.23) was in Ubth school.

4.1.3 Concentration of chromium in the soil of selected school

Mean concentration of chromium in the soil is shown in Table 4.1. The total chromium concentration recorded ranged between 1.56 to 15.44 mg/kg with Ubth being the lowest and Owina School being the highest. There was no significant difference ($p>0.005$) in the concentration of chromium between the schools. Duncan multiple range (DMR) post-hoc test showed two groupings. Ubth and impact academy were in the same homogenous subset and calvary crown, owina and olua schools were in the same subset. The highest mean concentration (11.57±1.09) was in owina school and the lowest (1.97±0.41) was in ubth school.

4.1.4 Concentration of copper in the soil of selected school

Mean concentration of copper in the soil is shown in Table 4.1. The total copper concentration recorded ranged between 0.73 to 19.26 mg/kg with Ubth being the lowest and Owina School being the highest. There was a significant difference ($p<0.005$) in the concentration of copper between the schools. Duncan multiple range (DMR) post-hoc test showed three groupings. Calvary crown was in the same homogenous subset with Owina School and they were significantly different from other subset. The highest mean concentration (19.12±0.15) was in Owina School and the lowest (2.24±1.51) was in Ubth School.

4.1.5 Concentration of lead in the soil of selected school

Mean concentration of lead in the soil is shown in Table 4.1. The total lead concentration recorded ranged between 0.38 to 1.44 mg/kg with Impact academy being the lowest and Calvary crown school being the highest. There was no significant difference ($p>0.005$) in the concentration of lead between the schools. Duncan multiple range (DMR) post-hoc test showed two groupings. Impact academy, Ubth, Owina and Olua were in the same homogenous subset while Calvary being the highest value was alone in a homogenous subset . The highest mean concentration (1.36±0.08) was in Calvary crown school and the lowest (0.39±0.02) was in Impact academy.

4.1.6 Concentration of nickel in the soil of selected school

Mean concentration of nickel in the soil is shown in Table 4.1. The total nickel concentration recorded ranged between 2.16 to 4.28 mg/kg with Ubth school being the lowest and Olua school being the highest. There was a significant difference ($p<0.005$) in the concentration of nickel between the schools. Duncan multiple range (DMR) post-hoc test showed three groupings. Calvary crown is in the same homogenous subset with owina and olua school and they have a significant difference with the other subset. The highest mean concentration (4.19±0.09) was in Olua school and the lowest (2.35±0.19) was in Ubth school.

4.1.7 Concentration of cadmium in the soil of selected school

Mean concentration of cadmium in the soil is shown in Table 4.1. The total cadmium concentration recorded ranged between 0.012 to 0.04 mg/kg with Impact academy being the lowest and Calvary crown being the highest. There was no significant difference ($p>0.005$) in the concentration of cadmium between the schools. Duncan multiple range (DMR) post-hoc test showed two groupings. Impact academy, Owina school, Ubth and Olua were in the homogenous subset while Calvary crown which was the highest value was in the next subset. The highest mean concentration (0.032±0.006) was in Calvary crown and the lowest (0.014±0.002) was in Impact academy.

Table 4.1: Concentration of Heavy metals in Soils of selected school

Parameter	Owina school Mean±SD (Min-Max)	Olua school Mean±SD (Min-Max)	Ubth school Mean±SD (Min-Max)	Calvary crown Mean±SD (Min-Max)	Impact academy Mean±SD (Min-Max)	P-value
Iron	106.79±8.37[c] (98.42-115.2)	71.54±2.8[b] (68.74-74.34)	15.46±0.89[a] (14.56-16.35)	104.35±16.9[c] (87.39-121.3)	50.23±2.95[b] (47.28-53.17)	p<0.005*
Zinc	41.55±1.67[c] (39.87-43.22)	30.87±1.59[b] (29.28-32.46)	6.21±0.23[a] (5.98-6.43)	35.1±3.44[b] (31.66-38.54)	13.07±1.89[a] (11.18-14.96)	p<0.001**
Chromium	11.57±1.09[b] (10.48-12.65)	12.86±2.58[b] (10.28-15.44)	1.97±0.41[a] (1.56-2.38)	9.86±0.57[b] (9.29-10.43)	4.19±0.03[a] (4.17-4.22)	p>0.005
Copper	19.12±0.15[c] (18.97-19.26)	12.49±0.79[b] (11.69-13.28)	2.24±1.51[a] (0.73-3.74)	16.69±1.42[c] (14.28-17.11)	7.98±0.62[b] (7.36-8.59)	p<0.005*
Lead	0.69±0.07[b] (0.63-0.76)	0.79±0.21[b] (0.58-0.99)	0.49±0.04[b] (0.46-0.53)	1.36±0.08[b] (1.28-1.44)	0.39±0.02[b] (0.38-0.41)	p>0.005
Nickel	3.47±0.19[b] (3.28-3.65)	4.19±0.09[c] (4.11-4.28)	2.35±0.19[a] (2.16-2.54)	3.94±0.18[b] (3.76-4.11)	2.59±0.26[a] (2.33-2.85)	p<0.005*
Cadmium	0.017±0.002[a] (0.015-0.018)	0.024±0.007[a] (0.017-0.031)	0.018±0.004[a] (0.014-0.021)	0.032±0.006[b] (0.027-0.04)	0.014±0.002[a] (0.012-0.016)	p>0.005

*p<0.01- Highly significant difference   p<0.05- Significant difference   p>No significant difference. * Indicates significant difference between locations at p<0.005. ** indicates highly significant difference at p< 0.001. [ab] The same superscripts indicate similar homogenous subsets based on Duncan multiple range post-hoc test.*

4.2 Concentration of heavy metal in *Aporrectodea longa* in selected schools

The result of the concentration of heavy metals in earthworms (*Aporrectodea longa*) found in the selected school is given below in Table 4.2.

4.2.1 Concentration of iron in earthworms of selected school

Mean concentration of iron in earthworm is shown in Table 4.2. The total iron concentration recorded ranged between 49.45 to 95.73 mg/kg with Impact academy being the lowest and Olua school being the highest. There was a highly significant difference ($p<0.001$) in the concentration of iron between the earthworms across the schools. Duncan multiple range (DMR) post-hoc test showed three groupings. Olua school was more significantly different from other homogenous subsets. Impact and Owina school were in the same homogenous subset. The highest mean of earthworm concentration (94.70±1.02) was in Olua school and the lowest (50.65±1.2) was in Impact academy.

4.2.2 Concentration of zinc in earthworms of selected school

Mean concentration of zinc in earthworm is shown in Table 4.2. The total zinc concentration recorded ranged between 18.93 to 108.7 mg/kg with Impact academy being the lowest and Olua school being the highest. There was a highly significant difference ($p<0.001$) in the concentration of zinc between the earthworms across the schools. Duncan multiple range (DMR) post-hoc test showed three groupings. Olua school was more significantly different from other homogenous subsets. Ubth and Owina school were in the same homogenous subset. Impact academy recorded the lowest level of concentration. The highest mean of earthworm concentration (105.1±3.64) was in Olua school and the lowest (21.2±2.27) was in Impact academy.

4.2.3 Concentration of chromium in earthworms of selected school

Mean concentration of chromium in earthworm is shown in Table 4.2. The total chromium concentration recorded ranged between 1.86 to 5.74 mg/kg with Owina school being the lowest and Calvary crown being the highest. There was a highly significant difference ($p<0.001$) in the concentration of chromium between the earthworms across the schools. Duncan multiple range (DMR) post-hoc test showed two groupings. Impact academy and Calvary crown are in the same homogenous subset and were found to be significantly different from the other subset. The highest mean of earthworm concentration (5.69±0.06) was in Calvary crown and the lowest (2.00±0.14) was in Owina school.

4.2.4 Concentration of copper in earthworms of selected school

Mean concentration of copper in earthworm is shown in Table 4.2. The total copper concentration recorded ranged between 6.47 to 50.27 mg/kg with Impact academy being the lowest and Olua school being the highest. There was a highly significant difference ($p<0.001$) in the concentration of copper between the earthworms across the schools. Duncan multiple range (DMR) post-hoc test showed three groupings. Olua school was more significantly different from other homogenous subsets. Ubth and Owina school were in the same homogenous subset. Impact academy had the lowest value of concentration. The highest mean of earthworm concentration (49.32±0.04) was in Olua school and the lowest (7.23±0.76) was in Impact academy.

4.2.5 Concentration of lead in earthworms of selected school

Mean concentration of lead in earthworm is shown in Table 4.2. The total lead concentration recorded ranged between 0.23 to 0.63 mg/kg with Calvary crown being the lowest and Impact academy being the highest. There was a significant difference ($p<0.005$) in the concentration of lead between the earthworms across the schools. Duncan multiple range (DMR) post-hoc test showed three groupings. Olua school and Impact academy were more significantly different from other homogenous subsets. Calvary and Owina school were in the same homogenous subset and had the lowest concentration. The highest mean of earthworm concentration (0.59±0.04) was in Impact academy and the lowest (0.25±0.02) was in Calvary crown.

4.2.6 Concentration of nickel in earthworms of selected school

Mean concentration of nickel in earthworm is shown in Table 4.2. The total nickel concentration recorded ranged between 0.22 to 0.62 mg/kg with Impact academy being the lowest and Ubth school being the highest. There was a significant difference ($p<0.005$) in the concentration of nickel between the earthworms across the schools. Duncan multiple range (DMR) post-hoc test showed three groupings. Ubth school was more significantly different from other homogenous subsets. Olua school and Calvary crown were in the same homogenous subset. Impact academy and Owina school recorded the lowest level of concentration. The highest mean of earthworm concentration (0.59±0.03) was in Ubth school and the lowest (0.25±0.03) was in Impact academy.

4.2.7 Concentration of cadmium in earthworms of selected school

Mean concentration of cadmium in earthworm is shown in Table 4.2. The total cadmium concentration recorded ranged between 0.04 to 0.14 mg/kg with Impact academy being the lowest and Ubth school being the highest. There was no significant difference ($p>0.005$) in the concentration of cadmium between the earthworms across the schools. Duncan multiple range (DMR) post-hoc test showed two groupings. Owina, Calvary crown, Olua and Ubth school are in the same homogenous subset. Impact academy recorded the lowest concentration. The highest mean of earthworm concentration (0.12±0.02) was in Ubth school and the lowest (0.05±0.002) was in Impact academy.

Table 4.2: Concentration of Heavy metals in Earthworms

Parameter	**Owina school** Mean±SD (Min-Max)	**Olua school** Mean±SD (Min-Max)	**Ubth school** Mean±SD (Min-Max)	**Calvary crown** Mean±SD (Min-Max)	**Impact academy** Mean±SD (Min-Max)	**P-value**
Iron	55.41±2.04^a (53.37-57.45)	94.70±1.02^c (93.68-95.73)	88.57±0.88^b (87.69-89.44)	80.31±2.07^b (78.24-82.37)	50.65±1.2^a (49.45-51.85)	$p<0.001^{**}$
Zinc	48.02±1.74^b (46.28-49.76)	105.1±3.64^c (101.4-108.7)	50.31±0.77^b (49.54-51.07)	74.64±2.69^b (71.95-77.32)	21.2±2.27^a (18.93-23.47)	$p<0.001^{**}$
Chromium	2±0.14^a (1.86-2.14)	2.37±0.15^a (2.22-2.51)	2.25±0.32^a (1.93-2.57)	5.69±0.06^b (5.63-5.74)	5.32±0.06^b (5.26-5.38)	$p<0.001^{**}$
Copper	15.48±0.91^b (14.57-16.38)	49.32±0.96^c (48.36-50.27)	16.23±1.1^b (15.13-17.33)	26.65±1.21^b (25.44-27.85)	7.23±0.76^a (6.47-7.98)	$p<0.001^{**}$
Lead	0.3±0.02^a (0.28-0.32)	0.5±0.02^c (0.48-0.52)	0.44±0.02^b (0.42-0.46)	0.25±0.02^a (0.23-0.27)	0.59±0.04^c (0.55-0.63)	$p<0.005^{*}$
Nickel	0.32±0.005^a (0.32-0.33)	0.4±0.02^b (0.38-0.42)	0.59±0.03^c (0.57-0.62)	0.43±0.03^b (0.4-0.46)	0.25±0.03^a (0.22-0.27)	$p<0.005^{*}$
Cadmium	0.09±0.002^b (0.08-0.09)	0.09±0.003^b (0.092-0.097)	0.12±0.02^b (0.09-0.14)	0.09±0.003^b (0.09-0.092)	0.05±0.002^a (0.04.0.05)	$p>0.005$

p<0.01- Highly significant difference   p<0.05- Significant difference   p>No significant difference. * Indicates significant difference between locations at p<0.005. ** indicates highly significant difference at p< 0.001. ^{ab} The same superscripts indicate similar homogenous subsets based on Duncan multiple range post-hoc test.

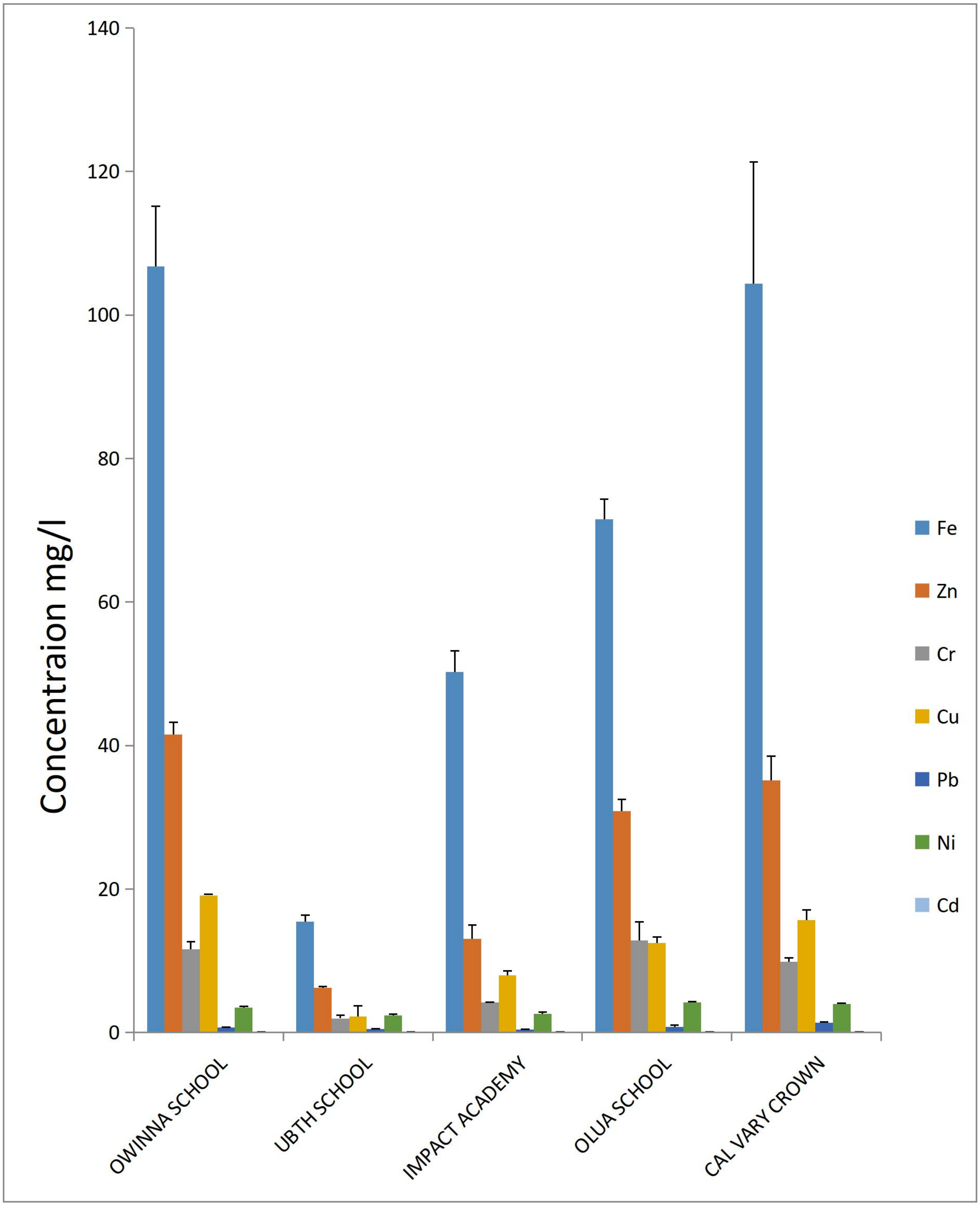

Figure 1: Concentration of heavy metals in soils across selected schools

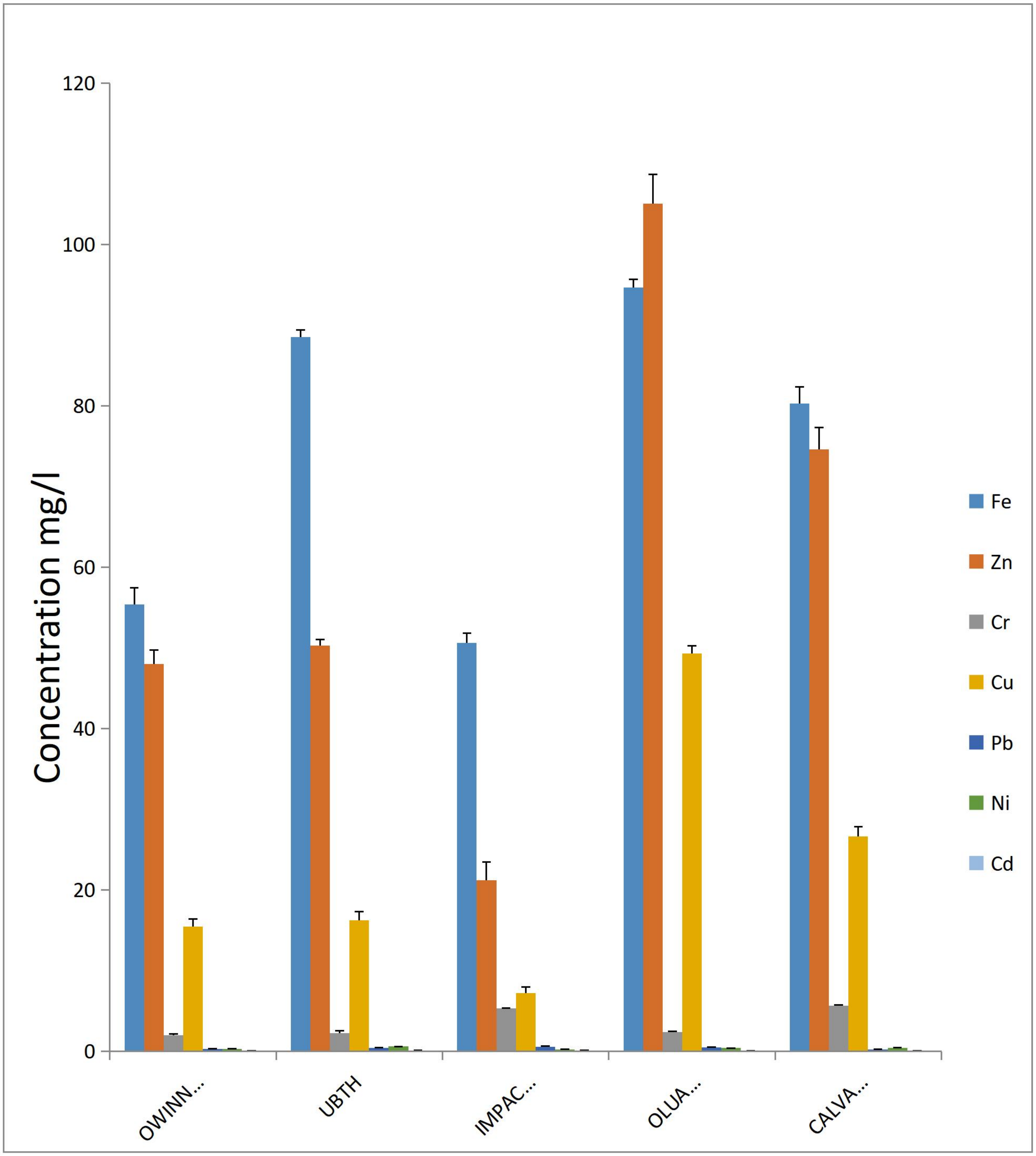

Figure 2: Concentration of heavy metals in earthworms across selected schools

CHAPTER FIVE

DISCUSSION OF RESULT

The concentration of all heavy metal observed in the soil showed a great significant difference ($p>0.05$) across the selected schools apart from Cr, Pb and Cd which had no significant difference across the schools. The result of this study showed that Fe was the most abundant heavy metal in soil and earthworm samples obtained across the various schools. This observation falls in line with the records of Akinwumi et al., (2017) who also had iron as the dominant heavy metal in the playgrounds of primary and nursery schools within Ibadan Northwest local government area, Nigeria. Generally, Cd was the least concentrated of all the heavy metals analyzed in this study. In ranking of these heavy metals in soils in order of decreasing concentration, slight differences was observed. In Owina, Ubth, Calvary crown and Impact academy, the order was Fe>Zn>Cu>Cr>Ni>Pb>Cd while the order in Olua school was Fe>Zn>Cr>Cu>Ni>Pb>Cd. The concentration of heavy metals in earthworm showed a highly significant difference ($p<0.001$) across the selected schools apart from Pb, Ni and Cd. The result indicates that Fe was the most abundant heavy metal observed in the earthworms across the various school apart from Olua school which showed Zn as the most abundant metal.

Iron is found everywhere in the external and internal environment e.g. utensils, machineries and tool, playground equipment, vehicles etc. They are built up in the environment and are likely the most abundant heavy metal recorded. The concentration of Fe at Owina, Olua, Ubth, Calvary crown and Impact academy are 106.79, 71.54, 15.46, 104.35, and 50.23 (mg/kg) respectively. Lower concentrations of Fe were recorded at Ubth staff school followed by Impact academy. The highest concentration of Fe was recorded at Owina School thereafter followed by Calvary crown school. Statistical analysis showed a significant difference ($p<0.005$) on the concentration of Fe in the soil. The concentration of Fe found in various soil samples were low when compared to the value of 22,991 mg/kg and 8522 mg/kg obtained in the playground in Hong Kong and Madrid, Spain respectively. The concentration of iron in earthworms in Owina, Olua, Ubth, Calvary crown and Impact academy is 55.41, 94.70, 88.57, 80.31 and 50.65 (mg/kg) respectively. The highest concentration of Fe was recorded at Owina School and the lowest at Impact academy.

The concentration of Zn at Owina, Olua, Ubth, Calvary crown and Impact academy are 41.55, 30.87, 6.21, 35.1 and 13.07 respectively. The highest concentration was recorded at Owina School. Statistical analysis showed a highly significant difference ($p<0.001$) on the concentration of Zn in the soil. The concentration of zinc in earthworms in Owina, Olua, Ubth, Calvary crown and Impact academy is 48.02, 105.1, 50.31, 74.64 and 21.2 (mg/kg) respectively. The highest concentration of Zn was recorded at Olua School and the lowest at Impact academy. Kamani *et al.,* (2011) reported the presence of high levels of zinc in soil which he attributed to close traffic area and wear and tear of vehicle tires. However, the prevalence of Zn, though the least toxic heavy metal (Lapido and Doherty, 2011) is an indication of the significance of this metal in our ecosystem (Olukanni and Adebayo, 2012). The health implications of increased level of Zn in human system include severe vomiting, bloody urine, diarrhea, liver and kidney failure.

The concentration of Cr at Owina, Olua, Ubth, Calvary crown and Impact academy are 11.57, 12.86, 1.97, 9.86 and 4.19 respectively. The highest concentration was recorded at Olua school and the lowest concentration recorded was at Impact academy. Statistical analysis showed no significant difference ($p>0.005$) on the concentration of Cr in the soil across the schools. It was observed that Olua and Owina schools both had high concentrations and this can be attributed to the fact that these school are along the road. The concentration of chromium in earthworms in

Owina, Olua, Ubth, Calvary crown and Impact academy is 2.0, 2.37, 2.25, 5.69 and 5.32 (mg/kg) respectively. The highest concentration of Cr was recorded at Owina School and the lowest at Calvary crown.

The concentration of Cu at Owina, Olua, Ubth, Calvary crown and Impact academy are 19.12, 12.49, 2.24, 16.69 and 7.98 respectively. The highest concentration was recorded at Owina school and the lowest concentration recorded was at Ubth school. Statistical analysis showed no significant difference ($p>0.005$) on the concentration of Cu in the soil across the schools. Too much intake of soluble copper can result in the bioaccumulation of copper in the system and may lead to inabilty of the liver to function properly. The concentration of copper in earthworms in Owina, Olua, Ubth, Calvary crown and Impact academy is 15.48, 49.32, 16.23, 26.65 and 7.23 (mg/kg) respectively. The highest concentration of Cr was recorded at Olua School and the lowest at Impact academy.

Lead is described as a classical chronic or cumulative poison, which may result in neurological, hematological, behavioral, renal, cardiovascular and reproductive effects at levels above the tolerable limit (WHO, 2011). The concentration of Pb at Owina, Olua, Ubth, Calvary crown and Impact academy are 0.69, 0.79, 0.49, 1.36, and 0.39 respectively. The highest concentration was recorded at Calvary crown school and the lowest concentration recorded was at Impact academy. Statistical analysis showed no significant difference ($p>0.005$) on the concentration of Pb in the soil across the schools. It has been reported that children are more susceptible to lead toxicity because intestinal absorption of lead is five times greater in children than in adults (Ikenaka *et al., 2010*). The concentration of lead in earthworms in Owina, Olua, Ubth, Calvary crown and

Impact academy is 0.3, 0.5, 0.44, 0.25 and 0.59 (mg/kg) respectively. The highest concentration of Pb was recorded at Impact academy and the lowest at Calvary crown.

The concentration of Ni at Owina, Olua, Ubth, Calvary crown and Impact academy are 3.47, 4.19, 2.35, 3.94 and 2.59 respectively. The highest concentration was recorded at Olua school and the lowest concentration recorded was at Impact academy. Statistical analysis showed a significant difference ($p<0.005$) on the concentration of Ni in the soil across the schools. The levels of nickel across the schools were within the permissible level according to the permissible limit by WHO. The concentration of nickel in earthworms in Owina, Olua, Ubth, Calvary crown and Impact academy is 0.32, 0.4, 0.59, 0.43 and 0.25 (mg/kg) respectively. The highest concentration of Ni was recorded at Ubth school and the lowest at Impact academy.

The concentration of Cd at Owina, Olua, Ubth, Calvary crown and Impact academy are 0.017, 0.024, 0.018, 0.032 and 0.014 respectively. The highest concentration was recorded at Calvary crown school and the lowest concentration recorded was at Impact academy. Statistical analysis showed no significant difference ($p>0.005$) on the concentration of Cd in the soil across the schools. The concentration of cadmium in earthworms in Owina, Olua, Ubth, Calvary crown and Impact academy is 0.09, 0.09, 0.12, 0.09 and 0.05 (mg/kg) respectively. The highest concentration of Cd was recorded at Ubth school and the lowest at Impact academy.

CONCLUSION

Heavy metal concentrations were relatively low when compared with the values obtained around the world, but the values in these selected schools can accumulate to constitute health hazards to children. Heavy metal concentrations (Fe, Zn, Cr, Cu, Pb, Ni and Cd) were measured in the playgrounds and around classrooms environment of selected nursey and primary schools in Benin City. The concentration of Fe and Zn in the soil and earthworm sample were relatively high and abundant. The high concentrations of heavy metals could be due to the schools' proximity to the main roads, bus stops, auto workshops, nearby industries or gas stations. According to the findings, the primary route of exposure for children to playground soil and classroom is accidental ingestion, followed by dermal exposure.

Effective measures to control heavy metal toxicities in children include the reduction of metal playground equipment which is a major source of these metals in the school environment and introduction of personal hygiene after children play in these contaminated soils. The present data can help in future monitoring programs that is focused on metal contamination in schools in Benin, Nigeria.

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