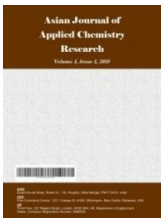

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Assessment of Heavy Metal and Selenium Levels in Leachates and Soils of Central Bank of Nigeria Dumpsite Makurdi

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Authors' contributions

This work was carried out in collaboration between all authors. Authors ISE and AJE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ISE, AJE and RAW managed the analyses of the study. Authors ISE and AJE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Leachates from dumpsite basically contain a wide range of heavy metals and selenium. However, heavy metals have negative public health and environmental impacts once the leachates are allowed to infiltrate into groundwater. This is one of the oldest, growing problems threatening the surrounding globally. Therefore, it is imperative to quantify the information on the environmental impact of heavy metal and selenium levels, and suggesting various techniques that could be used to clean-up their concentrations from the environment to the minimum to ameliorate the plight of the people. The aim of this study was to determine the concentration of heavy metal and selenium levels in leachate of Central Bank of Nigeria dumpsite along University of Agriculture Road-Makurdi and also to investigate their levels in soil around the dumpsite platform. The concentrations of some heavy metals such as Chromium (Cr), Lead (Pb), Cadmium (Cd), Mercury (Hg) and non metal Selenium (Se) levels in leachate from Central Bank of Nigeria Dumpsite platform and surrounding soil along University of Agriculture road, Makurdi, were determined using

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Atomic absorption spectrophotometry (Flame AAS) for Cr, Pb and Cd while cold vapour and hydride generation were used for Hg and Se respectively. The soil samples were collected at different depths (cm) 0 – 20, 20 – 40, 40 – 60 and 60 – 80. The levels of all heavy metals and non metal selenium in this study area were found to be higher than those of the control samples. The total mean concentration of the soil samples analysed for each metal and selenium levels at different depths range from Cr (74.7 – 2.6 mg/kg), Cd (7.41 – 0.6 mg/kg), Hg (4.45 – 1.4 mg/kg), Se (2.04 – 1.2 mg/kg) and Pb (8.53 – 1.7 mg/kg). The concentrations in leachates were Cr (0.079 mg/L), Cd (0.010 mg/L), but Pb, Hg and Se were not detected. The concentrations of Cr and Cd determined in leachate were below the WHO standard limits. Similarly, the concentrations of Pb, Hg and Se in soil analyzed in this study were within the permissible limits. However, the concentration of Cr and Cd were found to be higher than the permissible limits due to the increasing anthropogenic activities in the area. Awareness of the level of soil and leachate pollution around the dumpsite needs to be created urgently especially among people living in the environment. Proper and effective waste management plan should be developed and implemented.

Keywords: Heavy metals; leachate; dumpsite; AAS; soil.

1. INTRODUTION

Leachate can be defined as wastewater that infiltrate into groundwater. Leachate from dumpsite is one of the oldest, growing problems threatening the surroundings globally [1]. Dumpsites practice involves placing waste in one area with the main target of controlling pollution [1,2]. In developing countries this concept is usually an unlined shallow hollow pit not deeper than 50 cm. Tse and Adamu [3] defined dumpsite as a pit that receive solid wastes in a more or less uncontrolled manner, making uneconomical use of the available space which gives room to waste pickers, Distasteful and hazardous smoke are produced during cleanup process using slow-burning fire. Hence, leachate of diverse composition are been generated, based on the nature of site construction and running practice adopted. Apart from that, the age of the dumpsite, climatic and hydrological conditions and surface water ingress into the dumpsite Tse and Adamu [3] plays a vital role in leachate infiltration, making it possible to move vertically and horizontally into the environment by direct discharge into streams and natural water bodies around the dumpsite. In Makurdi, leachate from refuse or open waste dumpsites are considered as good source of heavy metal pollution to both soil and aquatic surroundings Odukoya et al. [4] because open waste disposal is a common practice by the inhabitants. Leachate is highly concentrated effluents which contain dissolved organic matters, inorganic compounds such as ammonium, calcium, magnesium, sodium, potassium, iron, sulphates, chlorides and heavy metals such as cadmium, chromium, copper, lead, zinc, nickel and xenobiotic organic substances Lohe et al. [5] which are also responsible for environmental pollution.

Over the years, various detection and removal methods have been used by different researchers with the basic aim of cutting down the rate of environmental pollution. A very good examples are fluorescent-based sensors and electrochemical sensors for detection purposes, immobilized enzyme-based catalytic systems and photocatalytic systems for degradation purposes, along with other physiochemical-based process [6,7,8]. The leachate pollution is worsened by the fact that many landfills are deficient in an appropriate bottom liner or collection system; increasing the prospect of dissipation of leachate through the landfill layers to contaminate ground water [9]. It can also cause serious problems when it gets in contact with the neighbouring soil, surface water and ground water leading to harmful effects on living organisms [10]. Exposure to toxic heavy metals like Pb and Cd has been reported to cause blood and bone disorders, kidney damage, decreased mental capacity and neurological damage Esakku *et al.,* Yurtsever and Sengil [11,12] in both human and animals. Sadly, in developing countries like Nigeria, awareness of the dangers of heavy metal and selenium levels to public health is deficient, therefore this research is imperative. The aim of this study was to determine heavy metal and selenium levels in leachate and soil of Central Bank of Nigeria dumpsite along University of Agriculture Road-Makurdi.

2. MATERIALS AND METHODS

2.1 Reagents

HCl (May and Baker Bagaenman England, M.S 0231), HNO_3 (BDH-Chemical Ltd Poole England, 29335), H_2SO_4 (Fisons Plc. Scientific Equipment Division Loughborough LEII Org. England, No.1830), NH_4OH (BDH Chemicals Ltd Poole England, 6902600), K_2CrO_7 (BDH Chemicals Ltd Poole England, No. 29605).

2.2 Equipments

Hot Plate, Glass electrode pH meter, Digital Weighing meter and AAS (Biotech Engineering Management Co. Ltd, FAAS Phonenix 986).

2.3 Reagents for Cold Vapour Method and Hydride Generation

Potassium borohydride (KBH_4) 2 g Potassium borahydride, 0.2 g sodium hydroxide and 200 Ml distilled water were used as carrier liquor (add 5 mL HCl into 500 ml volumetric flask and dil to 500 ml with water) Blank (add 20ml sulfuric acid into 500 mL volumetric flask and diluted to 500 mL plus sulfuric acid potassium permanganate and dilute to 500 mL to obtain a light purple solution).

2.4 System Conditions

Carrier gas flow rate: 100 mL/min, KBH4 concentration: 0.5-1.5% (medium 0.1% NaOH), Linearity range: 10-80 ng/mL, Sensitivity: 0.5ng/ml/1% A.

2.5 Study Area

Makurdi is the capital city of Benue State in North Central Nigeria and lies between Latitude 7º44 N and Longitude 8º54 N. The physical geography of the area ranges between 73 - 167 m above sea level. In the year 2007 Makurdi has an estimated population of 500,791 with a total land area of about 200 km^2 [13]. The study site is located along University of Agriculture Road Makurdi which lies between Latitude N 07^0 45' 49.1" and Longitude E 008º34'46. 2".The study location is surrounded by two communities: Ate-Akee community in the West and Menne community in the East and a water dam 500 meter adjacent to it. The population of these communities is about one hundred to one hundred and fifty persons and most of them are peasant farmers. The CBN platform dumpsite was well constructed with cements and also has a dimension of 60 ft by 40 ft by 6 ft (18 m by 12 m by 1.8) with a proper drainage that leads to the flowing stream.

2.6 Sample Collection

A total of three leachate samples were collected using a clean plastic container from the leachate collection points within the dumpsite at ambient temperature for three months. The leachate samples were collected on monthly basis for three consecutive months (June – August, 2016). The soil samples were collected at six (6) different points from the dumpsites using plastic hand trowel with the following sampling depths (cm) 0 – 20, 20 – 40, 40 – 60 and 60 – 80. The samples were collected into a clean polythene bags. Soil sample were collected at about 600 m away from the CBN dumpsite as control sample. A total of twenty five soil samples were collected. Three leachate samples were collected from the leachate collection points within the dump site area of CBN. The fourth leachates was collected at 600 m upstream from the dumpsite as control sample. All the plastic containers that were used for collection of the leachate samples were washed and rinsed using distilled water and the containers were tightly covered. The samples were appropriately labelled and samples for heavy metal and selenium determination were acidified with concentrated HNO_3 in order to keep the pH of the sample low subsequently preventing precipitation of the metal [14,15]. All samples collected were stored at 4ºC during transportation to the laboratory.

2.7 Sample Preparation and Analysis

The soil samples were air dried and sieved with a 2 mm mesh size sieve The glass electrode was used to determined the pH of the samples which involve taking the pH of 1:1 soil: Deionized water extracted with calibrated pH meter followed by digestion of the samples using nitric and hydrochloric acids to desorb and extract the metal contents rapt in the soil particles [16].

2.8 Digestion Procedure for Leachates Samples

A volume of 5.0 mL of leachate sample were transferred into a 250 mL beaker, 5 mL of concentrated nitric acid and 2 mL of 30 % (v/v) hydrogen peroxide were added. Then, samples were heated using a hot plate and concentrated

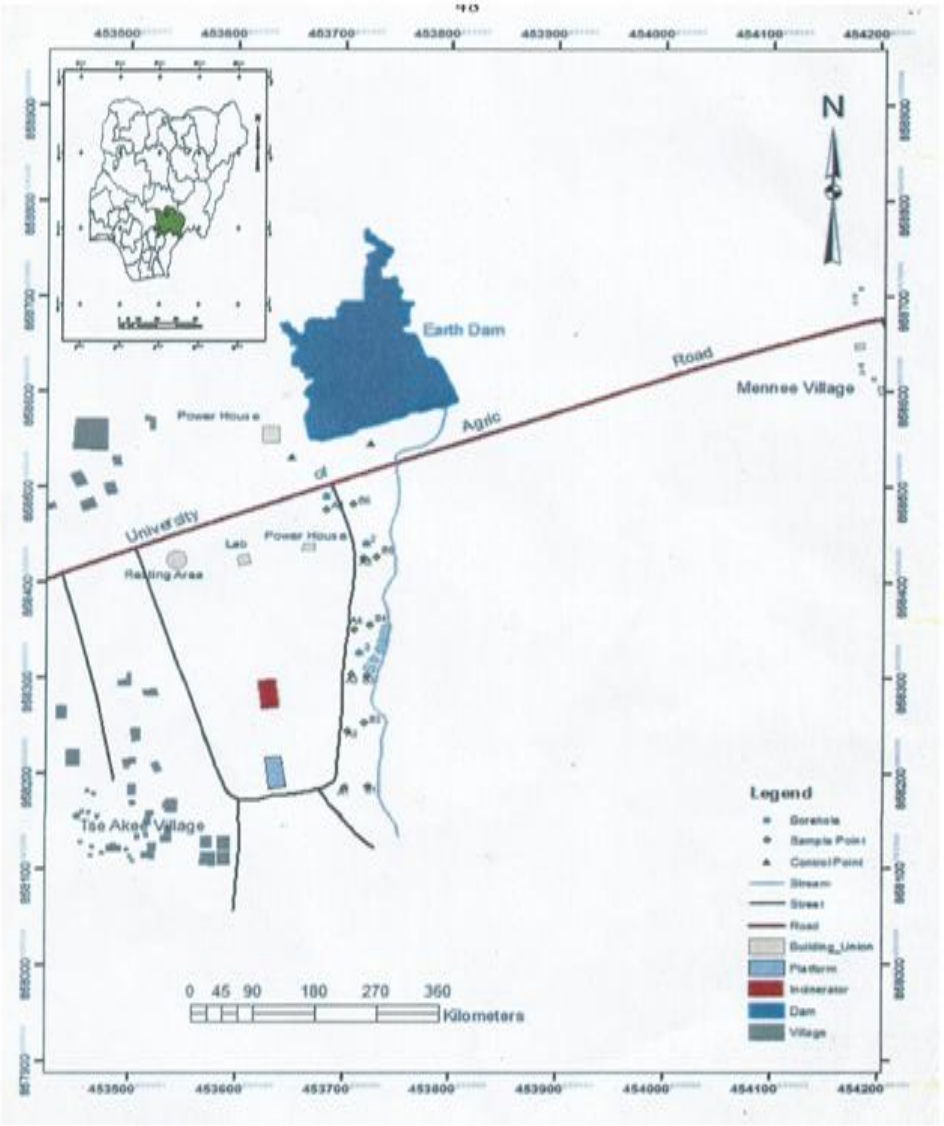

Fig. 1. Map of sampling site showing the dumpsite
Source [14]

nitric acid was added continuously to complete digestion for 30 minutes. The solutions were allowed to cool and then filtered through a Whatman No. 42 filter paper into a 100 mL standard volumetric flask and diluted to a final volume of 100 mL using deionized water [17].

2.9 Digestion of Soil Samples

Exactly 1.0 g of soil samples which had been dried and sieved (2 mm) were weighed into a 250 mL conical flask and 12 mL of freshly prepared Aqua-reqia (3 mL HNO_3 + 9 mL HCl) as described by [18] were added in a 250 mL beaker. The beaker was covered with a filter paper to enhance the digestion to take place under constant volume and the content was heated for 1 hour using a hot plate. The content was added continuously to enhance complete digestion and was allowed to cool. It was finally filtered using a whatman No.42 filter paper into a 100 mL standard volumetric flask. The filtrates were diluted to 100 mL with deionized distilled water and this procedure was repeated for all the soil samples for this study.

2.10 Mercury and Selenium Analysis by Cold Vapour Method and Hydride Generation

Using an AAS system with KBH_4 as carrier liquor and blank sample were connected into their respective sucking tubes. At the start of the hydride generator (connected to the main AAS), the solutions were automatically suck into the system where the hydride were produced and transmitted into the electric quartz absorption tube for detection. The concentrations were recorded in mg/L. The whistling of the hydride generator signals the completion of the hydride production and hence is ready for reading. After proper calibration with the standard ranging from 1-10 mg/L, the blank were replaced with sample to obtain the concentration of mercury and selenium [19].

2.11 Quality Control

Two blanks were prepared for the leachates namely A and B. Blank A comprises of 5 mL of concentrated nitric acid and 2 mL of 30% (v/v) hydrogen peroxide which was heated for 30 minutes and the content were allowed to cool and then filtered through a Whatman No. 42 filter paper into a 100 mL standard volumetric flask and diluted to a final volume of 100 mL with deionised water whereas, blank B was 100 mL of deionised water. The contaminants present in blank A and B were subtracted from the contaminants present in all the leachates samples collected and digested for this study. Similarly, two blanks were also prepared for soil samples coded C and D. Blank C comprises of 12 mL of freshly prepared aqua-reqia (3 mL HNO_3 + 9 mL HCl) which was heated for 1 hour and the content were allowed to cool and then filtered through a Whatman No. 42 filter paper transferred into a 100 mL standard volumetric flask and diluted to a final volume of 100 mL with deionised water whereas, blank D were 50 mL of deionised water. The contaminate present in blank C and D were subtracted from the contaminants present in all the soil samples collected and digested for this study to get the actual concentration of contaminants.

In addition, to ensure accuracy the AAS equipment was calibrated using a known concentration of metals. These metals were run in the AAS equipment to determine the absorbance and concentration. Calibration curves were obtained by plotting concentration against absorbance for lead, cadmium, mercury, chromium and selenium and the following R^2 value of 0.9958, 0.994, 0.9937, 0.9989 and 0.9989 were obtained respectively.

2.12 Data Analysis

The data was analyzed using descriptive statistics. The summary statistics of Cr, Cd, Pb, Hg and Se concentration (mg/kg and mg/L) in both soil and leachates samples were expressed in mean values with their respective standard deviations, minimum and maximum values. The results were also presented in tables and charts.

3. RESULTS AND DISCUSSION

3.1 Leachates

The results of the mean concentration of heavy metals in leachates expressed as mean is presented in Table 1.

Similarly, the variation of metal and selenium concentrations and months shows that some of the metals such as Pb, Cr, Hg, Cd and Se were not detected in early rainy season but as the intensity of the rain increases, Cr and Cd that were hanging on the platform were detected (Table 1). In CBN dumpsite metal concentration in leachates samples increases with increased rain intensity due to left over traces on the platform. Also some

Table 1. The Monthly concentration (mg/L) of heavy metals in Leachate samples and WHO permissible limits

Metals	June	July	August	Control	WHO [20]
Pb	N.D	N.D	N.D	N.D	5.0
Hg	N.D	N.D	N.D	N.D	0.2
Cr	N.D	N.D	0.079	0.006	5.0
Cd	N.D	N.D	0.010	0.003	1.0
Se	N.D	N.D	N.D	N.D	1.0

N.D = Not detected

Table 2. Mean concentration (mg/L) of heavy metals in leachate

Elements	Minimum	Maximum	Mean± S.D
Pb	N.D	N.D	N.D
Cr	0.006	0.079	0.05 ± 0.03
Hg	N.D	N.D	N.D
Cd	0.003	0.010	0.01 ± 0.00
Se	N.D	N.D	N.D

N.D = Not detected

of these metals could not be detected because concentration of these metals and selenium were below detection limit or not present at all. However, the finding is in agreement with the research work reported by [21]. The concentration of Cd is below the permissible limit of 1.0 mg/L WHO [20], due to the reduction in the volume of the leachate for ultimate treatment. This result is in agreement with the result presented by [22].

3.2 Soil

The mean concentration (mg/kg) of heavy metals and selenium analysed in soil at different depths at the CBN dumpsite. Chromium ranges between 70.7 – 77.2 mg/kg with an overall mean value of 73.3 ± 2.5 mg/kg at 0 – 20 cm depth. Cadmium at 0 – 20 cm depth ranges between 6.47 to 8.02 mg/kg with an overall mean value of 7.08 ± 0.6 mg/kg. Mercury ranges between 2.15 to 5.95 mg/kg with an overall mean value of 3.63 ± 1.4 mg/kg at 0 – 20 cm depth. Selenium ranges between 1.54 to 3.60 mg/kg with an overall mean value of 2.09 ± 0.8 mg/kg at 0 – 20 cm depth. Lead ranges between 5.87 to 10.3 mg/kg with an overall mean value of .59 ± 1.7 mg/kg at 0 – 20 cm depth. However chromium has the highest value, whereas selenium has the lowest value in this depth.

Chromium at 20 – 40 cm depth ranges between 77.2 to 83.7 mg/kg with an overall mean value of 80.0 ± 2.26 mg/kg. Cadmium ranges between 8.02 to 9.58 mg/kg with an overall mean value 8.67 ± 0.5 mg/kg at 20 – 40 cm depth. Mercury ranges between 5.95 to 9.74 mg/kg with an overall mean value of 7.53 ± 1.3 mg/kg at 20 – 40 cm depth. Selenium ranges between 0.65 to 3.6 mg/kg with an overall mean value 2.68 ± 1.5 at 20 – 40 cm depth. Lead ranges between 10.3 to 14.7 mg/kg with overall mean value 12.1 ± 1.5 mg/kg at 20 – 40 cm depth. However chromium has the highest mean concentration value and selenium has the lowest value in this depth.

Chromium ranges between 67.5 to 75.1 mg/kg with an overall mean value 70.3± 3.0 mg/kg at 40 – 60 cm depth. Cadmium ranges between 5.26 to 7.51 mg/kg with an overall mean value 6.38 ± 0.7 mg/kg at 40 – 60 cm depth. Mercury ranges between 0.26 to 4.68mg/kg with an overall mean value 1.93 ± 1.7 mg/kg at 40 – 60 cm depth. Selenium ranges between 0.65 to 3.60 mg/kg with an overall mean value 1.33 ± 1.2 mg/kg at 40 – 60 cm depth. Lead ranges between 3.67 to 8.81 mg/kg with an overall mean value 5.63 ± 2.0 mg/kg at 40 – 60 cm depth. Highest concentration in this depth is chromium whereas the lowest value concentration is selenium.

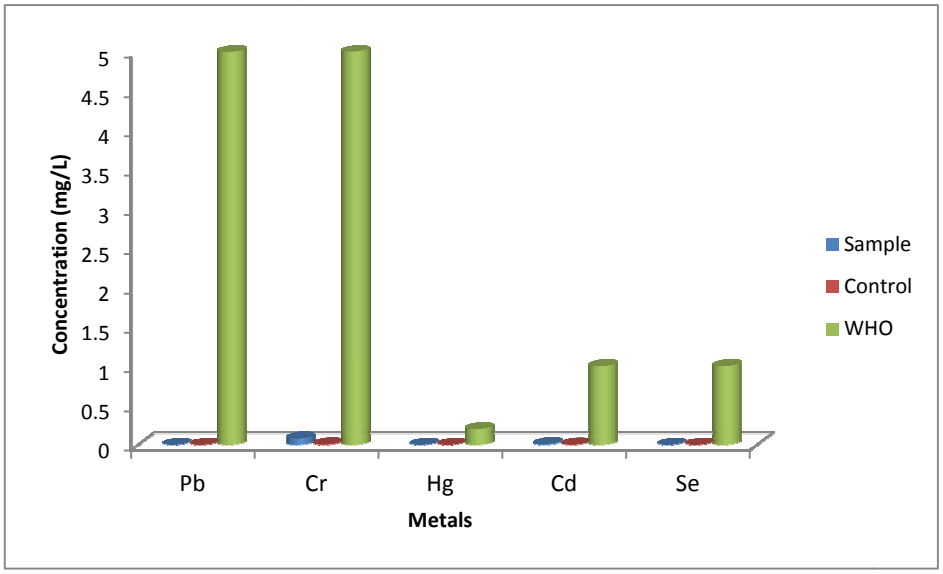

Fig. 2. Variation of heavy metal concentration in different months

Chromium ranges between 71.8 to 78.3 mg/kg with an overall mean value 75.1 ± 2.6 at 60 – 80 cm depth. Cadmium ranges between 6.73 to 8.28 mg/kg with an overall mean value 7.51 ± 0.61 at 60 – 80 cm depth. Mercury ranges between 2.79 to 6.58 mg/kg with an overall mean value 4.68 ± 1.5 mg/kg at 60 – 80 cm depth. Selenium ranges between 0.65 to 3.64 mg/kg with an overall mean value 2.04 ± 1.3 mg/kg at 60 – 80 cm depth. Lead ranges between 6.61 to 11.0 mg/kg with an overall mean value 8.81 ± 1.7 mg/kg at 60 – 80 cm depth. Chromium has the highest mean concentration whereas Selenium has the lowest value in this depth.

Cr: This research findings shows that chromium has the highest concentration from all collected soil samples at a depth of 20 – 40 cm with a mean concentration value of 80.0 ± 2.3 (mg/kg). This result is higher than the control value of 11.5 mg/kg, however the permissible limit of chromium varies from one country to another country. For example, the permissible limit of chromium concentration in the soil for United Kingdom is 400 mg/kg, for Sweden 60 mg/kg, Netherland 30 mg/kg, Luxembourg 100-200 mg/kg, France 150 mg/kg Germany 60 mg/kg and Austria 100 mg/kg (Table 1) European Commission Director General Environment [23]. Therefore, the chromium concentration in this research work in the soil sample is higher than some of the permissible limit in the following countries like Netherland, Germany and Sweden. The chromium concentration is at variance with [21]. The level was however found to be within the normal range in soils as reported by Radojevic and Bashkin [24] is as shown in Table 5. The values of Cr obtained in this study were lower than 900 – 2000 mg/kg reported by Adefemi and Awokunmi [25] in a similar work in impact of municipal solid waste disposal in Ado Ekiti metropolis, Ekiti State, Nigeria.

On the other hand Chromium (Cr) concentration obtained in this study area disagrees with 3.63±2.46 mg/kg mean concentration reported by Olayiwola and Onwordi [26] in Environmental Fate of Heavy Metals in Soil of Ido-Osun Waste Dump Site, Osogbo, Osun, Nigeria. The Chromium (Cr) concentration obtained in this study area also disagrees with that of Musa et al. [14] who reported low level Cr concentration (23.40 ± 7.45 mg/kg) in a similar study around CBN waste dumpsite in Makurdi, Benue State Nigeria. The values of chromium concentration obtained in this study were lower than 92.1 – 8.4 mg/kg reported by Sapana et al. [27] in the Assessment Of geo-accumulation index of heavy metal and source of contamination by multivariate factor analysis. This is as a result of less human activities capable of generating chromium in the environment [27]. Chromium +3 has less health implications due to their absorption by the body (<1%), but Cr +6 is

Table 3. Mean concentration (mg/kg) of heavy metals in the soil at different depths (cm) around CBN dumpsites

Soil depth (cm)	Elements	Minimum	Maximum	Mean ± SD
0 – 20	Cr	70.7	77.2	73.3 ± 2.5
	Cd	6.47	8.02	7.08 ± 0.6
	Hg	2.15	5.95	3.63 ± 1.4
	Se	1.54	3.60	2.09 ± 0.8
	Pb	5.87	10.3	7.59 ± 1.7
20 – 40	Cr	77.2	83.8	80.0 ± 2.3
	Cd	8.02	9.58	8.67 ± 0.5
	Hg	5.95	9.74	7.53 ± 1.3
	Se	0.65	3.67	2.68 ± 1.5
	Pb	10.3	14.7	12.1 ± 1.5
40 – 60	Cr	67.5	75.1	70.3 ± 3.0
	Cd	5.26	7.51	6.38 ± 0.7
	Hg	0.26	4.68	1.94 ± 1.7
	Se	0.65	3.60	1.33 ± 1.2
	Pb	3.67	8.81	5.63 ± 2.0
60 – 80	Cr	71.8	78.3	75.1 ± 2.6
	Cd	6.73	8.28	7.51 ± 0.6
	Hg	2.79	6.58	4.68 ± 1.5
	Se	0.65	3.64	2.04 ± 1.3
	Pb	6.61	11.0	8.81 ± 1.7

S.D = Standard Deviation

acutely poisonous and on contact with the skin, it triggers dermatitis, allergies and irritations, thus considered as carcinogenic to humans [28].Chromium is one of the heavy metals whose concentration in the environment is steady increasing due to industrial growth, especially the development of metal chemical and tanning industries. Sources of chromium might be due to wastes from household chemicals and cleaners, diesel engines utilizing anti-corrosive agents, rubber, candles and matches etc. Although there is no risk of chromium contamination on a global scale, local permeation of the metal to soil, water or the atmosphere might result in excessive amounts of this pollutant in biogeochemical circulation [29]. As observed by Ghosh and Singh [30] non-biodegradability of chromium is responsible for its persistence in the environment; once mixed in soil, it undergoes transformation into various mobile forms before ending into the environmental sink. Although Cr toxicity in the environment is relatively rare, it still presents some risks to human health since chromium can be accumulated on skin, lungs, muscles fat, and it accumulates in liver, dorsal spine, hair, nails and placenta where it is traceable to various heath conditions [31].

Pb: In this study lead concentration has the second highest mean value mean concentration at different depths as shown in Table 3. The mean value of Lead (Pb) in the soil is higher than the control level of 2.60 mg/kg away from the dumpsite. The maximum permissible Limit of Lead concentration varies widely with countries. The Pb values obtained are within the allowable limits in several countries, while on the other hand the values are below the allowable limits in several countries. The value of Lead in this study is lower than the mean concentration 48.60-36.72 mg/kg of Lead (Pb) reported by Ogunmodede et al. [32] in a similar work in Ado – Ekiti and Ijero Ekiti Nigeria. The Lead value obtained in this study is lower than the mean range 12.43 – 2.63 mg/kg of Lead reported by Musa et al. [14] in a similar around CBN waste dumpsite in Makurdi, Benue State Nigeria. On other hand mean level of Lead in this study was higher than what was obtained by [33,34].

The pollution of soil by Lead is very serious problems that have been given much attention by environment chemist since this metal is very toxic for humans and animals. This is due to the fact that lead is cumulative pollutant Dara [35] and the continuous disposal of Lead contains waste into the environment should be discouraged. Lead is known as poisoning in human as well as chronic neurological disorder especially in foetuses and children [36,37]. Lead toxicity also leads to anaemia both by mutilation of haemo-biosynthesis and increase of rate red blood cell destruction. In addition, Lead reduces sperm count, damages kidney, liver, blood vessels, nervous system and other tissues in human [27]. Lead production and operation facilities without waste-gas treatment system, battery production and scrap battery recovery facilities, thermal power plants, and iron–steel industries are the other sources of Lead in the environment [27,28]. Sorting and recycling of wastes should be intensified to reduce the quantity of these toxic metals in the dumpsites.

Cd: The mean concentration of cadmium varies from depth to depth (Table 3) in dumpsite with a control value of 0.76 mg/kg. The concentration value Cd is higher than the control value. The concentration values of cadmium obtained in this study was found to be above the critical permissible concentration in the various countries (Table 4). The study by [25] reported higher cadmium Level of 219 – 330 mg/kg which is higher than the concentration reported in this current research work. On the other hand the result of Cd concentration recorded in this study disagrees with that of [38] who reported low level of Cd concentration (0.60 - 00.14) mg/kg in heavy metals in Soils of auto- mechanic shops and refuse dumpsites in Makurdi Nigeria. The Cd

Table 4.Permissible limits of heavy metals in soil (mg/kg) of selected countries

Countries	Cadmium	Chromium	Lead
Austria	1 – 2	100	100
Germany	1	60	70
France	2	150	100
Luxembourg	1 – 3	100 – 200	50 – 300
Netherland	0.5	30	40
Nigeria	3	100	100
Sweden	0.4	60	40
United kingdom	3	400	300

Source: [23]

concentration obtained in this study also disagrees with that of Musa et al. [14] who recorded low level of Cd concentration (0.69 – 0.09) mg/kg in a similar work around CBN waste dumpsite in Makurdi, Benue State Nigeria. On the other hand, the mean concentration of cadmium reported in soil samples from Daudu is higher (28.32 mg/kg) compared to this current research work as reported by Egwumah et al. [39] in Bioaccumulation level of Cadmium concentration in Wild population of Black-Headed Oriole *Oriolus Brachyrhynchus* (Swainson, 1837) from some selected locality in Benue State, Nigeria and this is as a result of the anthropogenic activities in the environment.

This difference in metal concentration could be attributed to location and nature of waste disposal. The half-life of cadmium in human body is between one and four decades [40]. During decomposition, the Cd component is leached into the surrounding soil and over time gets accumulated in the soil. Cadmium is considered to be a toxin in phosphate fertilizers Bhavani and Sujath, Lane and Canty [41,42] which is added to soil to stimulate the growth of food crops through normal farming practice [43]. In all the dumpsites cadmium batteries, metal scraps, PVC plastics, motor oil and disposal sludge etc, are being dumped from the industrial and residential areas, which may have contributed to the large concentration of the metal [44,45]. The primary health risks of long term exposure are lung cancer and kidney damage [37].

Hg: The mean concentration level of mercury varies from depth to depth at the dumpsites while the control value was recorded as zero concentration. The mercury (Hg) values obtained from this study are within the permissible limits in different countries. The mean value concentration of mercury in this study is higher than the mean concentration (0.29 ± 0.22 mg/kg) reported by Ahmed et al. [46] in India. This current research work recorded a lower mercury concentration in soil compared to Hovart et al. [47], who reported mercury concentration of 289 mg/kg in contaminated soil in China. On the other hand, Hg concentration obtained in this study disagrees with that of Musa et al. [14] which ranges from 0.05 – 0.06 mg/kg in a similar work around CBN waste dumpsite Makurdi, Benue State Nigeria. The anthropogenic distribution of mercury in this location could be attributed to the disposal of batteries, fluorescent bulbs, thermometer, electrical gear and waste mercury compounds in the dump.

Soil conditions in general are conductive for the formation of inorganic compounds such as mercury chloride (HgCl), mercury hydroxide (HgOH) and inorganic mercury (II) compounds, which are capable of forming complexes with organic anions [39]. This complex behaviour limits mobility of mercury in soil so that much of the mercury in soil so that much of the mercury in soul usually sticks to bulk organic matter and they are easily subjected to surface runoff during excessive rainfall because they are only attached to suspended soil or humus this finding is in agreement with the research work of [39]. If you examined the biological pathway of mercury contamination in human, mercury is not commonly found in plant products but it can enter human bodies through vegetables and other crops. Significantly, high exposure to mercury may cause brain and kidney damage, lungs irritation, eye irritation, skin rashes, vomiting and diarrhoea [27].

Table 5. Concentration ranges of metals (mg/kg) in soils

Metal	Normal range in soils
Cr	5 – 1500
Hg	0.01 – 0.5
Cd	0.01 – 2
Pb	2 – 300

Source: [24]

Se: In this study selenium has the lowest mean concentration. The mean concentration value of selenium is higher than the control value of 0.22 mg/kg. The mean concentration value selenium obtained in this study is below the maximum permissible limit in soil which indicating that there is little anthropogenic activities associated with selenium pollution in the environment [27]. The value of selenium obtained in this study is higher than the value reported by Musa et al. [14] who recorded a lower selenium concentration of 0.038 – 0.037 mg/kg around CBN waste dumpsite Makurdi, Benue State Nigeria. In addition, higher selenium content in soil samples was also reported with a concentration range of 20–60 mg/kg in Enshi, China [48].

At the global scale, selenium is constantly recycled in the environment via the atmospheric, marine, and terrestrial systems. Estimates of selenium flux indicate that anthropogenic activity is a major source of selenium release in the cycle, whereas the marine system constitutes the main natural pathway [39]. Selenium is not distributed evenly across the planet, rather

concentrations differs depending on local conditions. An understanding of these variations is essential to aid the amelioration of health problems associated with selenium deficiency and toxicity [49].

4. CONCLUSIONS

The results show that chromium (Cr) had the highest concentration in both soil and leachate, with selenium having the lowest concentration in soil sample. Also the results revealed that some of the heavy metal and selenium levels in leachate were beyond detection limit. This may be attributed to their high affinity to be sorbed into the soil which is responsible for their non–detection in leachate. The metal concentrations in this study area have been found to be higher than the control collected at 600 m upstream from the CBN dumpsite. The heavy metal concentrations of soil in the dumpsite at different depths were all within WHO acceptable limit in the dumpsite except Cd which was above the permissible limit and Se which was below permissible limit. The concentrations of heavy metal and selenium levels in leachate were all below permissible limit of FEPA and WHO. This indicates a less significant risk to the people living in this environment. Consequently, it is imperative to continually evaluate and monitor the levels of heavy metals in the environment due to anthropogenic activities to reduce human exposure toxic substances which may promote sustainable environment management for present generation and generations yet unborn.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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