Assessment of Heavy Metal Enrichment and Level of Contamination of Floodplains Soil in Ondo State, Nigeria

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ABSTRACT

Flooding is one significant process that contributes to the movement of sediment and metals. With higher velocities of water, flooding can take contamination downstream. The soil samples were collected from three floodplains of Owena river, Ogbese river and Ala river in Ondo State were analyzed for their physico-chemical characteristics. The study also investigated the chemical speciation of Cd, Cu, Ni and Zn and total concentration in the soil samples. The concentration of the heavy metals in the selected floodplains were orderly as Zn > Cu > Ni > Cd. Investigating the speciation showed that contribution to the total metal content of the alluvial soil was from both geogenic and anthropogenic sources. Pollution/Contamination index evaluation showed that the alluvial soils had very slight metal contamination for all the metals except for Cd being found in the range of very severe contamination to slight contamination in Owena and Ala floodplains.

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The enrichment factor of the heavy metals had a general trend of Ni = Cu < Zn < Cd. The geo-accumulation index also had a general trend of Ni < Cu < Zn < Cd. The pollution index had highest value in Ala.

1. INTRODUCTION

In Nigeria, floods are common attributes during the rainy period (May – October), occurring naturally on the floodplains when water in the rivers and their tributaries overflow their banks. These floods are usually restricted to the river floodplains which are the low flat, periodically flooded lands adjacent to rivers, lakes and oceans and subject to geomorphic (land shaping) and hydrological (water flow) processes [1]. Flood water contains significant loads of suspensions and nutrients, as well as large amounts of organic compounds which are often toxic. This contamination by flood water is washed away from roads, football fields, warehouses and petrol stations, mechanic workshops, laundry places, places where solvents and pesticides are disposed, landfills and domestic septic tanks that collect household sewage [2]. Pollution carried by flood water can be divided into two major groups: the first group are primarily inorganic substances that contain heavy metals and nutrients, which are retained by physical or chemical sorption during the process of migration into the soil profile and finally enriching the flooded soil [3]. The other group consists of organic compounds present in the form of pre-decomposed remains of plant and animal tissues derived from municipal waste and organic matter contained in compost, manure, slurry tanks, and septic tanks as well as organic compounds that might have toxic properties [4,5]. In addition, these water contain compounds belonging to the group of persistent organic pollutants (POPs) [6]. Soil and sediment act as sinks for heavy metals, and fluvial processes are the primary mechanisms for transportation and redistribution of heavy metals [7,8]. Metals combine with sediment or particulate matter in aquatic environments by attaching to sediment particles [7,8]. Since these particles follow the same transportation paths in streams and rivers as other sediments, geomorphologic processes and channel sedimentation play a role in understanding these sediment-associated metals [6,8,9].

Flooding is one significant process that contributes to the movement of sediment and metals. With higher velocities of water, flooding can take contamination downstream. Moreover, flooding over riverbanks results in the deposition on the floodplain. Overbank floods serve the dual purpose of depositing and releasing metals [9,10,11]. The deposition of metals on the floodplain occurs when there are overbank floods. Sediment-associated metals have a residence time in soils ranging from decades to centuries [8,9,10,11]. These metals can remain stored in these alluvial environments from periods of decades to centuries, particularly by floodplains where flow rate of fluvial processes is low or those experiencing alluviation [9,10].

2. MATERIALS AND METHODS

2.1 Sampling

Soil samples were collected from six locations along the floodplains each of Owena river, Ogbese river and Ala river with the aid of soil auger to a depth 0-20 cm. The locations were geo-referenced with Geographical Position System (GPS) Germin 12 model for ease of reference. The sampling points along the flood plains are as indicated in the map (Fig. 1). Collected samples were kept in cleaned and well-labeled polyethylene bags and transferred to the laboratory.

2.2 Sample Treatment and Analysis

In the laboratory, samples were air-dried for two weeks. They were then ground into fine particles in a mortar, sieved through a 2 mm mesh and about 200 g of the sieved samples were sub–sampled by quartering for analysis.

2.3 Soil pH Determination

The pH of the soil sample was measured using pH meter calibrated with buffer solutions pH 4 and 9. Soil-water solution (1:2) was made by measuring 5 g of soil sample into 10 cm^3 distilled
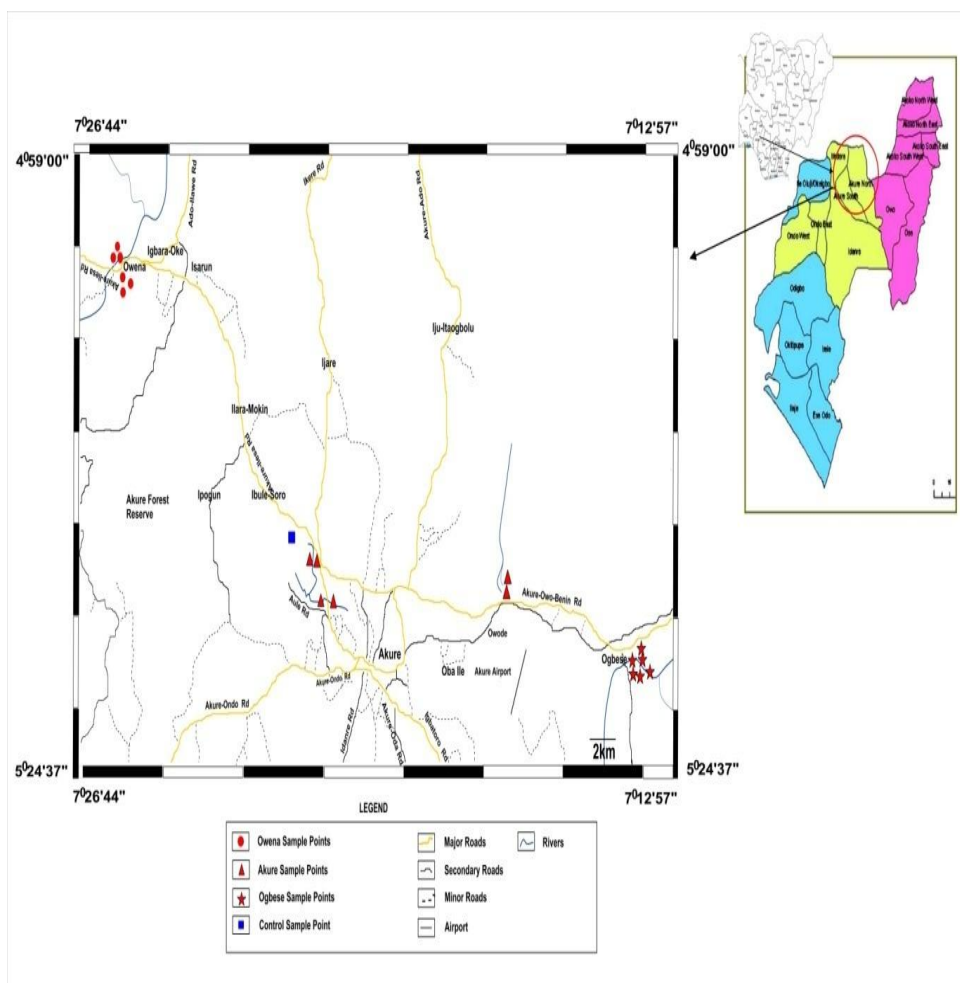
Fig. 1. Map of study area

water in a beaker, mixed thoroughly and allowed to equilibrate for 1 hour, stirring at 15 minutes intervals. The pH value of this solution was measured using a pH glass electrode system model SETRA PHS 25 [12].

2.4 Determination of Soil Organic Matter/Soil Carbon Content

Air-dried soil sample 1 g was weighed into a 250 cm^3 conical flask and 10 cm^3 of 0.167 M K$_2$Cr$_2$O$_7$ added and swirled gently; thereafter, 20 cm^3 of concentrated sulphuric acid was added, swirled and left to stand on a pad for 30 minutes in a fumes cupboard. Distilled water 100 cm^3 was added, after which, 3 drops of ferroin indicator was added and then the content titrated with 0.5 M iron (II) ammonium sulphate solution until the colour changed from greenish cast to dark green. At this point ferrous sulphate was added in

dropwise until colour changed sharply from green to brownish red. A blank titration was also performed following the same procedure in the absence of the sample.

$$Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \longrightarrow 2Cr^3 + 6Fe^{2+} + 7H_2O$$
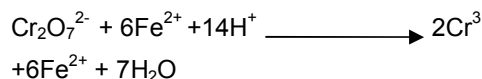
Calculation:

$$\%TOC = \frac{(B-S) \text{ X M of } Fe^{2+} \text{ X } 0.03 \text{ X } 1.33 \text{ X} 100}{W}$$

$$\%TOM = \%TOC \text{ X } 1.724$$

Where,

B is the blank titre value.
S is the sample titre value.
(B-S) is the difference between the blank titre volume and sample titre volume used.

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M of Fe^{2+} is the molarity of ferrous sulphate used.

W is the weight in gram of the sample.

% TOC is the percent amount of total organic carbon of the sample.

%TOM is the percent amount of total organic matter in the sample [13].

2.5 Determination of Particle Size

Air –dried sample 50 g was weighed into 250 cm^3 beaker and 100 cm^3 of 5% sodium hexametaphosphate (calgon) solution was added and allowed to soak overnight. The suspension was stirred for 3 minutes with mechanical stirrer; It was then quantitatively transferred to a sedimentation cylinder (tank) and filled to the mark with distilled water.

A stirrer with a circular end was inserted and moved upwards and downwards to mix the content thoroughly to dislodge the sediment. Stirring was finished with two slow smooth strokes. A drop of isopropyl alcohol was added to remove the foam on the surface of the suspension. A blank determination tank was set up along with sample sedimentation tank and treated in the same manner to sample sedimentation tank. The hydrometer was lowered gently into the sedimentation tank and was read forty seconds (Ra40 secs) and then two hours later along with temperatures of the suspension. The percentage sand, silt and clay were thus calculated [14].

Calculation:

$$\%\text{Silt} + \%\text{ Clay} \ = \ \frac{(Ra\ 40\ secs - Rb) + Rc\ X\ 100}{W}$$

$$\%\text{Clay} = \frac{(Rb - Rc) + Rd\ X\ 100}{W}$$

Ra = 40 seconds blank hydrometer reading.
Rb = 2 hours blank hydrometer reading.
Rc = 40 seconds correction factor (temp x 0.360)
Rd = 2 hours correction factor (temp x 0.360)
W = weight of soil.
%Sand + %Silt + %Clay = 100

2.6 Sequential Extraction

Trace metals in the soil from the different soil samples were sequentially extracted into different chemical forms (fractions). Each sample was treated in triplicate. Each air-dried sample 1 g was weighed and transferred into a 60 cm^3 polyethylene bottle. The sequential extraction

described by [15,16] was used for the chemical fractionation of metals in the soil.

2.6.1 Fraction I – exchangeable fraction

The soil sample was extracted at room temperature for 1h with 8 ml of $MgCl_2$ solution (1 M $MgCl_2$) adjusted to pH 7. Soil and extraction solution were thoroughly agitated throughout the extraction using a centrifuge at 4,000 rpm. The extract were decanted from the residue and analyzed for heavy metals using Atomic Absorption Spectrophotometer of Perkin Elmer, A. Analyst 400 model.

2.6.2 Fraction II – bound to carbonates

The residue of fraction 1 was leached at room temperature with 8 cm^3 of 1 M sodium acetate solution adjusted to pH 5.0 with acetic acid. Continuous agitation was maintained for 5 hours at room temperature with thorough agitation using a centrifuge at 4,000 rpm. The extract were decanted from the residue and analyzed for heavy metals using Atomic Absorption Spectrophotometer.

2.6.3 Fraction III – bound to iron and manganese oxides

The residue from fraction 2 was extracted with 20 cm^3 of 0.04M hydroxylamine hydrochloride in 25% (v/v) acetic acid and was heated to 96°C with occasional agitation for 6 hours in a water bath. The extract was decanted from the residue and analyzed for heavy metals using Atomic Absorption Spectrophotometer.

2.6.4 Fraction IV – bound to organic matter and sulphide

The residue from fraction 3 was oxidized as follows: 3 cm^3 of 0.02M HNO_3 and 5 cm^3 of 30% (v/v) hydrogen peroxide, which has been adjusted to pH 2, were added to the residue from fraction 3. The mixture was heated to 85°C in a water bath for 2 hours with occasional agitation and allowed to cool down. Another 3 cm^3 of 30% hydrogen peroxide, adjusted to pH 2 with HNO_3, was then added. The mixture was heated again at 85°C for 3 hrs with occasional agitation and allowed to cool down. Then 5 cm^3 of 3.2M ammonium acetate in 20% (v/v) HNO_3 was added, followed by dilution to a final volume of 20 cm^3 with de-ionized water and agitated continuously for 30 minutes. The extract was decanted from the residue and analyzed for

heavy metals using Atomic Absorption Spectrophotometer.

2.6.5 Fraction V – residual or inert fraction

Residue from fraction 4 was digested with a mixture of 5 cm^3 Concentrated nitric acid, 10 cm^3 of hydrofluoric acid and 10 cm^3 of perchloric acid in Platinum Crucible. The digestate was decanted and analyzed for heavy metals using Atomic Absorption Spectrophotometer. The digested soil samples were analysed for Cd, Cu, Zn and Ni using a flame Atomic Absorbtion Spectrophotometer.

Prior to analysis all glasswares were previously soaked in 14% nitric acid for 24 hours to remove possible entrained metals, washed with detergent and rinsed with deionized water. Quality control was assured by the use of triplicates standard reference materials and procedural blanks.

2.7 Data Analysis

Data generated on total concentration of each metal were analysed for spatial variations using one way analysis of variance (ANOVA) with SPSS package. One level of significance ($p<0.05$) was considered in the results interpretation.

3. RESULTS AND DISCUSSION

The physicochemical properties of the samples are presented on Table 1. Where OG_1, OG_2, OG_3, OG_4, OG_5 and OG_6 represents Ogbese, OW_1, OW_2, OW_3, OW_4, OW_5 and OW_6, represent Owena, AL_1, AL_2, AL_3, AL_4, AL_5, and AL_6, represent Ala and CT represent control.

Table 1. Physico-chemical properties of soil

Sites	pH	TOM(%)	TOC(%)	Sand(%)	Silt(%)	Clay(%)
OG_1	5.97±0.10	15.20±0.16	8.81±0.14	71.50± 2.50	13.00±0.42	15.50±0.32
OG_2	5.52±0.10	21.79±0.24	12.6±0.12	59.54±1.20	17.64±0.50	22.82±0.24
OG_3	6.90±0.15	17.17±0.14	9.96±0.16	55.00±1.40	14.00±0.32	31.00±0.50
OG_4	5.65±0.12	19.50±0.20	11.30±0.18	49.54±0.52	16.64±0.45	33.82±0.46
OG_5	6.16±0.18	21.1±0.26	12.26±0.35	65.00±1.50	21.00±0.24	14.00±0.16
OG_6	5.36±0.14	19.15±0.18	11.11±0.20	39.46±0.40	23.82±0.68	36.92±0.22
OW_1	6.39±0.20	9.43±0.12	5.57±0.12	81.00±1.70	13.00±0.46	6.00±0.22
OW_2	6.64±0.16	25.09±0.32	14.60±0.82	60.24±1.20	13.07±0.26	26.68±0.25
OW_3	7.12±0.20	21.80±0.14	12.67±0.35	71.50±0.84	11.80±0.20	16.70±0.33
OW_4	5.54±0.15	12.90±0.12	7.47±0.25	68.03±0.72	07.81±0.32	24.16±0.10
OW_5	7.11±0.14	18.40±0.20	10.67±0.42	69.00±1.20	12.00±0.24	19.00±0.76
OW_6	5.80±0.12	27.40±0.36	15.80±0.16	48.31±0.21	19.78±0.72	31.90±0.66
AL_1	7.11±0.30	19.50±0.18	11.30±0.22	62.89±1.50	4.99 ±0.10	32.12±0.30
AL_2	6.69±0.24	23.11±1.20	13.40±0.72	58.10±0.50	7.99± 024	33.90±0.18
AL_3	7.53±0.25	19.5±0.16	11.3±0.50	47.10±1.10	17.10±0.64	34.90±0.75
AL_4	7.20±0.16	29.10±0.40	16.85±0.84	54.96±070	13.35±0.26	31.69±0.50
AL_5	7.02±0.20	20.90±0.82	12.10±0.18	56.00±0.60	15.00±0.40	29.00±0.40
AL_6	6.82±0.18	16.40±0.76	9.50±0.11	66.00±0.56	14.00±0.34	20.00±0.14
CT	5.93±0.12	19.15±0.34	11.11±0.14	57.96±0.84	30.90±0.82	11.14±0.12

Table 2. Mean Total concentration (mg/kg) of heavy metals in soils floodplains

Sample location	Cd	Cu	Zn	Ni
Owena	0.82[a]±0.26	6.69[a]±0.32	31.41[b]±1.12	14.82[b]±1.14
Ogbese	*0.71[a]±0.38*	8.55[a]±0.66	23.47[a]±1.71	6.77[a]±0.82
Ala	1.39[b]±0.59	11.49[b]±0.92	35.0[b]±1.34	7.02[a]±0.41

Superscripts with the different letters down the column show significant variation, while those with the same letter does not at $p < 0.05$

Table 3. Maximum allowable limits (MAL) and target values for heavy metals in soil

Heavy metal	Austria[a]	Dutch[a]	G.Britain[a]	Germany[a]	DPR[b]	Sample
Cd	5.00	0.80	3.00	2.00	0.80	Owena-0.82 Ogbese-0.71 Ala-1.39
Cu	100	36	100	50	36	Owena-6.69 Ogbese-8.55 Ala-11.49
Zn	300	200	250	300	140	Owena-31.41 Ogbese-23.47 Owena-35.00
Ni	100	85	100	50	35	Owena-14.82 Ogbese-6.77 Ala-7.02

Source: [a]Aiyesanmi and Idowu [20]; [b]DPR, (2002)

3.1 Comparison of Heavy Metals Concentration in Floodplain Soil with Standard

The Department of Petroleum Resources [17] provides the Nigerian reference standards for heavy metals 'contents' in soil (target value) and their estimation specific to each type using conversion formulae similar to the Dutch system, that incorporates the clay and organic matter content of the investigated soil [18]. The target value represents the concentration of each metal required for sustainability, or level ultimately aimed for the soil sustainability [17]. The concentrations of Cu, Ni and Zn in the analyzed soil samples are lower than the maximum allowable limit (MAL) of heavy metals in soils in other countries (Table 3). However, the concentration of Cd in samples collected from Ala floodplains is higher than DPR target value, while in samples from Ogbese floodplain, the concentration of Cd is within the permissible limit of DPR. In sample from Owena floodplain, the concentration of Cd is lower than the DPR target value. Such high level of toxic heavy metals above their target levels and maximum allowable limits may induce negative effects on soil functions and pose a great risk to the environment [19,20].

3.2 Appraisal of Heavy Metals Contamination/Pollution in the Floodplain Soils

Assessment of soil samples for heavy metals based on the absolute metals content values provide inadequate information on the significance of the values obtained with the intrinsic soil features and how the values are related to the maximum allowable limits for each metal. Hence, contamination/pollution of the floodplain soils will be appraised using contamination/pollution index, enrichment factor, geo-accumulation index and pollution load index.

3.3 Contamination/Pollution Index (C/P) of the Metals

The contamination /Pollution index of the metals in the soils was calculated using pre-industrial reference level, the pre-industrial reference level of Cu, Zn, Ni and Cd is 50,175, 49.7 and 1.0 (µg/g) according to [21].

$$C/PI = \frac{\text{Concentration of metal in soil}}{\text{Reference value/baseline level/national criteria of metal}}$$

Using Lacatusu model for interpretation, Contamination/Pollution index value greater than 1, defines pollution range, but when it is less than 1, it defines contamination range. From Table 4. it can be deduced the values for all the metals were in the range that fall within the range of contamination (less than 1) except for Cd in Ala. Following the categorization of the contamination/pollution index, all the metals were in range that showed very slight contamination except Cd which showed severe contamination in Ogbese, very severe contamination in Owena and slight pollution in Ala.

3.4 Pollution Load Index (PLI)

The PLI is defined as the nth root of the multiplications of contamination factor of metals.

$$PLI = (CF_1 \times CF_2 \times CF_3 \times CF_4 \times \text{--------------------} \times CF_n)^{1/n}$$

6

Where n is the number of metals studied and CF is the contamination factor, which is the ratio of measured concentration of metal to pre-industrial value of metal [20]. To assess the pollution index of the soil, an integrated approach of pollution index of the four metals was calculated. The pollution load index is a potent tool in heavy metal pollution that provides a simple and comparative means for assessing the level of heavy metal pollution. The PLI represents the number of times by which the metal content in the soil exceeds the average natural background concentration, and gives a summative indication of the overall level of heavy metal toxicity in a particular sample [21].The PLI value of Zero indicates perfection, a value less than one indicates no pollution, whereas values equal to 1 indicates heavy metals loads close to background level, values above one would indicate progressive deterioration of the site [22]. The PLI of the floodplains are 0.22 for Owena, 0.18 for Ogbese and 0.28 for Ala respectively, indicating that the soils were moderately contaminated.

3.5 Geo-accumulation Index

The index of geo-accumulation actually enables the assessment of contamination by comparing the current levels of metal concentrations and the original pre-industrial concentration in the soils [22]. For the purpose of this study, the world surface average was used as reference baseline. The degree of metal pollution is assessed in terms of seven contamination classes based on the increasing numerical value of the index as described by [23]. The geo-accumulation index values (I_{geo}) showed very low values(0<) which

means practically uncontaminated for all the metals in the alluvial soils of the floodplain except for Cd metal in Owena and Ogbese which was in the range of uncontaminated to moderately while at Ala it is moderately contaminated.

3.6 Enrichment Factor

Enrichment factor is used to evaluate how much the soil is impacted with heavy metal, and then calculate the enrichment factor (EF) for metal concentration above un-contaminated background levels [23]. The EF method normalizes the measured heavy metal content with respect to a sample reference such as Fe, Al or Ti [24]. The EF of each element was calculated to evaluate anthropogenic influence on heavy metals content in soil, using the formula given by [25]

$$EF = \frac{C_m/C_{fe\ sample}}{B_m/B_{fe\ background}}$$

Where, C_m/C_{Fe} is the ratio of concentration of heavy metals C_m to that of iron (Fe) in the soil sample and $B_m/B_{Fe\ background}$ is the ratio of concentration of the reference element in the examined environment to that of iron (Fe) in the reference environment. For the purpose of this study Iron (Fe) was used as the reference element at the world average shales value. The values for the enrichment factor are given in Table 6. The Enrichment factor categories proposed by Sutherland [23] were used for interpretation. From the result Cd exhibits moderate enrichment while Cu, Ni and Zn exhibit deficiently to minimal enrichment to moderate enrichment.

Table 4. Heavy metal pollution appraisal in floodplains

Location	Metal	Significance	Symbol
Owena	Cd	Very severe contamination	v.s.t.l
Ogbese	Cd	Severe contamination	s.t.l
Ala	Cd	Slight pollution	s.p
Owena	Cu	Very Slight contamination	v.s.l
Ogbese	Cu	Slight contamination	s.l
Ala	Cu	Slight contamination	s.l
Owena	Zn	Slight contamination	s.l
Ogbese	Zn	Slight contamination	s.l
Ala	Zn	Slight contamination	s.l
Owena	Ni	Slight contamination	s.l
Ogbese	Ni	Very slight contamination	v.s.l
Ala	Ni	Very slight contamination	v.s.l

3.7 Mobility and Bioavailability of the Heavy Metals in the Soil

Table 7 showed mobility and bioavailability of heavy metals in soil. It is important to evaluate the bioavailability and mobility of heavy metals to establish environmental guidelines for potential toxic hazard and to understand chemical behaviour and fate of heavy metals contamination in soils [26]. Sequential extraction provides predictive insights into bioavailability, mobility and fate of heavy metals in soil. The five geochemical forms are operationally define by extraction sequence that followed the order of decreasing solubility [27]. Assuming that bioavailability is related to solubility, then metal bioavailabity decreases in the order of exchangeable > carbonate > Fe-Mn oxide> organic > residual. This order offers only quantitative information about metal bioavailability. Based on the above information, we can further assume that metals in the non-residual fractions are more bio-available than metals associated with the residual fractions. The non-residual fraction is the sum of all geochemical fractions except the residual fractions. Mobility of metals in the soil may be evaluated on the basis of relative contents of fraction weakly bound to soil components. The relative index of metal mobility was calculated as a mobility factor (MF) [26].

$$MF = \frac{F1+F2+F3}{F1+F2+F3+F4+F5} \times 100$$

The above index describes the potential mobility [26], since it's a ratio of proportion mobile (F1+F2+F3) to the sum total of the fraction.

Where, F1= exchangeable metal concentration, F2= metal concentration bound to carbonate fraction, F3= metal concentration bound to Fe-Mn oxide fraction, F4= metal content bound to organic matter fraction, F5 = Residual metal content fraction.

Table 5. Geoaccumulation Index

Location	Metal	I_{geo}
Owena	Cd	0.87
Ogbese	Cd	0.71
Ala	Cd	1.62
Owena	Ni	-2.81
Ogbese	Ni	-3.93
Ala	Ni	-3.86
Owena	Cu	-3.45
Ogbese	Cu	-3.00
Ala	Cu	-2.57
Owena	Zn	-2.18
Ogbese	Zn	-2.60
Ala	Zn	-2.02

The MF gave the value in the range (3.00-52.00%) for all the metals in soils analysed in floodplain soils of Owena. High mobility factor was observed for Cd in Owena site. The relatively high mobility factor observed for Cd is quite in agreement with the high percentage of exchangeable fractionation results. The high MF value in these soil samples is due to relatively high lability and biological availability of heavy metals in soil [26]. The indices of mobility were lower for (MF Cu =37, Zn=26 and Ni= 3). The low MF value in these soil is as a result of high stability of heavy metals in these soil samples. This finding agrees with Olajire et al. [26] who

Table 6. Enrichment factor

Location	Metal	Value	Category
Owena	Cd	12.42	Significant enrichment
Ogbese	Cd	12.3	Significant enrichment
Ala	Cd	17.1	Significant enrichment
Owena	Cu	0.44	Deficiently to minimal enrichment
Ogbese	Cu	0.98	Deficiently to minimal enrichment
Ala	Cu	0.93	Deficiently to minimal enrichment
Owena	Zn	2.38	Moderate enrichment
Ogbese	Zn	1.28	Deficiently to minimal enrichment
Ala	Zn	1.36	Deficiently to minimal enrichment
Owena	Ni	0.98	Deficiently to minimal enrichment
Ogbese	Ni	0.52	Deficiently to minimal enrichment
Ala	Ni	0.38	Deficiently to minimal enrichment

Table 7. Mobility and bioavailability of the heavy metals in soil

Location	Metal	Mobility factor	Bioavailability
Owena	Cd	52.00	0.52
Ogbese	Cd	35.00	0.35
Ala	Cd	55.00	0.55
Owena	Cu	37.00	0.37
Ogbese	Cu	43.00	0.43
Ala	Cu	51.00	0.51
Owena	Zn	26.00	0.26
Ogbese	Zn	47.00	0.47
Ala	Zn	58.00	0.58
Owena	Ni	3.00	0.03
Ogbese	Ni	9.00	0.09
Ala	Ni	13.00	0.13

reported similar observation in contaminated soils in Oyo State. In Ogbese floodplain the MF gave value in the range (9.00-47.00%) for all the metals in soils analysed. Zn has the highest MF of 47% in Ogbese floodplain. The mobility factor (MF) follow the order Zn > Cu > Cd > Ni. Whereas, in Ala floodplain the MF gave the value in the range (13-58 %) for the metals in soil samples analysed. The MF for the metals are high except for Ni with MF of 13%. The high MF of Cd in the soil is most likely from deposition from floods on the floodplain due to used oil lubricant, phosphate fertilizers from farmland and spent oil from automobile mechanical workshop situated in the vicinity of the river Ala. This finding agrees with Aiyesanmi et al. [16] who reported similar observation in sediments of Ala river. Copper has high MF of 51%, this represents high proportion in mobile fraction, thereby making it more mobile and available in soil than the metals that were mostly abundant in the residual fraction. This finding agrees [28] with who reported that average potentia mobility of Cu in soil of Agbabu bitumen area of Ondo State was 44% and that under strong oxidizing condition, due to degradation of organic matter, Cu becomes very available and toxic in the environment. Ni has low mobility. This agrees with earlier that Ni in soil and sediment has a moderate tendency of binding to the silicate [16]. The high concentration of Ni found in this residual fraction is however, not likely to be available to enter the food chain since the residual fraction is very stable, less reactive and less bio-available.

4. CONCLUSION

The speciation of heavy metals in the selected flood plains through sequential extraction led to the detection of differing concentration of Cd, Cu, Ni and Zn in the soil. The study also provides baseline information on the concentration of the metal in the floodplains with which future anthropogenic influences could be evaluated. Contribution to the total metal content of the soil was from both geogenic and anthropogenic sources. The pollution index assessment confirmed that the soils had very slight metal contamination for all the metals except for Cadmium being found in the range of very severe contamination to slight pollution in Owena and Ala alluvial soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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