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Heavy Metals Assessment in Sediments of Afelele (Offa) and Oyun Local Government Reservoirs Dam, Kwara State, Nigeria

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ABSTRACT: The negative impact of anthropogenic operations in Afelele-Oyun water dam in Offa and Oyun Local Government,Kwara State, Nigeria is a serious public health concern, not to mention the adverse effect on the water quality. Therefore, the purpose of this study was to evaluate the degree of heavy metal contamination in the water sediments of the Oyun-Afelele dams and its confluence.At several locations, appropriate sediment samples were picked at randomand at a depth of 6cm, poured into pre-labelled sterilized amber bottles and transported to the laboratory within 1 hr. for analysis, following standard laboratory procedures. Four (4) samples were obtained from Oyun and Afelele dams respectively while two (2) samples were collected at their confluence. Five (5) selected heavy metal were examined in these samples, using an Atomic Absorption Spectrophotometer (AAS) and Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES), for specific metal (Fe, Zn, Cu, Cd, and Cr) concentrations determination in the sediments. The result obtained revealed that the concentration of the heavy metals (Fe, Zn, Cu, Cd) in sediments were within the permissible limit except Cr that exceeded the permissible limit in all stations. The results were as follows in decreasing order of concentration of heavy metal concentrations: Fe > Cr > Zn > Cu. However, Cd was below the detection limit,which could be attributed to absence of mechanical activities within the surroundings of both dams.Considering the data, there is only a slight ecological risk to the aquatic environment from metal pollution, with the presence of Cr being significantly higher than the allowable level. Hence, monitoring of sediment quality is highly recommended for this two Dams and necessary precautions should be created in order to ensure the waterwaysare free of Cr as clearly revealed by this research.

KEYWORDS: Heavy metal, Sediment, Afelele, Oyun, Dams

I. INTRODUCTION

Water ‘mother of all living world’ the formation of the universe and daily life on Earth are governed by water [1]. However, it has become extensively polluted with several harmful pollutants as a result of urbanization, industrialization, agricultural operations and others, making freshwater contaminated [2]. Currently, Earth is the only planet with water content more than 70%. [3]. When the chemical and physical properties of water are altered and have a negative effect on aquatic life, the water is deemed to be polluted [4,5]. Heavy metal deposition from anthropogenic activities, such as the disposal of treated and untreated waste effluents containing metals, is one of these contaminants [6].The primary mechanism of heavy metals introduction into the environment is by the leaching of metals from waste [7]. Once they are present in the environment, regardless of their quantities, it is hard to completely eliminate them [8]. It is crucial to explicitly address these difficult environmental issues since heavy metal contamination has increased in prevalence [9]. Despite the fact that some metals are essential for biological systems and need to exist within a certain concentration range, large or extremely low concentrations can negatively affect plant or animal metabolism or even be poisonous[10].High concentrations of heavy metal exposure can cause major health problems by interfering with our regular

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physical activities, such as obsessive compulsive disorder, hearing loss, and disturbance in the development of perceptual-motor mechanisms [11]. While some heavy metals, such as copper, iron, and nickel, are harmful at elevated concentration, yet beneficial to human health at low concentrations. The speciation pattern rather than the total content of the metal affects its toxicity, solubility, and bioavailability [12]. Sediments are a mixture of different mineral species' constituent parts and organic waste [13]. The suspected polluted silt at the sampling region must be thoroughly analyzed to determine the types of pollutants present and relative quantities, so as to conduct risk assessment analysis [14].As a result, sediment is crucial in determining the amount of heavy toxic metals in the waterways. In the major cities of Kwara State, Nigeria, there are two flowing Dams: Oyun and Afelele reservoirs, located in Offa and Oyun Local Government. Afelele reservoir, in particular, has severe pollution issues, due to n Several anthropogenic activity, including waste discharge from buildings (stores, homes, hotels, schools), animal excrement from markets, and more may be seen along these dams. Due to these underlying problems, there is a great deal of pollution concerns surrounding Oyun and Afelele Dams, as well as their confluence point, which could be hazardous to the communities depending on directly or indirectly on this water. The study is designed to examine the level of heavy metal concentrations in the sediment of these Dams, as to the extent of metal pollution in order to raise awareness about the possible uses of these Dams.

II. MATERIALS AND METHODS

2.1. Description of the Study Area: Oyun dam is located at Oyun local Government, Kwara State, Nigeria, longitude 08°30' N and latitude 08°15'E. It's a Dam reservoir on Oyunriver, created to supply portable water for domestic and industrial uses to an estimated population of about 300,000 people. Subsistence and commercial fishing activities are also carried out on the reservoir. The reservoir has a maximum length of 128 m, maximum width of 50m. The surface area is 6.9 x 10^5 m^2 while the water volume is 3.50 x 10^6 m^3. The net water storage capacity is 2.9 x 10^6 m^3. While Afelele dam is in Offa, Offa local Government, Kwara State, longitude 04°41'N and latitude 08°15'E. Fig. 1 shows the location of Kwara state (marked red) on the map of Nigeria while Fig.2 shows the location of Afelele and Oyun dams in Offa and Oyun LGA on the map of Kwara State [15].

2.2. Sample Digestion and Metal Extraction: The reagents used for this experiment were of analytical grade, and solutions were prepared with distilled water. The amber bottles were soaked in 5% HNO_3 for 24 hr. and rinsed with distilled water. The total metal analysis procedure for the metal speciation analysis of heavy metals in sediment was done according to method [10, 16]. All samples were analysed in triplicate, followed by metal concentrations measurement using AAS (Atomic Absorption Spectrophotometer) and ICP-OES (Inductive Couple plasma Optical Emission Spectroscopy).All the data were statistically analysed by Statistical package for social sciences (SPSS).

Fig. 1: Image showing KwaraState on Nigeria Map

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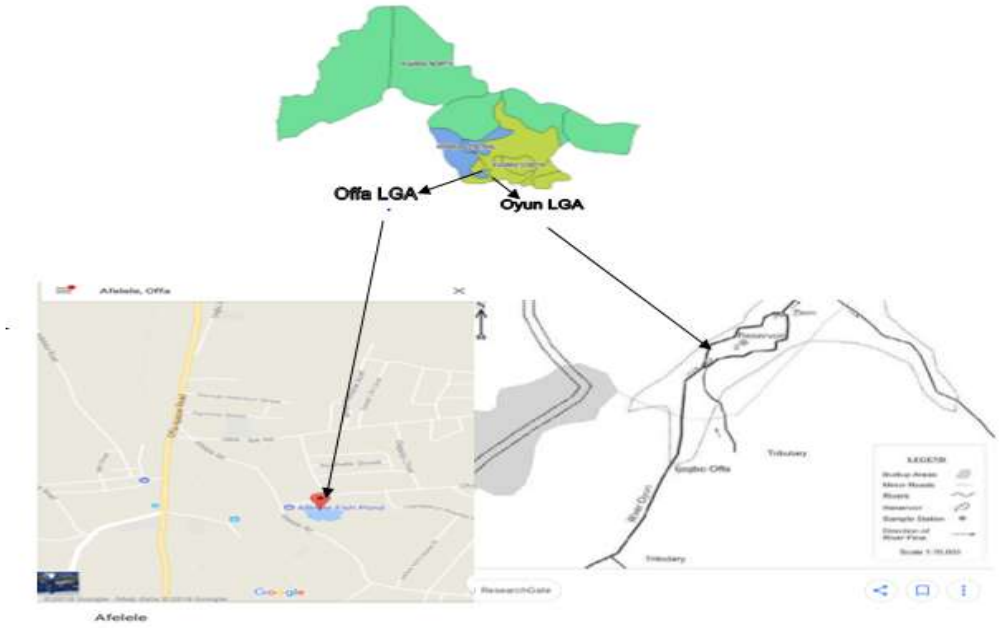

Fig.2: Map showing the location of Afelele Lake in Offa LGA and Oyun dam in Oyun LGA on the map of Kwara State [15]

III. RESULT AND DISCUSSION

2.1. Metal concentrations in sediment samples for sampling locations: The average metal concentration in sediments of Oyun, Afelele Dams and Confluence, denoted as Location I, II, and III respectively showing different sampling stationsas described in Table 2 and Figure 3 below. The quality of the waterways is significantly impacted by the presence of heavy metals in sediments. The result of sediment analysis shows various variations of metals based on their different sampling stations reflecting the level of metals concentration because of anthropogenic activities in such area. The order of totalmetal concentrations for the three-sampling location is as follows: Fe > Cr > Zn > Cu.Chromium exists in sediments in two oxidation states: Cr(III), which is relatively insoluble and nontoxic, and Cr(VI), which is much more soluble and toxic. Cr(VI) is thermodynamically unstable in anoxic sediments, and acid-volatile sulfide is formed only in anoxic sediments [17]. The Cr concentrations at all sampling points were above the standard permissible limit, while Zn and Fe metal concentrations were within the permissible limit of World Health Organization/Food and Agricultural OrganizationWHO/FAO.The sediments result is like the result obtained by [18] that the sampling site recorded the highest average of Cr concentration. This result is also in conformity to the result obtain by [19] that total Cr concentration was high in sediments exceeding almost all the study stretch, and the US Environmental Protection Agency Sediment Screening levels (SSL) for ingestion or inhalation of total Cr.

Zinc concentration is highest at location II (Afelele Dam) and lowest at Location I (Oyun Dam), the average value is the reflection at confluence, Zn concentrations at all locations and stations are within WHO/FAO permissible limit of (60 mg/kg) [20, 21], stated that Zn enrichment in surface sediments at the sampling sites of Umeda River was not natural but anthropogenic which is like the nature of Zn availability in the sediment samples.

Availability of heavy metals in the sediments depends on the quality and quantity of contaminants heaped up by waste products in the ecosystem [10]. Cd is below the detection limit all through the locations and sampling points as presented in Table 2. According to [22] Cadmium Cd has had the lowest concentration of 0.07 ± 0.001 mg/Kg in the upstream area. Cadmium is considered one of the most toxic elements to the

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environment. It poses a serious ecological threat and contributes greatly to the toxicity response rates and the concentration profile in relation to the other elements is low[23]. This is consistent with cadmium concentrations in river sediments recently determined [24]. These levels are below the maximum values reported in this study. The presence of cadmium in sedimentsis considered totally extraneous to life and its presence in sediments is mainly due to human action.

Fe concentration in the sediment exceeds all other heavy metals been analyzed in this research but the concentration is within WHO permissible limit. Fe has its highest concentration at confluence point 31.83 mg/kg station 9 while Fe lowest concentration was at location 1 station 4 (21.29 mg/kg).

The highest average concentration of Cu is at Location I and Station 3(0.87 mg/kg) and the lowest concentration at Location I and Station 1 is 0.05 mg / kg. The permissible limit of Cu is the highest at Location I - Station 3 yet, it's extremely below the limit of WHO/FAO.The low concentration of Cuwas because of low pH value. At station III the pH value is higher than other observed stations so the heavy metal will never settle. The temperature value at station III is higher than other observed stations which will also negate precipitation of heavy metals [25].

The heavy metal (Fe, Cr, Zn and Cu) contents at location II (AfeleleDam) are higher when compared to location I (OyunDam) and location III (The Confluence). This result is similar to [26]. The confluence station shows the reflection of how the sediment concentration at both location I and location II contribute to the concentration of the heavy metals at confluence point while the reservoir dam serves as metal carrier from one location to the other.

Table 1: Mean heavy metal contents in the sediments from 10 sampling points with WHO/FAO standard [27]

Location	Stations	Cr (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Fe (mg/kg)	Cu (mg/kg)
Standard	WHO/FAO	0.1	60	1	48	30
Location I	S1	0.4363	0.19	ND	28.04	0.05
	S2	0.3172	0.23	ND	31.16	0.07
	S3	0.4281	0.28	ND	38.24	0.87
	S4	0.3812	0.22	ND	21.29	0.28
Location II	S5	0.4604	0.284	ND	24.31	0.21
	S6	0.3921	0.371	ND	29.04	0.06
	S7	0.5011	0.263	ND	33.22	0.31
	S8	0.4153	0.31	ND	27.41	0.19
Location III	S9	0.3671	0.288	ND	31.83	0.11
	S10	0.4522	0.302	ND	29.66	0.19

ND: Not detected, S: sampling point, S1-S4 (Location I: Oyun dam), S5-S8 (Location II: Afelele dam), S9-S10 (Location III: Confluence)

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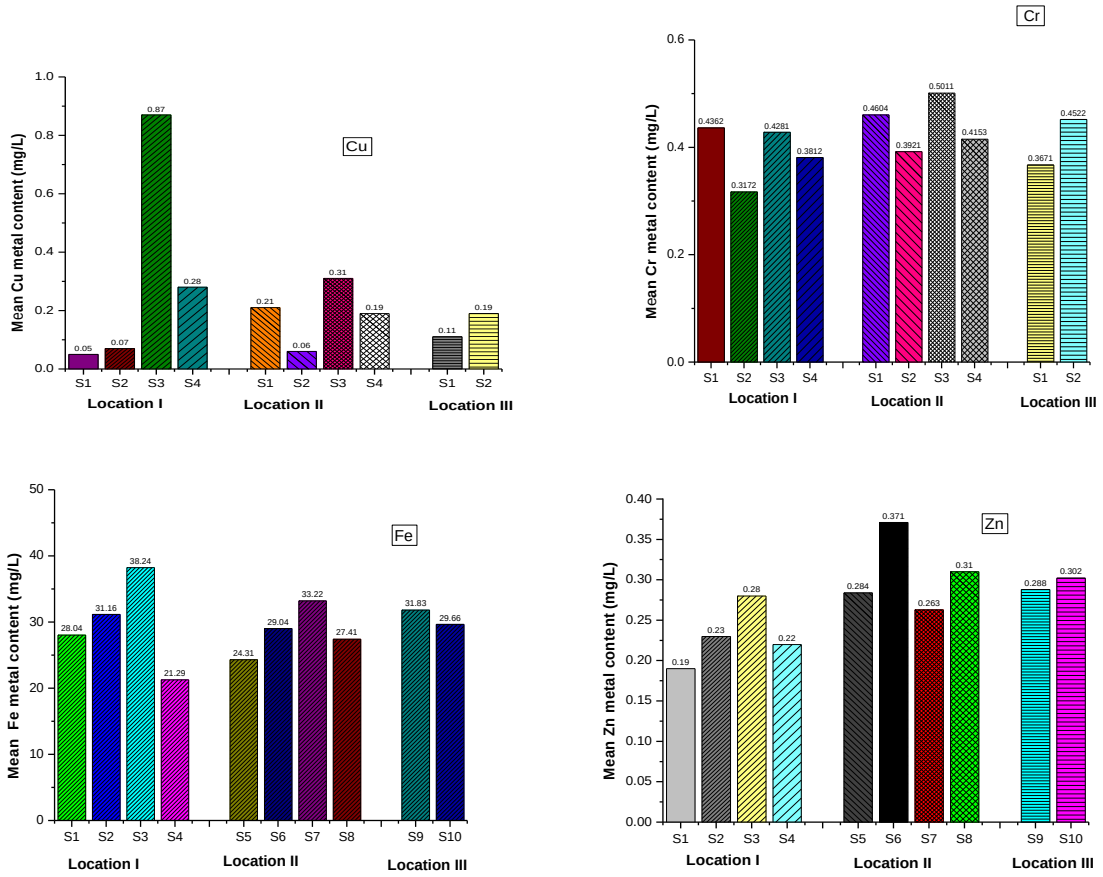

Figure 3: Mean metals concentration in sediments samples at different sampling points of Oyun (location I: S1-S4), Afelele (location II:S5-S8), confluence (location III:S9-S10) respectively.

2.2 Data analysis: The statistical analysis of data obtained was carried out asdescribed in Table 2, 3 and 4 representing sampling location I,II and III respectively. The results presented in Table 2 shows the mean and the standard deviation of metal concentrations at location I (Oyun dam) between the month of January to May, 2022. The order of metal concentrations in a decreasing order is as follows: Fe> Cr> Zn> Cu. Increasing order of each metal concentrationswas observed until the month of May where the metal concentration began to decrease except Fe concentration that exist within the limit and Cu concentration that was extremely low. The level of Crcontent in Oyun dam sediments was observed to be higher than the maximum permissible limit, according to Table 2. The amount of other metal concentrations in location I is presented in Figure 4 (i-ii). Location II and III SPSS case summaries results is in line with result obtain in location I were presented in Table 3 and 4.

The Pearson correlation coefficient of metals (Table not included)reveals there was a significant correlation at the 0.01 level probabilities among Zn and Fe with Cu and Fe metals. These correlations at 0.01 significant indicated that the heavy metals are from a common source because of human activities like dumping of refuse in the flowing streamsburning of different source of waste along the stream banks, defecations, industrial effluents, and other anthropogenic means through human use of these Dams.

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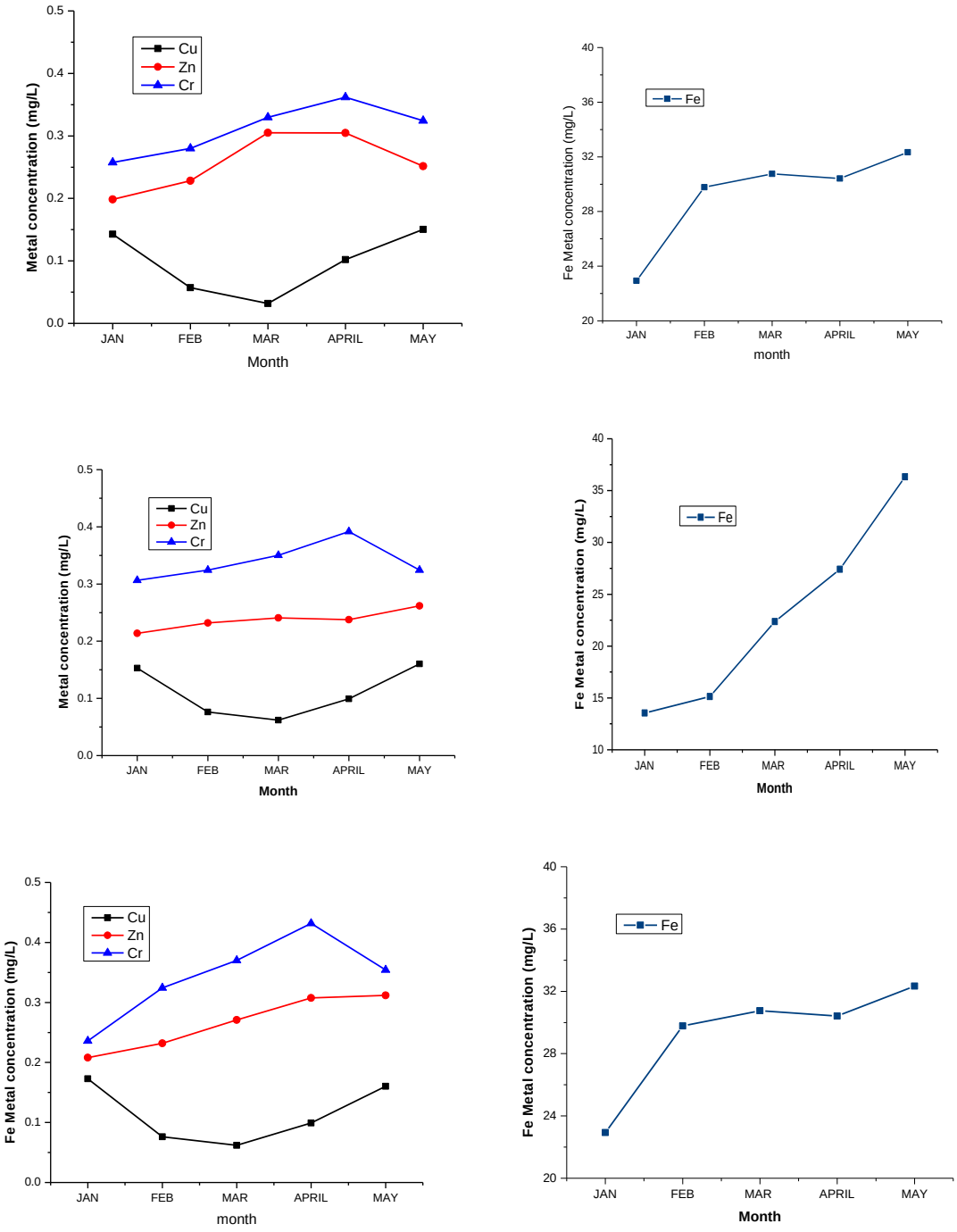

Figure 4: The graph of Mean concentrations of metals in (i-ii) location I (Oyun dam); (iii-iv) location II (Afelele dam); and (v-vi) location III (confluence)

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Table 2: Case Summary of metal concentrations data obtained in sediment (Jan. to May 2022) for location I (Oyun dam)by SPSS

			Cr (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Fe (mg/kg)	Cu (mg/kg)
WHO/FAO			0.1	60	1	48	30
JAN. 2022	Total	Mean	.2775	.1983	ND	22.9350	.1428
		Minimum	.15	.11	ND	17.09	.02
		Maximum	.43	.36	ND	31.42	.40
		Std. Deviation	.11925	.09368	ND	5.39857	.16388
		Std. Error of Mean	.04868	.03825	ND	2.20396	.06690
FEB. 2022	Total	Mean	.2801	0.2481	ND	29.7831	.0570
		Minimum	.21	25.20	ND	25.20	.02
		Maximum	.39	36.90	ND	36.90	.10
		Std. Deviation	.06086	4.83447	ND	4.83447	.02651
		Std. Error of Mean	.02484	1.97366	ND	1.97366	.01082
MAR. 2022	Total	Mean	.3297	.3050	ND	30.7578	.0319
		Minimum	.21	.10	ND	19.33	.02
		Maximum	.44	1.23	ND	52.57	.04
		Std. Deviation	.08284	.45311	ND	12.06768	.00955
		Std. Error of Mean	.03382	.18498	ND	4.92661	.00390
APR. 2022	Total	Mean	.5418	.3047	ND	30.4156	.1020
		Minimum	.38	.12	ND	26.57	.04
		Maximum	.75	.87	ND	34.63	.19
		Std. Deviation	.14195	.28656	ND	2.93443	.04904
		Std. Error of Mean	.05795	.11699	ND	1.19798	.02002
MAY. 2022	Total	Mean	.2942	.2517	ND	32.3376	.1504
		Minimum	.27	.12	ND	23.77	.04
		Maximum	.32	.41	ND	52.57	.24
		Std. Deviation	.02055	.11033	ND	10.51504	.07748

ND:Not Detected

Table 3: Case Summary of metal concentrations data obtained in sediment (Jan. to May 2022) for location II (Afelele dam) by SPSS

			Cr (mg/Kg)	Zn (mg/Kg)	Cd (mg/Kg)	Fe (mg/Kg)	Cu (mg/Kg)
WHO/FAO			0.1	60	1	48	30
JAN. 2022	Total	Mean	.3064	.2138	ND	13.5410	.1528

		Minimum	.21	.17	ND	11.10	.04
		Maximum	.53	.42	ND	24.02	.30
		Std. Deviation	.12533	.1306	ND	7.18547	.14824
		Std. Error of Mean	.02663	.040251	ND	1.80962	.09430
FEB. 2022	Total	Mean	.3242	.2319	ND	15.1386	.0763
		Minimum	.32	2.5	ND	20.14	.04
		Maximum	.41	.63	ND	27.65	.17
		Std. Deviation	.08446	.2361	ND	2.74834	.03156
		Std. Error of Mean	.05109	.05175	ND	1.4676	.01185
MAR. 2022	Total	Mean	.37006	.2709	ND	22.3667	.0619
		Minimum	.41	.10	ND	26.33	.02
		Maximum	.46	2.23	ND	27.78	.04
		Std. Deviation	.12465	.5371	ND	8.0756	.00955
		Std. Error of Mean	.05333	.14928	ND	3.2691	.00390
APR. 2022	Total	Mean	.4318	.3075	ND	27.4156	.09910
		Minimum	.38	.12	ND	26.57	.06
		Maximum	.75	.87	ND	34.63	.21
		Std. Deviation	.14195	.28656	ND	2.93443	.04004
		Std. Error of Mean	.05795	.11699	ND	1.19798	.02002

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MAY. 2022	Total	Mean	.2542	.2217	ND	36.3376	.1604
		Minimum	.27	.12	ND	26.77	.04
		Maximum	.32	.41	ND	54.57	.24
		Std. Deviation	.02055	.11033	ND	10.5150	.07748

ND: Not Detected

Table 4: Case Summary of metal concentrations data obtained in sediment (Jan. to May 2022) for location III (Confluence) by SPSS

			Cr (mg/Kg)	**Zn (mg/Kg)**	**Cd (mg/Kg)**	**Fe (mg/Kg)**	**Cu (mg/Kg)**
WHO/FAO			0.1	60	1	48	30
JAN. 2022	Total	Mean	.2358	.2081	ND	15.4105	.1728
		Minimum	.18	.15	ND	12.14	.04
		Maximum	.34	.27	ND	24.22	.38
		Std. Deviation	.11323	.1528	ND	6.15473	.14824
		Std. Error of Mean	.02936	.01261	ND	1.90263	.09430
FEB. 2022	Total	Mean	.3242	.2319	ND	15.1386	.0763
		Minimum	.32	2.5	ND	20.14	.04
		Maximum	.41	.63	ND	27.65	.17
		Std. Deviation	.08446	.2361	ND	2.74834	.03156
		Std. Error of Mean	.05109	.05175	ND	1.4676	.01185
MAR. 2022	Total	Mean	.37006	.2709	ND	22.3667	.0619
		Minimum	.41	.10	ND	26.33	.02
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		Std. Error of Mean	.05333	.14928	ND	3.2691	.00390
APR. 2022	Total	Mean	.4318	.3075	ND	27.4156	.09910
		Minimum	.38	.12	ND	26.57	.06
		Maximum	.75	.87	ND	34.63	.21
		Std. Deviation	.14195	.28656	ND	2.93443	.04004

		Std. Error of Mean	.05795	.11699	ND	1.19798	.02002
MAY. 2022	Total	Mean	.2542	.2217	ND	36.3376	.1604
		Minimum	.27	.12	ND	26.77	.04
		Maximum	.32	.41	ND	54.57	.24
		Std. Deviation	.02055	.11033	ND	10.1623	.07748

ND: Not Detected

IV. CONCLUSION

Anthropogenic activities serve as a serious pollution in the environment today, thereby causing deterioration on our environment. Sedimenthas been affected majorly due to various man-made activities such as improper waste disposal, lack of toilet with soak - away in homes, lack of drainage systems, and improper effluents discharges into water bodies which eventually settles in the water sediments. These sources of pollution can either be prevented or monitored. In this research, the assessment of Fe, Cu, Zn and Cd concentrations in sediment were within the permissible limits of regulatory standards WHO/FAO throughout the sampling periods while Cr exceeded the guideline values of regulatory standards throughout the sampling period at the 10 sampling stations (3 sampling locations). Cd was below detection limit.

Based on the obtained results, it was found that the concentrations of metals in both dams are not highly polluted to cause the interaction of heavy metals between the water and sediment which may lead to adverse effect on the water consumers and for irrigation purpose. However, the concentration of Cr in the sediment is of high concern with respect to the quality of water based on sediment level of pollution by Chromium which made the water not fit for drinking. Moreso, it is glaring thatAfeleleDam (Location II) is more polluted as compared to location I and the influence of the waterways serve as carrier of heavy metals from the two locations and causes interactions of heavy metal concentration at location III.

Conflicts of Interest

The authors declare no conflicts of interest regarding this paper.

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