RISK ASSESSMENT OF TOXIC METALS IN WATER FROM ARTIFICIAL FISHPONDS IN MAKURDI

Supported by tetfund

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Received: February 14, 2025, Accepted: April 28, 2025

Abstract: This study assessed the risk of toxic metals in water from artificial fishponds in Makurdi. Water samples were collected from nine sampling sites; earthen pond, concrete and other fishponds and treated using Standard Laboratory Methods. The toxic metals including Zn, Mn, Cu, Ni, Pb, and Cd were analysed in water, using AAS across the nine fishponds in the study area and found to be present except Ni and Pb which were absent in all the sampling points. The analysed results were subjected to World Health Organization (2020) permissible limits for aquatic water quality. The average concentrations of all the heavy metals; Cd: 0.0014 mg/L, Cu: 0.0008 mg/L, Mn: 0.0470 mg/L and Zn: 0.0420 mg/L analysed in water samples across the nine ponds within the study area were below the maximum limit by WHO. Contamination factor revealed that water was not contaminated with heavy metals with decreasing trend, Cd>Zn>Mn>Cu in pond water across the study area and was not polluted except pond I (1.29×10^{0}) which was polluted and the trend of PLI in water was found in the order:, I >A >B =G=H >E >D >C >F. Ecological Risk Index for water showed low risk (E_r^i < 40 and RI < 150) for all the heavy metals present in the water samples. The trend of ecological risk across the nine fishpond water analysed is, E >A >C >D >H >I >B >F >G. The study, however, recommends regular check on fish pond water in order to prevent pollution and indeed the quality of fish been reared.

Key words: Artificial fishponds, Risk assessment, Toxic metals, Water.

Introduction

Metals are freely found in all the natural environment including water, soil, air and biota. These metals become toxic to the environment and living things when their levels exceed their natural thresholds. Many anthropogenic activities including industrial, agricultural and urban activities and other economic development projects have redistributed the natural occurrence of metals and triggered their increasing level into the environment, causing environmental degradation and toxicity to living things (Maleki and Zarasvand, 2008).

Fish production is regarded as the fastest growing business in the world due to economic and health benefits. This has triggered individual farmers, organized groups and institutions to construct ponds and rear fish with the aim of making profit while less attention is given to environmental and human challenges.

Water supply for fish pond farming usually comes from freshwater sources like rivers/streams, wells, boreholes, dames and municipal water (Kiros *et al.*, 2021). Toxic metals enter into the fish pond mainly through water source and feeds though runoffs, atmospheric depositions, geologic weathering and other farm management practices such as medicants, feed additives, antibiotics, fertilizers, disinfectants, hormones, therapeutants and anesthetics, commonly applied during farm operations could also be potential sources (Oluseye *et al.*, 2019).

Toxic metals could affect the health of the farmed fish and if carelessly discharged may contaminate soils, water bodies and even human food chain. Keeping in view their toxic effects, monitoring and assessment of toxic metals from fish ponds are of significant importance for managing environmental health.

Materials and Methods

Materials

In addition to routine materials in a standard chemical laboratory, the following were used: concentrated nitric acid (HNO_3,), concentrated perchloric acid ($HClO_4$), concentrated hydrochloric acid (HCl), concentrated sulfuric acid (H_2SO_4) and de-ionized water.

Study Area

The study area is bounded by latitude 7° 44N and 7° 55N, and longitude 8° 20E and 8° 40E. It has two seasons, raining season and dry season. The raining season lasts from May to October and the dry season lasts from November to April. Makurdi is made up of two geopolitical division, North and South separated by the river Benue. Makurdi South has more land coverage than Makurdi North, hence sampling of the fishponds was carried out in the ratio of 2:1, therefore, six (6) sampling sites at the south and 3 sampling sites at the north, making a total of nine (9) sampling sites.

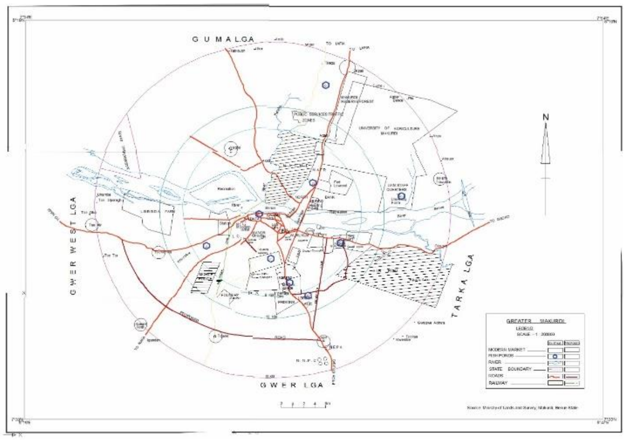

Figure 1: Map showing 9 fish ponds areas in Makurdi Metropolis used for the analysis

Water Sample Collection

Water samples in each of the nine ponds were drawn randomly and homogenized in sterile 500 mL bottles and labeled; $\mathbf{A_W}$, $\mathbf{B_W}$, $\mathbf{C_W}$, $\mathbf{D_W}$, $\mathbf{E_W}$, $\mathbf{F_W}$ for ponds from Makurdi South and $\mathbf{G_W}$, $\mathbf{H_W}$, and $\mathbf{I_W}$ for ponds at Makurdi North. The water samples collected were then be filtered through 0.45-µm filters to remove particulate matter and transported to laboratory for physiochemical analysis, noting the type of fish pond, the source of water and the type of fish in each of the ponds (Orobator *et al.*, 2020).

Digestion of Water Samples for Heavy Metals Analysis

Nitric acid (5 mL) was added to 100 mL of water sample and the mixture was slowly evaporated to near dryness. The remaining liquid was filtered into a 100 mL standard flask and made up to the mark with distilled water (Vodopivez *et al*., 2019).

All samples digested were analyzed for copper (Cu), cadmium (Cd), lead (Pb), manganese (Mn), zinc (Zn) and nickel (Ni) by atomic absorption spectrophotometry, atomic absorption spectrophotometer (PinAAcle 900F) AAS (Buck Scientific Model 210VGP)

As part of quality control, all glass apparatus used were leached with dilute acid and washed many times with distilled-deionized water to ensure no metal contaminants were introduced. Accuracy of the analytical method was validated by digesting and analyzing spiked distilled-deionized water samples, with recovery ranging from 97.2% to 99.1%.

Contamination Factor

This index enables the assessment of substance contamination, taking into account the content of heavy metal from the surface of the substance and values of geochemical background of the metals reference levels given by Ha°kanson (1980).

Cf is calculated by the following formula:

$$C_F = \frac{C(sample)}{C(shale)} \quad (1)$$

where;

C_F = contamination factor

C (Sample) = the levels of each metal,

C(Shale) = geochemical background.

Table 1: Classification of Contamination Factor

CF	Status
CF < 1	Low contamination
1 ≤ CF ≥ 3	Moderate contamination
3≤CF ≥ 6	Considerable contamination
CF >6	Very high contamination

Source: Ehiemere *et al.* (2022).

Pollution Load Index

This index provides an easy way to prove the deterioration of the substance conditions as a result of the accumulation of heavy metals (Varol, 2011). PLI compares the contamination status among the study sites and is calculated as a geometric average of PI based on the following formula (Ab Manan *et al.*, 2018).

$$PLI = \sqrt[n]{PI_1 \times PI_2 \times PI_3 \times ...PI_n} \quad (2)$$

where;

n—the number of analyzed heavy metals and

PI—calculated values for the Single Pollution Index.

Table 2: Classification of Pollution Load Index

PLI	Status
<0	Not polluted
0–2	lowly polluted
2–4	moderately polluted
4–6	severely polluted
6–8	severely polluted
<8 above	extremely polluted

Source: Singh *et al.* (2020).

Potential Ecological Risk

The potential ecological risk coefficient (E_r^i) of a single element and the potential ecological risk index (RI) of the multielement were computed using the following equations:

$$C_f^i = C_s^i / C_n^i \quad (3)$$

$$E_r^i = T_r^i \times C_f^i \quad (4)$$

$$RI = \sum_{i-1}^{n} E_r^i \quad (5)$$

C_f^i is the pollution coefficient of a single element of "i";

C_s^i is the measured level (sedimentary/water) of heavy metal;

C_n^i is the background level of heavy metal

E_r^i is the potential ecological risk index of metal i;

T_r^i is the toxic response factor of metal i, RI is the risk index

The average shale background concentration of water was selected as the reference baselines in this study: C_n^i for Cu = 45, Zn = 95, Pb = 20, Mn= 850, Cd = 0.3, Cr = 90, Ni = 68, As = 13, Hg = 0.4 (Jonathan *et al.,* 2016; Wuana *et al.,* 2020). Average global shale values and average crustal abundance have been commonly used to provide elemental background concentrations (Uluturhan *et al.,* 2011).

T_r^i is the toxic response factor for the given element of "i", which accounts for the toxic requirement and the sensitivity requirement. The toxic response factors for As, Hg, Pb, Cd, Cr, Cu, Zn, Ni and Mn are 10, 40, 5, 30, 2, 5, 1, 6 and 1respectively (Izah *et al.,* 2018; Wuana *et al.,* 2020). Table 3 shows the grading of E_r^i and RI values.

Table 3. Classification of the potential ecological risk index and integrated potential ecological risk index

Scope of Potential Ecological Risk (E_r^i)	**Risk Level**	**Scope of Integrated Potential Ecological Risk (RI)**	**Risk Level**
$E_r^i < 40$	Low	RI < 150	Low
$40 \leq E_r^i < 80$	Moderate	150 ≤ RI < 300	Moderate
$80 \leq E_r^i < 160$	Considerable	300 ≤ RI < 600	High
$160 \leq E_r^i < 320$	High	RI ≥600	Severe
$E_r^i \geq 320$	Significantly high		

Source: Cheng *et al.* (2019)

Results

Table 4: Mean Concentrations of Metals in Pond Water

Ponds Sample Identity	**Metals in Water mg/L**					
	Cd	**Mn**	**Zn**	**Cu**	**Ni**	**Pb**
A_W	0.0018±0.000	0.1780±0.000	-	-	-	-
B_W	0.0014±0.000	0.0300±0.000	0.0286±0.000	-	-	-
C_W	0.0016±0.000	0.0561 ±0.000	0.0390±0.000	0.0006±0.000	-	-
D_W	0.0016±0.000	0.0224±0.000	0.0309±0.003	0.0024±0.000	-	-
E_W	0.0018±0.000	0.0371±0.000	0.0368±0.000	0.0019±0.000	-	-
F_W	0.0009±0.000	0.0234±0.000	0.0374±0.000	0.0019±0.000	-	-
G_W	0.0008±0.000	0.0244±0.000	0.0374±0.001	-	-	-
H_W	0.0014±0.000	0.0265±0.000	0.1009±0.001	-	-	-
I_W	0.0014±0.000	0.0259±0.000	0.0676±0.001	-	-	-
Range	0.0008-0.0018	0.0224-0.1780	0.0286-0.1009	0.0006-0.0024		
Mean	0.0014±0.000	0.0470±0.000	0.0420±0.000	0.0008±0.000		
WHO limit	0.0030	0.5000	2.0000	2.0000	0.0700	0.0100

Note; A_w, B_w, C_w, D_w, E_w, F_w for water in ponds from Makurdi South and G_w, H_w, and I_w for ponds at Makurdi North

Table 5: Contamination Factors for Heavy Metals in Water

Ponds Sample Identity	metals	Contamina-tion factors	Contamina-tion status	Ponds Sample Identity	Para-meters	Contamina-tion factors	Contamina-tion status
A_w	Cd	6.00×10^{-3}	None	B	Cd	4.67×10^{-3}	None
	Cu	-			Cu	-	
	Mn	2.09×10^{-4}	None		Mn	3.53×10^{-5}	None
	Zn	-			Zn	3.01×10^{-4}	None
	Ni	-			Ni	-	
	Pb	-			Pb	-	
C_w	Cd	5.33×10^{-3}	None	D	Cd	5.33×10^{-3}	None
	Cu	1.33×10^{-5}	None		Cu	5.33×10^{-5}	None
	Mn	6.6×10^{-5}	None		Mn	2.65×10^{-5}	None
	Zn	4.11×10^{-4}	None		Zn	3.25×10^{-4}	None
	Ni	-			Ni	-	
	Pb	-			Pb	-	
E_w	Cd	6.00×10^{-3}	None	F	Cd	3.00×10^{-3}	None
	Cu	4.22×10^{-5}	None		Cu	4.22×10^{-5}	None
	Mn	4.36×10^{-5}	None		Mn	2.75×10^{-5}	None
	Zn	3.87×10^{-4}	None		Zn	3.94×10^{-4}	None
	Ni	-			Ni	-	
	Pb	-			Pb	-	
G_w	Cd	2.67×10^{-3}	None	H	Cd	4.67×10^{-3}	None
	Cu	-			Cu	-	
	Mn	2.87×10^{-5}	None		Mn	3.12×10^{-5}	None
	Zn	3.94×10^{-4}			Zn	1.06×10^{-3}	None
	Ni	-			Ni		
	Pb	-			Pb		
I_w	Cd	4.67×10^{-3}	None				
	Cu	-					
	Mn	3.05×10^{-5}	None				
	Zn	7.12×10^{-4}	None				
	Ni	-					
	Pb	-					

Note; A_w, B_w, C_w, D_w, E_w, F_w for waters in ponds from Makurdi South and G_w, H_w, and I_w for ponds at Makurdi North

Table 6: Pollution Load Index for Heavy Metals in Water

Samples	PLI	Status
A	1.00×10^{-1}	Not polluted
B	2.00×10^{-2}	Not polluted
C	3.53×10^{-3}	Not polluted
D	3.67×10^{-3}	Not polluted
E	4.03×10^{-3}	Not polluted
F	3.33×10^{-3}	Not polluted
G	2.00×10^{-2}	Not polluted
H	2.00×10^{-2}	Not polluted
I	1.29×10^{0}	Lowly Polluted

Table 7: Ecological Risk Index for Toxic Metals in Water

Samples Identity	Potential Ecological Risk Factor						RI	Risk grade
	Cd	Cu	Mn	Zn	Ni	Pb		
A_w	0.18000	-	0.00020	-	-	-	0.18020	slight
B_w	0.14000	-	0.00004	0.00030	-	-	0.14030	Slight
C_w	0.16000	0.00067	0.00007	0.00041	-	-	0.16120	Slight
D_w	0.16000	0.00027	0.00003	0.00033	-	-	0.16060	Slight
E_w	0.18000	0.00021	0.00004	0.00039	-	-	0.18060	Slight
F_w	0.09000	0.00021	0.00003	0.00039	-	-	0.09060	Slight
G_w	0.08000	-	0.00003	0.00039	-	-	0.08040	Slight
H_w	0.14000	-	0.00003	0.00106	-	-	0.14110	Slight
I_w	0.14000	-	0.00003	0.00071	-	-	0.14070	Slight
Mean	0.14000	0.00015	0.00006	0.00044	-	-	0.1407	slight

Note; A_w, B_w, C_w, D_w, E_w, F_w for water in ponds from Makurdi South and G_w, H_w, and I_w for ponds at Makurdi North, RI = Risk Index

Discussion

Heavy Metal Concentration in Water

Among the six metals analysed in the nine pond water samples including Cd, Mn, Cu, Ni, Pb and Zn, Ni and Pb were absent in all the analysed results. The concentrations of of all the individual metals in the water samples across the study area were below WHO threshold limit except the concentration of Mn in pond A which was above the recommended limit. The trend of the detected metal in water samples is Mn>Zn>Cd>Cu.

Concentration of Cd in Water

Cadmium was detected in all the water samples analysed but the concentrations were below the recommended. The concentration of Cd in the various ponds across the study area ranged from 0.0008-0.0018 mg/L with a mean of 0.0014±0.000 mg/L which is below but close to the permissible limit of Cd in pond water of 0.003 mg/L. The trend across the ponds is A=E **>** C=D > B=H=I >F > G**.** Ponds A and E have the highest and common concentration of Cd in water of 0.0018 mg/L. Pond C and D also have a common concentration of Cd in the ponds with value of 0.0016 mg/L. This is followed by ponds B and H also having a common Cd value of 0.0014 mg/L. Finally, ponds F and G have the least values of Cd in the pond water of 0.0009 and 0.0008 respectively. The observed values of Cd could be from agricultural activities including the use of pesticides and fossil fuels (Jiang *et al.*, 2019), also, the sources of water used could influence Cd in the ponds around the ponds in the study area. The concentrations of cadmium in this study contrast 0.15–0.27 mg/L high values reported by Akaahan *et al.* (2015) in the River Benue. (Jiang *et al.*, 2019).

Concentration of Cu in Water

In water, Cu was only detected in pond C, D, E and F. This could be attributed to excessive feeds, chemical treatments and run off from copper-rich agricultural and domestic wastes running into the ponds. The mean concentration of Cu in water was 0.0008±0.000 mg/L which ranged from 0.0006-0.0024 mg/L. The mean concentration and all the values recorded in the ponds were below permissible limit. The mean copper concentrations in this study were lower the 2 mg/L copper set by WHO for protection of freshwater aquatic ecosystems and human health (WHO, 2020). The concentrations of copper are comparable to the 0.093–0.280 mg/L low values of copper reported by Alinnor *et al.* (2016) in Oguta lake. The trend across the ponds is D >E =F >C.

Concentration of Mn in water

Manganese like Cd was detected in all the water samples analysed with a mean concentration of 0.047±0.000 mg/l and ranged from 0.0224-0.1780 mg/L which is below the permissible limit by WHO, indicating that the water from the pond is desirable and there is no risk or any adverse effect on consumers of fish obtained from the pond as a result of manganese contamination. The mean concentrations of manganese are comparable to 0.097–0.109 mg/L reported for manganese in Nkisa River (Alinnor and Alagoa, 2014). All the values recorded across the various water pond were also below permissible limit of 0.5 mg/L except the value recorded at pond A (0.1780 mg/L) which is an earthen pond. This could be through runoff or leaching facilitated by agricultural activities while anthropogenic sources include agro chemicals (Shaheen *et al.*, 2017). Similar result was obtained by Selina *et al.*, (2021). The trend across the ponds is A >C>E>B>H>I>G>F>D.

Concentration of Zn in water

Zinc was detected in all water samples across the fish ponds examined except in pond A. Zn across the ponds ranged from 0.0286-0.1009 mg/L with a mean concentration of 0.042±0.000 mg/L which is below permissible limit by WHO. The mean concentrations of is comparable to 0.030–0.054 mg/L reported for zinc in Nkisa River (Alinnor and Alagoa, 2014). The highest concentration of Zn was at pond H (0.1009 mg/L) while the lowest concentration was at pond B (0.0286 mg/L). The trend of Zn in the fish pond water analysed is H >I>C>F=G>E>D>B.

Contamination Factors in Water

Contamination factor (CF) of metals in water for all the ponds under the study area is presented in Table 5. The Table showed that the contamination factors for all the metals detected across the nine fish ponds were low since $0 \geq Cf < 1$ (Shaheen *et al.*, 2017).

Cd and Mn were 6×10^{-3} and 2.09×10^{-4} respectively for the analysed pond A water with a trend that showed Cd > Mn. No value of contamination factor was detected for Cu, Zn, Pb and Ni in pond A. Pond B showed that Cd, Mn and Zn had CF values of 4.67×10^{-3}, 3.53×10^{-5} and 3.01×10^{-4} respectively with the trend of contamination factor being Cd >Zn >Mn. No value of contamination factor was detected for Cu, Pb and Ni in pond B. Pond C showed that Cd, Cu, Mn, Zn had CF values of 5.33×10^{-3}, 1.33×10^{-5}, 6.6×10^{-5} and 4.11×10^{-4} respectively with Cd >Zn >Cu>Mn. Pond D showed that Cd, Cu, Mn, Zn had CF values of 5.33×10^{-3} 5.33×10^{-5}, 2.65×10^{-5} and 3.25×10^{-4} respectively and a trend of contamination factor as Cd >Zn >Cu>Mn. The contamination factor for pond E showed that Cd, Cu, Mn, Zn had CF values of 6×10^{-3}, 4.22×10^{-5}, 4.36×10^{-5} and 3.87×10^{-4} respectively and a trend that showed Cd >Zn >Cu > Mn. Pond F shows that Cd, Cu, Mn and Zn had CF values of 3×10^{-3}, 4.22×10^{-5}, 2.75×10^{-5} and 3.94×10^{-4} respectively and trend of contamination factor; Cd >Zn >Cu>Mn. Pond G showed that Cd, Mn and Zn had CF values of 2.67×10^{-3}, 2.87×10^{-5} and 3.94×10^{-4} respectively which trend; Cd >Zn >Mn. The contamination factor for pond H showed that Cd, Mn and Zn had CF values of 4.67×10^{-3}, 3.12×10^{-5} and 1.06×10^{-3} and a trend of; Zn > Cd >Mn. No value of contamination factor was detected for Pb and Ni in pond C, D, E, F, G and H. The contamination factor for pond I showed that Cd, Mn and Zn had CF values of 4.67×10^{-3}, 3.05×10^{-5} and 7.12×10^{-4} respectively and a trend of contamination factor thus; Cd >Zn >Mn. No value of contamination factor was detected for Cu, Pb and Ni in pond I.

From Table 5, it could be seen that, the trend of contamination factor for Cd in the nine pond waters in the study area is C=D >B=H=1 >G >A=E >F with range of 5.33×10^{-3} – 3.00×10^{-3} and an average of 4.70×10^{-3}. Cu was only detected in four out of the nine fish pond water analysed and the trend of contamination factor for Cu in the pond waters in the study area is D >E=F>C with range of 5.33×10^{-5} -1.33×10^{-5} and an average of 1.68×10^{-5}.

The trend of contamination factor for Mn in the nine pond waters in the study area is A >C >E >B>H>I>G>F>D with range of 2.09×10^{-4} - 2.65×10^{-5} and an average of 5.54×10^{-5}.

Zn was detected in all the water samples from the fish ponds except in pond A. The trend of contamination factor for Zn in the eight water samples in the study area is H>I>C>G=F>E>D>B with a range of 1.06×10^{-3}-3.01×10^{-4} and an average of 4.43×10^{-4}. Across the pond, Cd was found to be more contaminated in the water sample, follow by Zn, Mn and Cu.

Pollution Load Index for Heavy Metals in Water

Pollution severity and its variation along the sites was determined with the use of pollution load index calculated from the values of contamination factor obtained from individual heavy metals in the water samples of the nine fish ponds across the study area. This index is a quick tool in order to compare the pollution status of different places (Adebowale *et al*., 2009). The values of Pollution Load Index in water samples were found to be generally low (PLI<1) in all the studied stations except in pond I (1.29×10^{0}) where the pollution load index (PLI > 1). The high value of PLI for water in pond I could be due to the influence of external discrete sources like industrial activities, agricultural runoff and other anthropogenic inputs (Wuana *et al*,. 2020). This suggests that the water of the nine fish pond under study in Makurdi metropolis was not polluted but under threat of being polluted. Similar result was reported by Ehiemere *et al.* (2022) in a fish farm cluster in Niger Delta region, Nigeria.

Ecological Risk Index for Toxic Metals in Water

Table 7 showed that the Ecological Risk Indices for water across the ponds were low since Eri < 40. Pond A showed that Cd and Mn had risk factor values of 0.18 and 0.00020 and a trend that showed Cd>Mn. No value of Ecological Risk Index was detected for Cu, Zn, Pb and Ni in pond A. The Ecological Risk Index for water in pond B shows that Cd, Mn and Zn had risk factor values of 0.14, 0.00004 and 0.00030 respectively and a trend of Cd>Zn>Mn. No value of Ecological Risk Index was detected for Cu, Pb and Ni in pond B.Pond C shows that Cd, Cu, Mn and Zn had risk factor values of 0.16, 0.00027, 0.00003 and 0.00033 respectively with trend that showed Cd>Zn>Cu>Mn. Pond D showed that Cd, Cu, Mn and Zn had risk factor values of 0.16, 0.00027, 0.00003 and 0.00033 and trend values; Cd>Zn>Cu>Mn. Pond E presents that Cd, Cu, Mn and Zn had risk factor values of 0.18, 0.00021, 0.00004 and 0.00039 respectively and a trend of Cd>Zn>Cu>Mn. Pond F shows that Cd, Cu, Mn and Zn had risk factor values of 0.09, 0.00021, 0.00003 and 0.00039 respectively and a trend of Cd>Zn>Cu>Mn. No value of Ecological Risk Index was detected for Pb and Ni in ponds C, D, E and F. Pond G shows that Cd, Mn and Zn had risk factor values of 0.08, 0.00003 and 0.00039 respectively and a trend of Cd>Zn>Mn. Pond H shows that Cd, Mn and Zn had risk factor values of 0.14, 0.00003 and 0.00106 respectively and a trend of; Cd>Zn>Mn. Pond I showes that Cd, Mn and Zn had risk factor values of 0.14, 0.00003 and 0.00071 respectively and trend that follows Cd>Zn>Mn. No value of Ecological Risk Index was detected for Cu, Pb and Ni in ponds G, H and I.

The trend of Ecological Risk Index for Cd in the water is A=G>C=D>B=H=I>F>G with range of 0.18-0.08 and an average of 0.14, therefore the RI of Cd in the entire study area is low. Cu was only found in four out of the nine waters of the fish ponds in the study area. The trend of ecological risk index for Cu in water of the pond is C>D>E=F, with a range of 0.00067-0.00021 and an average of 0.00015 which showed that the RI of Cu in the waters of the ponds to be low.

Across the nine ponds, the trend of Ecological Risk Index for Mn in the water is A>C>B=C>D=F=G=H=I with range of 0.00020-0.00003 and an average of 0.00006, therefore the RI of Mn in the entire study area is low. Across the nine ponds, the trend of Ecological Risk Index for Zn in the water is H>I>C>E=F=G>D>B with range of 0.00106-0.00030 and an average of 0.00044, therefore the RI of Zn in the entire study area is low.

Ecological risk index values for all the toxic metals in water were all far below 30, showing slight risk of toxic metal poisoning from ingestion of water. This indicates safe water from the ponds and poses no ecological hazard to aquatic life or humans that come in contact with them. Similar result was obtained by Wuana *et al.* (2020). The trend of ecological risk across the nine fish pond water analysed is, E >A >C >D >H >I >B >F >G. Rozirwan *et al*. (2024) on Ecological Risk Assessment of Heavy Metal Contamination in Water, Sediment, and Polychaeta (*Neoleanira Tetragona*) from Coastal Areas Affected by Aquaculture, Urban Rivers, and Ports in South Sumatra revealed low contamination and safe ecological environment for heavy metals analysed in pond water.

Conclusion

All the heavy metals in the water samples were in compliance with the regulatory standards approved for water use in aquaculture.

Contamination factor was below one for all the toxic metals under study in water samples analysed. This means there is generally, low contamination from these metals through water. Across the pond, Cd was found to be more contaminated in the water sample, follow by Zn, Mn and Cu. The values of Pollution Load Index in water samples were found to be generally low (<1) in all the studied stations except in pond I where the pollution load index was found to be > 1. Ecological risk index values for all the toxic metals in water were all far below 30, showing slight risk of toxic metal poisoning from ingestion of water. This indicates safe water from the ponds and poses no ecological hazard to aquatic life or humans. The overall risk index (RI) for all the toxic metals in water is to be graded as A (slight), since the values are way below 30. The study however, recommends regular check on fish pond water in order to prevent pollution and indeed the quality of fish been reared.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

(ALL THE FONT OF THE TABLES ARE CORRECTED, ERRORS DETECTED HAVE BEEN REMOVED, REPORTS ON SEDIMENTS REMOVED FROM THE WORK, 'MAJOR CORRECTION ARE EFFECTED IN BLUE COLORATION' FOR YOU TO SEE

References

Ab Manan, W. N. A., Sulaiman, F. R., Alias, R., and Laiman, R. (2018). Determination of selected heavy metal concentrations in an oil palm plantation soil.

Journal of Physical Science, 29, 63–70. doi:10.21315/jps2018.29.s3.8.

Adebowale K.O. Agunbide F.O., and Olu-Owolabi, B. (2009). "Trace metal concentration, site variations and partitioning pattern in water and bottom sediments from coastal area: A case study of Ondo Coast, Nigeria", *Environmental Research Journal*, Vol.3, No.2, pp. 46-59.

Akaahan, T.J., Olabanji, F. M. and Azua, E. T. (2015) Studies on contamination of surface waters of River Benue with trace elements at Makurdi, Benue State, Nigeria. *Journal of Environmental Chemistry and Ecotoxicology*, 7 (5), 49–55.

Alinnor, I. J., Ayuk, A.A. and Igbomezie, M.C. (2016). Distribution of elemental contaminants in water and fish samples from Oguta Lake, Nigeria. *International Journal of Fisheries and Aquatic Studies,* 4 (3), 659–664.

Alinnor, I. J. and Alagoa, A. F. (2014). Trace metal distribution in fish, sediment and water samples from Nkisa River, Nigeria. *British Journal of Applied Science Technology*, 4 (20), 2901–2913.

Cheng, H., Lei Huang, Pengtu Ma and Yi Shi. (2019). Ecological Risk and Restoration Measures Relating to Heavy Metal Pollution in Industrial and Mining Wastelands. *International Journal of Environmental Research and Public Health,* 217-234.

Ehiemere,V.C Ihedioha, J.N., Ekere,N.R., Ibeto, C.N., and Abugu, H.O. (2022). Pollution and risk assessment of heavy metals in water, sediment and fish (Clarias gariepinus) in a fish farm cluster in Niger Delta region, Nigeria*. Journal of Water and Health,* 20 (6), 928-945.

Izah S. C., Bassey S. E., and Ohimain E. I. (2018). Ecological Risk Assessment of Heavy Metals in Cassava Mill Effluents Contaminated Soil in a Rural Community in the Niger Delta Region of Nigeria. *Molecular Soil Biology,* 9, 1-11.

Jiang, F.; Ren, B.; Hursthouse, A.; Deng, R.;Wang, Z. (2019). Distribution, source identification, and ecological-health risks of potentially toxic elements (PTEs) in soil of thallium mine area (southwestern Guizhou, China). *Environmental Science and Pollution Research,* **26**, 16556–16567.

Jonathan, B. Y., Maina, H. M., and Maitera, O. N. (2016). Heavy Metal Pollution Assessment in the Sediments of Lake Chad, Nigerian Sector. *Bayero Journal of Pure and Applied Sciences,* 9, 213-216. https://doi.org/10.4314/bajopas.v9i1.33

Kiros, G. G., Goitom, G. B., Amanual, H. T., and Samuel, E. G. (2021). Assessment of Some Physicochemical Parameters and Heavy Metals in Hand-Dug Well Water Samples of Kafta Humera Woreda, Tigray, Ethiopia. *International Journal of Analytical Chemistry*, 1-9.

Maleki, A., and Zarasvand,M. A. (2008). Heavy metals in selected edible vegetables and estimation of their daily intake in Sanandaj, Iran. *Journal of Research in Forestry, Wildlife and Environment*, 12(1): 24-33.

Oluseye, O. A., Adebanjo, J. A., Shola, H. A., Oluwaseun, C. A., Babatunde, T. A. and Mabel O. I. (2019). Histopathological biomarking changes in the internal organs of Tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*) exposed to heavy metals contamination from Dandaru pond, Ibadan, Nigeria. *Journal of Taibah University for Science*, 13: 903-911.

Orobator, P. O., Akiri-Obaroakpo, T. M. and Orowa, R. (2020). Water Quality Evaluation From Selected Aquaculture Ponds in Benin City, Nigeria. *Journal of Research in Forestry, Wildlife and Environment*, 12(1): 24-33.

Rozirwan, Az-Zahrah, S.F., Khotimah, N.N., Nugroho, R.Y., Putri, W.A., Fauziyah, Agustriani, M.F., and Siregar, Y.I. (2024). Ecological Risk Assessment of Heavy Metal Contamination in Water, Sediment, and Polychaeta (*Neoleanira Tetragona*) from Coastal Areas Affected by Aquaculture, Urban Rivers, and Ports in South Sumatra. *Journal of Ecological Engineering*, 25(1), 303–319.

Singh, J.K., Kumar, P., Kumar, R., (2020). Ecological risk assessment of heavy metal contamination in mangrove forest sediment of Gulf of Khambhat region, West Coast of India. *SN Applied Sciences*, 2(12), 1–11.

Uluturhan, E., Kontas, A., and Can, E. (2011). Sediments Concentrations of Heavy Metals in the Homa Lagoon: Eastern Agean Sea, Assessment of Contamination and Ecological Risks. *Marine Pollution Bulletin,* 62, 1989-1997. https://doi.org/10.1016/j.marpolbul.2011.06.019

Varol, M. (2011). Assessment of heavy metal contamination in sediments of the Tigris River (Turkey) using pollution indices and multivariate statistical techniques. *Journal of Hazardous Materials,* 195, 355–364.

World Health Organization (WHO). (2020). "Water Quality Requirements https://www.who.int/water_sanitation_health/resourcesquality/wpcchap2.pdf. 2020 [Online].

Wuana, R., Ogbodo, C., Itodo, A. U. and Eneji, I. S. (2020). Ecological and Human Health Risk Assessment of Toxic Metals in Water, Sediment and Fish from Lower Usuma Dam, Abuja, Nigeria. *Journal of Geoscience and Environment Protection*, 8, 82-106. https://doi.org/10.4236/gep.2020.85006.