EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Coden USA: EJBPBO
Volume: 13
Issue: 4
Year: 2026

HEAVY METAL CONTAMINATION OF WATER, SEDIMENTS, AND FISH FAUNA IN WOJI CREEK AND ITS HEALTH IMPLICATIONS IN THE NIGER DELTA, NIGERIA

[1]Dorah Israel Gwunireama, *[2]Okezie Chinedu Ugwa

[1]Department of Aquaculture and Fisheries, Ignatius Ajuru University of Education, Rumuolumeni, P.M.B. 5047, Port Harcourt. Rivers State. Nigeria.
[2]Department of Anatomical Pathology, University of Port Harcourt, Rivers State, Nigeria.

***Corresponding Author: Okezie Chinedu Ugwa**
Department of Anatomical Pathology, University of Port Harcourt, Rivers State, Nigeria.

DOI: https://doi.org/10.5281/zenodo.19508450

How to cite this Article: [1]Dorah Israel Gwunireama, *[2]Okezie Chinedu Ugwa. (2026). Heavy Metal Contamination of Water, Sediments, and Fish Fauna In Woji Creek and Its Health Implications In The Niger Delta, Nigeria. European Journal of Biomedical and Pharmaceutical Sciences, 13(4), 483–491.

Article Received on 15/03/2026 **Article Revised on 05/04/2026** **Article Published on 10/04/2026**

ABSTRACT
Heavy metal contamination of aquatic ecosystems poses significant environmental and public health risks, particularly in communities dependent on such resources for water and food. This study evaluates the potential human health risks associated with heavy metal contamination of fish and aquatic environments in Woji Creek, Niger Delta, Nigeria. Samples of water, sediment, and fish were collected monthly from five stations between October 2023 and September 2024 and analyzed using flame atomic absorption spectrophotometry, while physicochemical parameters were determined using standard methods. Mean total dissolved solids (5432.03 mg/L), hardness (4158.40 mg/L), and chloride (8790.14 mg/L) exceeded World Health Organization WHO limits, while dissolved oxygen (2.72 mg/L) was below recommended levels. Lead (Pb) (0.163 mg/L) and Chromium (Cr) (0.408 mg/L) exceeded permissible limits in water, with seasonal variations showing higher Manganese (Mn), Cr, and Nickel (Ni) in the dry season and Pb in the wet season. In sediments, only Cadmium (Cd) (6.843 mg/kg) exceeded limits. In fish, Pb, Mn, Cr, and Ni exceeded Food and Agriculture Organization, FAO/WHO limits. The elevated concentrations of heavy metals, particularly in fish, indicate significant contamination and potential health risks to consumers, necessitating urgent monitoring and remediation are recommended to improve water quality and ensure food safety.

KEYWORDS: Bioaccumulation, Fish contamination, Heavy metals, Public health risk, Water quality, Woji Creek.

INTRODUCTION

The aquatic environment (seas, oceans, rivers and lakes) which covers about 70$^o/_o$ of the earth surface is one of man's great hopes for future food supplies.[1] The release of toxic pollutants into aquatic environments has significantly increased due to industrialisation and growing human activities, including the discharge of untreated municipal and industrial effluents. This has degraded water quality and made many water resources dangerous for both humans and ecosystems.[2,3]

Consumers of contaminated water and fish face serious health hazards due to the persistent and non-biodegradable nature of many heavy metals deposited into water systems. These metals can bioaccumulate in aquatic creatures and biomagnify across food chains.[2,4]

Bioaccumulation is a term used to describe the process by which chemicals are taken up by an organism either directly from exposure to a contaminated medium or by consumption of food containing the chemical.[5] These chemicals can be taken up through any route, including respiration, ingestion or direct contact.[5]

Heavy metals are persistent, toxic pollutants that accumulate in fish organs and can cause serious physiological and health effects to humans when they eat these fishes.[2] Heavy metals are released into rivers, lakes, streams, and groundwater due to industrial effluents, mining, agricultural runoff, inappropriate waste management, and acid rain.[5]

Lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), manganese (Mn), and zinc (Zn) are the six heavy metals of concern that are the subject of this investigation.

The negative impacts of these heavy metals on the environment are well documented. Lead (Pb; atomic number 82) is a toxic heavy metal that affects multiple organ systems. High exposure can cause microcytic hypochromic anemia, severe stomach ache, muscle weakness and brain damage, while even low-level exposure especially in children can impair cognitive development and cause long-term health effects.[6,7,8]

Cadmium (Cd; atomic number 48) is present as an impurity in disposal of smelted metal, batteries, paints, phosphate fertilizers, detergents, refined petroleum products and plastics in water bodies leading to contamination of these water bodies.[9] Chronic exposure is linked to bone damage such as osteomalacia and osteoporosis.[10]

Chromium (Cr, atomic number 24) is widely used in metal alloys, pigments, and industrial materials that can accumulate in aquatic life and increase the risks to humans who eat contaminated fish. Chronic exposure, particularly to hexavalent chromium, can irritate skin, cause ulcers, and damage the liver, kidneys, and nervous system.[11,12]

Nickel (Ni, atomic number 28) is released into the air by power plants, trash incinerators and wastewater discharges, where it can contaminate air, soil, and surface water.[9] While nickel may have trace biological roles, excessive exposure can cause allergic dermatitis, respiratory diseases (e.g., asthma and chronic bronchitis), reproductive effects, and increased risks of lung and nasal cancers.[13]

Manganese (Mn; atomic number 25) is an essential trace element that is frequently employed in the manufacturing of steel, seen in fuel additives like MMT, pesticides, and work environments like welding[14,15] Chronic overexposure has been linked to probable reproductive consequences, motor impairment (manganism), and psychological problems.

Zinc (Zn; atomic number 30) is an abundant metal and an essential trace nutrient vital for growth, immune function, and overall health. However, excessive zinc intake can cause toxicity, including gastrointestinal symptoms and copper deficiency due to impaired absorption, and elevated environmental zinc levels can be harmful to aquatic organisms.[16]

The collection of fish species both benthic and pelagic that live in a specific aquatic area at a specific period is referred to as fish fauna. Oyster and other bivalve shellfish serve as important indicators of aquatic ecosystem health because they are filter-feeding organisms that integrate environmental conditions over time, improve water quality by removing suspended particles and nutrients, and occupy key positions in aquatic food webs as both prey and human food resources.[17]

Sediments are particulate inorganic and organic materials derived from weathering and erosion, transported by wind, water, ice, or gravity, and deposited in aquatic environments where they accumulate and influence habitat structure and nutrient cycling.[18,19] In aquatic systems, sediments function both as sinks and potential secondary sources of heavy metals through adsorption–desorption and redox processes, thereby affecting metal bioavailability, ecological integrity, and potential human exposure via the food chain.[20,21]

There is very little information on the levels of heavy metals in water, sediment and fish fauna of Woji creek. The Woji Creek is a very important water body in the Port Harcourt metropolis since it connects to so many communities and it is also used by the inhabitants of these communities for various purposes such as drinking, cooking, fishing, boating, washing, and bathing. This study aims to evaluate the potential human health risks associated with heavy metal contamination of fish and aquatic environments in Woji Creek, Niger Delta, Nigeria. Specifically, the study seeks to achieve the following:

a) To determine the levels of selected heavy metals in the water, sediment and fish fauna of Woji Creek and compare it with the standard acceptable by regulatory bodies such as World Health Organization (WHO), Food and Agricultural Organization (FAO), etc.
b) To determine the spatio-temporal variations in the water, sediment and fish fauna of Woji Creek.
c) To recommend approaches in reducing the negative impacts of heavy metals in water and seafoods to ensure food safety among consumers.

Ethical considerations

Ethical approval for this study was obtained from the Research Ethical Committee of the University of Port Harcourt Teaching Hospital, Rivers State with reference number: UPTH/ADM/90/S.II/VOL/XI/476.

MATERIALS AND METHODS

Study Area

The study was conducted at Woji Creek, a tributary of the Bonny Estuary located in Port Harcourt receiving domestic and industrial effluents. Located between 4°48′–4°57′N and 6°55′–7°05′E, it flows through several communities and is dominated by dominated by Nypa palms (*Nypa fructicans*) and mangrove (*Avicennia nitida* and *Rhizophora racemosa*). Sampling was done monthly for 12 months from October, 2023 to March, 2024 were used to represent the dry season, while April, 2024 to September, 2024 were used to represent the wet season across five stations approximately 500m apart along the creek using GPS and accessed by boat. A total of 540 water, sediment, and fish samples were collected, and key physicochemical parameters analyse.

Sample Collection

Water samples were collected monthly for 12 months from five stations at a depth of 4–5 cm below the water-surface using pre-labelled 50 cl plastic bottles and transported on ice to the laboratory for analysis. Sediment samples were collected in triplicate from mainland, coastal, and mid-shore locations using a locally fabricated Ekman grab, stored in clean polyethylene bags, and transported on ice for analysis. Fish samples were obtained from local fishermen operating within the creek, stored in clean polyethylene bags, and conveyed on ice to the laboratory for further analysis.

Sample analysis

The analysis was carried out at Jawura Environmental Services at No. 27 Andrews street, Rumuobiakani, Port Harcourt, Rivers State. Parameters analysed were;

1. **Physico-Chemical Parameter of the Water:** The physicochemical parameters were analyzed both *in situ* (temperature, pH, and salinity) and in the laboratory (DO, TDS, chloride, hardness, turbidity, nitrate, and total suspended solids) using standard methods, the values were recorded.
2. **Heavy Metals Analysis in Water Sample:** In the laboratory, water samples were acidified with nitric acid and analyzed for heavy metals using flame Atomic Absorption Spectrophotometry (AAS) following APHA standard methods.
3. **Heavy Metal Analysis in Sediment Samples:** The Sediment samples were dried at 105 °C, ground, sieved, digested with nitric acid (HNO_3), filtered, and analyzed for heavy metals using flame Atomic Absorption Spectrophotometry (AAS; Buck Scientific Model-210)
4. **Heavy Metal Analysis in Fish Samples:** Metals in fish samples (*Oreochromis niloticus* and *Uca* tangeri) were processed and analyzed for heavy metals using flame AAS in accordance with APHA methods. the samples.

Statistical analysis

Analysis of variance (ANOVA) and descriptive statistics were used to analyse the data, using SPSS software programme.

RESULTS

Five different stations along the Woji Creeks were considered in this study. The physico-chemical parameters of the water were measured at each station, and the concentrations of selected heavy metals were analyzed in the water, sediments, and fish fauna.

From table 1 below, spatial distribution showed that the maximum and minimum mean temperatures, pH, and salinity were recorded at Station 4 and Station 1, respectively**.** The maximum and minimum mean Dissolved Oxygen (DO) and Total Dissolved Solids (TDS) were recorded at Station 5 and Station 1, respectively, whereas Hardn**ess** and Turbidity were highest at Station 4 and Station 1, respectively, with their lowest values at Stations 2 and 3, respectively**.** Chloride and Total Suspended Solids recorded their maximum values at Station 5 and lowest at Station 1 and Station 2, respectively**.** Although pH and nitrate showed no significant spatial variation ($P > 0.05$), temperature, TDS, salinity, dissolved oxygen, hardness, and chloride showed significant differences among some stations ($P < 0.05$).

Table 1: Mean values (±S.E) of the physico-chem ical parameters of Woji Creek.

Parameters	Sampling Stations					
	1	2	3	4	5	Total (Mean)
Temp (^oc)	27.217± 0.309	28.025± 0.194	28.508± 0.320	28.592± 0.315	28.375± 0.255	28.143± 0.139
PH	6.780± 0.246	6.930± 0.202	7.001± 0.160	7.040± 0.186	7.018± 0.121	6.954± 0.082
Salinity (mg/l)	5.098± 0.530	6.890± 0.363	7.500± 0.571	8.692± 0.643	8.617± 0.685	7.359± 0.300
D O(mg/l)	2.075± 0.114	2.300± 0.115	2.933± 0.169	3.108± 0.287	3.183± 0.275	2.720± 0.107
Hardness(mg/l)	3486.167± 518.240	2870.000± 323.929	4600.000± 787.689	5808.333± 1207.769	4027.500± 490.182	4158.400± 342.808
Chloride(mg/l)	4577.718± 706.181	5551.259± 531.725	10813.463± 1504.044	11252.096± 1643.132	11756.179± 1691.217	8790.143± 693.377
TDS (mg/l)	3316.700± 309.380	4310.467± 259.813	6289.725± 782.406	6180.708± 863.548	7062.533± 1384.042	5432.027± 401.229
TSS (mg/l)	8.500± 1.183	7.367± 1.275	8.908± 2.592	7.867± 1.862	8.483± 2.034	8.225± 0.807
Turbidity(NTU)	7.372± 0.395	5.818± 0.470	5.543± 0.403	5.663± 0.405	5.815± 0.366	6.042± 0.197
Nitrate (mg/l)	4.761± 1.009	3.960± 0.893	4.144± 0.883	4.454± 0.940	4.023± 0.846	4.268± 0.397

Table 2 shows the seasonal variations showed that temperature, pH, hardness, chloride, TDS, TSS, and nitrate were generally higher during the dry season, while salinity, dissolved oxygen (DO), and turbidity were higher in the wet season. Overall, these variations indicate moderate seasonal influences on the physicochemical characteristics of Woji Creek.

Table 2: Seasonal variations in the physico-chemical parameters of Woji creek.

Parameters	Seasons	
	Dry	Wet
Temperature(°c)	28.217	28.070
pH	7.089	6.818
Salinity(mg/l)	6.717	8.002
DO(mg/l)	2.543	2.897
Hardness(mg/l)	4903.467	4746.936
Chloride(mg/l)	10328.365	6224.937
TSS(mg/l)	4088.810	675.243
TDS(mg/l)	10.843	5.607
Turbidity(NTU)	5.400	5.841
Nitrate(mg/l)	6.240	2.296

Table 3 presents the comparison between the mean physicochemical parameters of water from Woji Creek and the permissible limits recommended by the World Health Organization (WHO)**.** The mean temperature (28.14 °C) and pH (6.95) were within the recommended limits, while nitrate (4.27 mg/L), salinity (7.36 mg/L), and total suspended solids (8.23 mg/L) were also below the guideline values. However**,** total dissolved solids (5432.03 mg/L), chloride (8790.14 mg/L), hardness (4158.40 mg/L), and turbidity (6.04 NTU) exceeded the recommended limits, whereas dissolved oxygen (2.72 mg/L) was lower than the recommended range**,** indicating potential deterioration in water quality.

Table 3: Comparison of the mean total variation of physic-chemical parameters of water of Woji Creek with permissible limits by some regulatory bodies.

Parameters	Total mean level in Woji creek	W. H.O. Permissible level
Temp (°C)	28.143	30-35
Ph	6.954	6.5-8.5
TDS (mg/l)	5432.027	500
D O (mg/l)	2.720	5.00-7.00
Chloride (mg/l)	8790.143	250
Hardness (mg/l)	4158.400	300
Nitrate (mg/l)	4.268	45
Turbidity (NTU)	6.042	<5
Salinity (mg/l)	7.359	200
TSS (mg/l)	8.225	500

Table 4 represents the sample report for the five different stations from the water, sediments and the fish fauna (Uca tangeri) respectively. In the creek, the maximum mean concentration of Cadmium (0.004mg/l) at station 2, Lead (Pb) at station 3 (0.201mg/1), Manganese (Mn) at station 1 (0.036mg/l), Chromium (0.446mg/l) at station 5, Nickel at station 1 (0.066mg/l), Zinc (0.068mg/l) at station 4 while the minimum mean concentration for each heavy metal was; (0.122mg/l) for lead at station 1, Manganese at station 4 (0.020mg/l), Chromium (0.375mg/l) at station 3, Nickel (0.051mg/l) at station 4, Zinc (0.008mg/l) at station 5. No significant spatial or seasonal variations were observed (p > 0.05), and the overall abundance of metals followed the order: Cd < Zn < Mn < Ni < Pb < Cr**.**

The second section of the table shows spatial distribution of heavy metals in the sediments of Woji Creek. Mean concentrations ranged from 5.221–9.508 mg/kg for Cd, 5.442–7.308 mg/kg for Pb, 26.034–40.843 mg/kg for Mn, 10.375–12.118 mg/kg for Cr, 2.899–3.928 mg/kg for Ni, and 26.168–49.563 mg/kg for Zn, with the highest values generally recorded at Stations 1, 2, or 5 depending on the metal. The overall abundance followed the order Ni < Pb < Cd < Cr < Mn < Zn**,** with no significant spatial variation (P > 0.05) for Cd, Pb, Cr, and Ni**,** whereas Zn and Mn showed significant spatial differences among stations.

The last section of the table shows the spatial distribution of heavy metals in the fish fauna. The maximum mean concentration (0.129mg/kg) and minimum mean concentration (0.063mg/kg) of Cd were recorded in station 4 and station 1 respectively. The maximum mean concentration (9.713mg/kg) and minimum mean concentration (5.236mg/kg) of Pb concentration were recorded at station 4 and station 1 respectively. The maximum mean concentration (77.612mg/kg) and minimum mean concentration (64.541mg/kg) of Mn were recorded at stations 1 and 4 respectively. The maximum mean concentration (66.008mg/kg) and minimum mean concentration (49.493mg/kg) of Cr were recorded in station 1 and station 3 respectively. The maximum mean concentration (3.541mg/kg) and minimum mean concentration (2.414mg/kg) of Ni were recorded in station 1 and station 5 respectively. The mean maximum concentration (190.973mg/kg) and minimum (57.076mg/kg) of Zn were recorded in station 1 and station 4 respectively. The mean total concentrations of heavy metals in the biological samples of Woji creek was found to be in the following pattern: Cd < Ni < Pb < Cr < Mn < Zn. There was no significant difference (P>0.05) in the spatial variations of Cd, Pb, Mn, Cr and Ni but there was for Zn (P < 0.05).

Table 4: Mean concentration (±S.E) of heavy metals in the Woji Creek, sediment and fish fauna (*Uca tangeri*) samples respectively across five (5) sampling stations.

	Station	Metals (mg/kg)					
		Cd	Pb	Mn	Cr	Ni	Zn
	1	0.001±0.000	0.122±0.072	0.036±0.011	0.412±0.150	0.066±0.038	0.013±0.004
WATER	2	0.004±0.002	0.154±0.091	0.025±0.007	0.380±0.137	0.060±0.038	0.009±0.003
	3	0.001±0.000	0.201±0.103	0.026±0.009	0.375±0.123	0.055±0.032	0.009±0.004
	4	0.001±0.000	0.147±0.077	0.020±0.007	0.430±0.140	0.051±0.029	0.068±0.002
	5	0.002±0.001	0.191±0.088	0.021±0.006	0.446±0.144	0.061±0.035	0.008±0.001
	Total (mean)	0.002±0.001	0.163±0.038	0.026±0.004	0.408±0.600	0.059±0.015	0.009±0.001
	1	9.508±6.848	7.308±1.440	26.034±4.596	10.375±2.530	3.323±0.652	49.563±8.166
	2	7.563±5.957	5.442±1.643	28.590±5.338	11.541±1.919	3.928±0.812	43.472±7.415
SEDIMENT	3	5.630±2.887	5.858±1.422	31.894±4.404	10.827±1.112	2.956±0.673	32.071±5.280
	4	6.292±2.910	5.894±2.212	28.508±1.892	11.056±1.805	3.055±0.584	26.168±5.466
	5	5.221±2.520	5.508±2.068	40.843±7.235	12.118±1.716	2.899±0.212	31.507±5.481
	Total (mean)	6.843±1.994	6.002±0.777	31.174±2.261	11.183±0.812	3.232±0.272	36.556±3.011
	1	0.063±0.026	5.236±1.389	77.612±12.306	66.008±12.355	3.541±0.650	190.973±92.669
	2	0.071±0.033	7.406±2.162	70.553±11.027	58.238±9.378	3.454±0.629	109.575±12.433
FISH	3	0.087±0.030	8.038±2.719	70.709±8.426	49.493±8.968	2.887±0.485	83.991±10.898
FUANA	4	0.129±0.041	9.713±3.856	64.541±10.74	64.179±10.142	2.357±0.374	57.076±9.030
	5	0.113±0.041	9.286±4.617	70.601±10.841	55.101±9.574	2.414±0.367	76.429±10.038
	Total (mean)	0.092±0.015	7.936±1.383	70.803±4.670	58.604±4.454	2.930±0.232	103.609±19.348

Table 5 shows the season variations in the water, sediment and the fish fauna. The water section for each heavy metal shows; dry season mean Cd concentration (0.003mg/l) was higher than that of the wet season (0.001mg/l). The wet season mean concentration of Pb (0.298mg/l) was higher than the dry season mean concentration (0.028mg /l). The dry season mean concentration of Mn (0.297mg/l) was higher than that of the wet season (0.001mg/l). The dry season mean concentration (0.802mg/l) of Cr was higher than that of the wet season (0.014mg/l). The dry season mean concentration of Ni (0.120mg/l) was higher than that of the wet season (0.005mg/l) (Table 4.7). The mean total concentration of Ni was 0.059mg/l. The dry season mean concentration of Zn (0.017mg/1) was higher than that of the wet season (0.002mg/l).

The second section presents the seasonal variation of heavy metals in the sediments of Woji Creek. The wet season recorded higher mean concentrations of Cd (6.177 mg/kg) and Mn (32.868 mg/kg) compared to the dry season values of 0.034 mg/kg and 29.480 mg/kg, respectively. In contrast, Pb (6.339 mg/kg), Cr (15.552 mg/kg), Ni (3.438 mg/kg), and Zn (46.839 mg/kg) showed higher mean concentrations during the dry season compared with the wet season values of 5.665 mg/kg, 6.817 mg/kg, 3.026 mg/kg, and 26.265 mg/kg, respectively. Overall, the mean concentrations of heavy metals followed the order Ni < Pb < Cd < Cr < Mn < Zn, with seasonal variations showing significant differences for some metals.

The third section shows the seasonal variation of heavy metals in the fish fauna of the Woji Creek. The dry season mean concentration of Cd (0.170mg/kg) was higher than that of the wet season (0.015mg/kg). Dry season mean Pb concentration (8.186mg/kg) was higher than that of the wet season (7.685mg/kg). Dry season mean Mn concentration (55.520mg/kg) was lower than that of the wet season (86.087mg/kg). The dry season mean concentration of Cr (79.098mg/kg) was higher than that of the wet season (38.109mg/kg). The dry season mean Ni concentration (2.803mg/kg) was lower than that of the wet season (3.058mg/kg). The dry season mean concentration (87.008mg/kg) of Zn was higher than that of the wet season (84.211mg/kg). The mean total concentrations of heavy metals in the biological samples of Woji creek was found to be in the following pattern: Cd < Ni < Pb < Cr < Mn < Zn. There was no significant difference (P>0.05) in the spatial variations of Cd, Pb, Mn, Cr and Ni but there was for Zn ($P < 0.05$).

Table 5: Mean concentrations of heavy metals in water, sediment and fish fauna (*Uca* tangeri) samples of Woji Creek during dry and wet seasons.

Medium	Season	Metals (mg/kg)					
		Cd	Pb	Mn	Cr	Ni	Zn
Water	Dry	0.003	0.028	0.297	0.802	0.120	0.017
Water	Wet	0.001	0.298	0.001	0.014	0.005	0.002
Sediment	0.034	6.339	29.480	15.552	3.438	46.389	0.034
Sediment	6.177	5.665	32.868	6.817	3.026	26.265	6.177
Fish Fauna	Dry	0.170	8.186	55.520	79.098	2.803	87.008
Fish Fuana	Wet	0.015	7.685	86.087	38.109	30.58	84.211

Table 6 shows value of the different heavy metals from the components of the creek in comprised with the permissible limits of some regulatory bodies. The comparison between the mean total concentrations of heavy metals in the water of Woji Creek with permissible limits recommended by the Federal Environmental Protection Agency (FEPA), United States Environmental Protection Agency (USEPA), and the joint standards of the Food and Agriculture Organization / World Health Organization. The mean concentrations recorded were 0.002 mg/L for Cd, 0.163 mg/L for Pb, 0.026 mg/L for Mn, 0.408 mg/L for Cr, 0.059 mg/L for Ni, and 0.009 mg/L for Zn. While Cd, Mn, and Zn were within the recommended limits, Pb, Cr, and Ni exceeded the permissible standards of some regulatory bodies, indicating potential heavy metal contamination in the water of Woji Creek.

The second section compares the mean total concentrations of heavy metals in the sediments of Woji Creek with the permissible limits established by the Federal Environmental Protection Agency (FEPA) and the United Nations Environment Programme (UNEP). The mean concentrations recorded were 6.843 mg/kg for Cd, 6.002 mg/kg for Pb, 31.174 mg/kg for Mn, 11.183 mg/kg for Cr, 3.232 mg/kg for Ni, and 36.556 mg/kg for Zn**.** Compared with the guideline limits, Cd and Cr exceeded the recommended thresholds, while Pb, Mn, Ni, and Zn were within or close to the permissible limits**,** indicating varying levels of heavy metal accumulation in the sediments of Woji Creek.

The third section compares the mean concentrations of heavy metals in fish fauna from Woji Creek with the permissible limits recommended by the World Health Organization and the Food and Agriculture Organization. The mean concentrations recorded were 0.092 mg/kg for Cd, 7.936 mg/kg for Pb, 70.803 mg/kg for Mn, 58.604 mg/kg for Cr, 2.930 mg/kg for Ni, and 103.609 mg/kg for Zn. While Cd and Zn were within the recommended limits, the concentrations of Pb, Mn, Cr, and Ni exceeded the permissible levels, suggesting potential health risks associated with the consumption of fish from Woji Creek.

Table 6: Comparison of mean concentrations of heavy metals in water, sediment and fish fauna samples respectively of Woji creek with permissible limits of some regulatory bodies.

	WATER				SEDIMENT			FISH	FUANA
Metals	Mean T.C in water (mg/l)	P.L(mg/l) for FEPA (1991)	P.L (mg/l) for USEPA (1986)	P.L (mg/l) for FAO/WHO (2003)	Mean T.C in sediment (mg/l)	P.L (mg/kg) for FEPA (1991)	P.L (mg/kg) for UNEP (1985)	Concentration in biological sample (mg/kg)	P.L (mg/kg) according to WHO (1985)/FAO (1983)
Cd	0.002	0.003	0.01	0.003	6.843	0.05-0.2	0.03-0.3	0.092	0.1
Pb	0.163	0.1	0.05	0.05	6.002	0.2-10	0.3	7.936	2.0
Mn	0.026	0.05	0.15-0.05	0.04	31.174	0.1-32.5	-	70.803	2.5
Cr	0.408	0.05	0.05	0.05	11.183	0.1	-	58.604	1.0
Ni	0.059	0.05	0.02	0.02	3.232	-	0.2-16.0	2.930	0.5
Zn	0.009	1.0	1.0	-	36.556	-	50	103.609	1000

DISCUSSION

The physicochemical parameters of aquatic ecosystems play a critical role in determining water quality and ecological stability because they play a major relevance in the safety of water resources used for domestic activities, food production and human consumption.[22,23] The mean water temperatures recorded across the sampling stations in Woji Creek were relatively similar, which is characteristic of tropical estuarine environments where climatic conditions remain fairly stable throughout the year. Slightly higher temperatures observed at Station 4 may be attributed to the absence of marginal vegetation, which typically reduces solar radiation reaching the water surface. Increased temperatures during the dry season may also be associated with longer photoperiods and higher solar radiation intensity. Temperature differences influences many biological and chemical processes in aquatic environments, including metabolic activities of aquatic organisms, survival and the solubility of gases such as oxygen as well as serving as an the fishes being an important dietary protein source for human populations.[24]

The pH of the water ranged from slightly acidic to slightly alkaline (from 6.780 to 7.040), indicating that the creek environment falls within acceptable aquatic environment limits. However, pH is a key indicator of water quality because it influences the solubility and bioavailability of heavy metals in aquatic systems. Changes in pH can affect the toxicity of metals and their uptake by aquatic organisms such as fish, which may subsequently be consumed by humans.[2] The slightly higher pH recorded during the dry season may be attributed to increased photosynthetic activity by aquatic plants and algae, which removes carbon dioxide from the water and increases alkalinity.

The relatively low dissolved oxygen levels recorded in the creek suggest possible organic pollution and high biological oxygen demand within the aquatic system. Reduced dissolved oxygen levels can negatively affect fish survival and aquatic biodiversity, potentially disrupting local fisheries that serve as an important source of food and livelihood for surrounding communities. Furthermore, degraded aquatic ecosystems may promote the accumulation of contaminants in aquatic organisms, thereby increasing the likelihood of human exposure to toxic substances through fish consumption.[25]

The concentrations of heavy metals recorded in the water column were generally lower than those found in sediments and biological samples. This observation is consistent with findings from many aquatic ecosystems, where sediments act as major sinks for heavy metals through adsorption and precipitation processes. Sediments thus play a critical role in storing contaminants and may release them back into the water column under changing environmental conditions.[26] The higher accumulation of metals in sediments compared with water has been widely reported in aquatic environments and is attributed to the affinity of heavy metals for fine sediment particles and organic matter.

The elevated concentrations of lead (Pb) and chromium (Cr) detected in the water may be linked to untreated industrial effluents, mechanical workshops, and chemical industries located around the creek. Industrial activities are widely recognized as major contributors to heavy metal contamination in aquatic ecosystems. These metals are persistent, non-biodegradable contaminants that can accumulate in living organisms and pose serious health risks to humans when exposure occurs through contaminated water or seafood consumption.[2] Heavy metals such as lead, cadmium, chromium, and nickel are non-biodegradable and can persist in aquatic environments for long periods, thereby posing significant ecological and public health risks. Lead exposure, for example, is known to cause neurological damage, cognitive impairment, hypertension, and kidney dysfunction, particularly in children and pregnant women. Cadmium exposure has been linked to bone demineralization, kidney damage, and carcinogenic effects, while chromium compounds are known to cause respiratory disorders, skin irritation, and potential carcinogenic effects in humans.[25] Nickel exposure may result in allergic reactions, respiratory problems, and possible carcinogenic effects when accumulated at high concentrations.[2]

The accumulation of heavy metals in fish samples from Woji Creek has important ecological and public health implications because fish represent a major dietary protein source for many communities in the Niger Delta region Fish can accumulate heavy metals through direct absorption from contaminated water and through ingestion of contaminated sediments and prey organisms. As these metals move through the food chain, their concentrations may increase through biomagnification, resulting in higher levels in fish tissues consumed by humans.[26] Chronic exposure of fishes to heavy metals can also cause physiological stress, impaired growth, reproductive dysfunction, and tissue damage in fish organs such as the liver, kidneys, and gills.[27] Given the importance of fish as a major protein source for many populations, the presence of elevated heavy metal concentrations in fish from Woji Creek raises concerns regarding food safety and potential long-term health risks among local consumers. The detection of high levels of these heavy metals in fish samples from Woji Creek therefore suggests potential food safety concerns for local communities that depend on fish as a primary source of protein.

Seasonal variations in heavy metal concentrations were also observed, with generally higher concentrations during the dry season compared to the wet season. This pattern may be attributed to dilution effects during the rainy season when increased water volume reduces the concentration of dissolved contaminants. Seasonal fluctuations in heavy metal concentrations have been widely reported in aquatic ecosystems and are often influenced by rainfall, runoff, and hydrological conditions.[2]

Overall, the findings indicate that anthropogenic activities such as industrial discharge, domestic waste disposal, and other human activities around Woji Creek contribute to the accumulation of heavy metals in the aquatic environment. Continuous environmental monitoring, pollution control measures, and public health interventions are therefore necessary to reduce heavy metal contamination and protect both aquatic organisms and human populations that rely on the creek for food and livelihood.

CONCLUSION

The results obtained from this study revealed that the heavy metal concentrations in the biological samples of Woji creek are high and this might be hazardous to humans who consume them. Although most of the heavy metals in the water and sediment are still within the permissible limits for now, if they are not put in check, they might bioaccumulate over time.

Studies on the physico- chemistry of this Woji Creek show that the water is polluted thereby causing decrease in fish biomass and abundance. If drastic measures are not taken to restore the water quality, it might become too polluted to support aquatic life in future. If this happens, the socio-economic live of the people will become unbearable, since most of them depend upon it for survival.

Recommendations

The rate of discharge of untreated industrial, agricultural, and domestic wastes into the water body should be significantly reduced or completely prevented to minimize pollution. Regulatory bodies saddled with this responsibility should enforce compliance. Bioremediation strategies, particularly phytoremediation using higher plants such as *Salvinia molesta*, should be implemented to enhance water quality. Further research is recommended to investigate the levels of other toxic metals in the water, sediments, and fish to ensure seafood safety for local populations. Additionally, periodic clean-up of particulate wastes on the water surface should be encouraged to reduce pollution levels and improve accessibility for fishing activities.

Author Contributions

Author 1: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Funding acquisition.
Author 2: Data curation, Writing-original draft, Writing-review & editing, Visualization, Supervision, Project administration

REFERENCE

1. Raja P, Veerasingam S, Suresh G, Marichamy G, Venkatachalapathy R. Heavy metals concentration in four commercially valuable marine edible fish species from Parangipettai Coast, south east coast of India. *Int J Anim Vet Adv*., 2009; 1(1): 10–14.
2. Saravanan P, Saravanan V, Rajeshkannan R, Rajasimman M, Baskar G, Pugazhendhi A. Comprehensive review on toxic heavy metals in aquatic systems and associated health risks. *Environ Res*., 2024; 258: 119440.
3. Adeyemi OG, Adeyinka AS. An overview of heavy metal pollution and control. In: *ACS Symposium Series*, 1456. Washington (DC): American Chemical Society; 2023. Available from: https://doi.org/10.1021/bk-2023-1456.ch001
4. Kayani KF, Mohammed SJ. Heavy metal pollution in aquatic environments and removal using highly efficient bimetallic metal–organic framework adsorbents. *RSC Adv*., 2025; 15(43): 35756–35769. Available from: https://doi.org/10.1039/D5RA06296A
5. U.S. Environmental Protection Agency (USEPA). Solid waste and emergency response glossary: bioaccumulation. Washington (DC): USEPA, 2010; 34.
6. Physicians for Social Responsibility. Heavy metals and human health. Washington (DC): Physicians for Social Responsibility, 2009.
7. World Health Organization. (2023). *Lead poisoning and health*.
8. Centers for Disease Control and Prevention (CDC). *Heavy metal poisoning: Questions and answers*. Atlanta (GA): CDC, 2024.
9. Rao KV, Mukherjee SC, Smith FWK. Lead and cadmium in aquatic environment: sources, accumulation and health effects. *Res J Biol Sci.*, 2010; 5(7): 517–520.
10. World Health Organization. Cadmium in drinking-water: background document for development of WHO guidelines for drinking-water quality. Geneva: World Health Organization, 2011.
11. Kamila S, Shaw P, Islam S, Chattopadhyay A. Ecotoxicology of hexavalent chromium in fish: An updated review. *Sci Total Environ*., 2023.
12. National Institute of Environmental Health Sciences (NIEHS). Hexavalent chromium and its health effects, 2024.
13. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for manganese. Atlanta (GA): U.S. Department of Health and Human Services, 2023. Available from: https://www.atsdr.cdc.gov
14. Kondakis XG, Makris N, Leotsinidis M, Prinou M, Papapetropoulos T**.** Possible health effects of high manganese concentration in drinking water. *Arch Environ Health*, 1989; 44(3): 175–178. doi:10.1080/00039896.1989.9935883
15. World Health Organization (WHO). Manganese in drinking-water: background document for development of WHO guidelines for drinking-water quality. Geneva: World Health Organization, 2021.
16. National Institutes of Health. (2024). *Zinc: Fact sheet for health professionals*. Office of Dietary Supplements, National Institutes of Health.
17. National Oceanic and Atmospheric Administration Sea Grant Program. Oysters: nature's water filtration system [Internet]. NOAA; 2025 [cited 2026 Mar 27]. Available from: https://seagrant.noaa.gov
18. National Centers for Environmental Information (NCEI). Sediments. *Global Change Master Directory – Earth Science > Paleoclimate > Land Records* [Internet]. National Oceanic and Atmospheric Administration, 2024.
19. United States Geological Survey (USGS). Sediment and suspended sediment [Internet]. Reston (VA): USGS, 2023. [cited 2026 Mar 17]. Available from:

https://www.usgs.gov/special-topics/water-science-school/science/sediment-and-suspended-sediment

20. World Health Organization (WHO). *Guidelines for drinking-water quality*. 4th ed., incorporating 1st addendum. Geneva: WHO Press, 2017.
21. Förstner U, Wittmann GTW. *Metal pollution in the aquatic environment*. 2nd ed. Berlin/Heidelberg: Springer, 2012.
22. Chapman D. *Water quality assessments: A guide to the use of biota, sediments and water in environmental monitoring*. 2nd ed. London: E & FN Spon, 1996.
23. Wetzel RG. *Limnology: Lake and river ecosystems*. 3rd ed. San Diego (CA): Academic Press, 2001.
24. Chapman D. *Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring*. Paris: UNESCO, 2018.
25. Genchi G, Carocci A, Lauria G, Sinicropi MS, Catalano A. Nickel: Human health and environmental toxicology. Int J Environ Res Public Health, 2020; 17(3): 679.
26. Kumar M, Singh S, Jain A, Yadav S, Dubey A, Trivedi SP. A review on heavy metal-induced toxicity in fishes: Bioaccumulation, antioxidant defense system, histopathological manifestations, and transcriptional profiling of genes. J Trace Elem Med Biol., 2024; 83: 127377. doi: 10.1016/j.jtemb.2023.127377.
27. Ghafarifarsani H, Rohani MF, Raeeszadeh M, Ahani S, Yousefi M, Talebi M, et al. Pesticides and heavy metal toxicity in fish and possible remediation: A review. Ann Anim Sci., 2024; 24(4): 1007–24. doi: 10.2478/aoas-2024-0012.