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RESEARCH ARTICLE

Determination and Evaluation of Potentially Toxic Heavy Metals in Some Selected Rivers within Ijebu-North, Nigeria

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Abstract: Human health would be at risk if water which is essential for every human activity is contaminated with carcinogenic substances including heavy metals, this present study evaluated potentially toxic metal concentration in some selected rivers in Ijebu-North of Nigeria to determine the concentration of heavy metals and evaluate the pollution index. Ten (10) rivers were randomly selected for the purpose of this study. Samples were collected using a labelled acid pre-cleaned polyethylene container so as avoid wall absorption, the samples were collected from different points at different locations along the course of the river. The samples were filtered, acidified with HNO3 and analysed for heavy metals using Atomic Absorption Spectrometer (AAS). Concentrations of Pb, Ni, Cr and Cu in all the rivers were higher than the WHO limit. However Hg, Cd, Ag, Al, and Mn values are below the recommended values. The contamination factor (C_f) for the Pb varied from 2.18-4.04, Ni varied from 3.0-14.0, Hg was between 0.00-0.03333, Cd was between 0.16667-0.6667, Cr varied between 8.00-48.40, Cu varied between 4.00-12.00, Ag varied between 0.01-0.02, Se varied from 0.05-1.25, Al varied between 0.12-0.46 and Mn varied from 0.020-0.028, Cu values fall within the range of very severe pollution. The results from this study revealed that some rivers within the study area were polluted and recommended for treatment before they can be used domestically and for other purposes.

Keywords: *Heavy metals, Ijebu-North, Rivers, Pollution Indices, Contamination factor.*

Introduction

Safe drinking water is essential to healthy living; its availability should be a top priority to both individual and governmental/non-governmental agencies. Water supply systems and drinking water inaccessibility in developing countries is a global concern that calls for immediate action (Garibov et al., 2020). About 884 million people in the world still do not get their drinking water from good and reliable sources, and a large percentage of people effected with this menace are from developing nations (WHO, 2010). Provision of quality drinking water to people will serve as the breaking point of poverty alleviation in most developing countries, especially in Africa, where substantial amount of national budgets are used to treat preventable waterborne diseases (Cobbina et al., 2013). Accessibility to reliable and drinkable water has been recognized by United Nations as a human right of all and sundry. Water is posed too many contamination including improper disposal of chemicals, animal wastes; pesticides; E-waste, wastes injected from the underground; and naturally-occurring radionuclides (Sall et al., 2020). Also, industrial, domestic, agricultural, medical and technological applications could lead to contamination of water by metals. Heavy metals exist as natural constituents of the earth crust, they have a high atomic weight and a density at least 5 times greater than that of water (United Nations Environmental Protection, 2004). Globally, there is a great concern over potential effects of heavy metals on human health and the environment, however, toxicity of heavy metals depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals (Paul et al., 2014). Arsenic, Cadmium, Chromium, Lead and

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Mercury have been identified as heavy metals with high toxicity, they are threat to human existence and consequently pose great concerns to public health (Kassimu et al., 2017). There is no doubt that human health would be at risk if water which is essential for every human activity is contaminated with carcinogenic substance including heavy metals. The purpose of this study was to investigate and evaluate heavy metal: aluminum (Al), cadmium (Cd), copper (Cu), chromium (Cr), manganese (Mn), mercury (Hg), lead (Pb), nickel (Ni), selenium (Se) and silver (Ag) contamination in some selected rivers in Ijebu-North Local Government Area of Ogun State, Southwestern Nigeria.

Materials and methods

The Study Area

Selection of sampling site was based on potential areas prone to pollution viz: industrial units, habitation sites, industrial and sewage. Table 1 shows the names and the GPS location of the Ten (10) rivers that were investigated in this present study.

Table 1: Description of the sampling points

S/N	Sample	River	Location
1.	A1	Owon	Abapanu Road
2.	A2	Yemoja	Aba Mamu
3.	B1	Egudu	Ilaporu-Ijebu
4.	B2	Ekuruwa	Idofe-Ijebu
5.	C1	Lapata	Ijebu-Igbo
6.	C2	Ogbere	Ijebu-Igbo
7.	D1	Ereru	Okenugbo
8.	D2	Ome	Ago-Iwoye
9.	E1	Erigba	Erigba-Ijebu
10.	E2	Etiri	Etiri-Ijebu

Sampling and sample analysis

Samples were collected using a labelled acid pre-cleaned polyethylene container so as avoid wall absorption (Sall et al., 2020), five water samples were collected from each of the rivers water samples, the samples were collected from different points at different locations along the course of the river). However, selection of sampling site was based on potential areas prone to pollution viz., industrial units, habitation sites, industrial and sewage. The samples were sealed and labelled to avoid mix up and contaminations. Furthermore, the samples were wrapped using insulation tape to avoid spill during transport of the samples from sampling point to laboratory for preparation and analysis in the laboratory, the samples were filtered, acidified with HNO3 and analyzed for heavy metals using Atomic Absorption Spectrometer (AAS, Shimadzu AA-6300).

Determination of contamination factor (*C_f*)

The contamination factor of the individual metals in water was calculated from the formula adopted from Simeon and Friday (2017) as:

$$C_f = C_m / C_b$$

Where C_f is the contamination factor,
C_m = concentration of metal measured in the water sample,
C_b = background concentration of the metals in water or sediment.

Pollution index (PI)

Pollution index is a measure of the degree of overall contamination in a sample station. The procedure of Tomlinson et al., (1980) was used to calculate the Pollution Index (PI) for each site is given as

$$PI = (C_f 1 \times C_f 2 \times C_f 3 \times \ldots \ldots C_f n)^{1/n}$$

Where n = No. of heavy metals and, C_f = Contamination factor.

The PI is a potent tool used in heavy metal pollution assessment.

Table 2: Recommended Heavy Metals' level in Drinking water

S/N	Heavy Metals	Levels (mg/L)
1.	Lead (Pb)	0.10
2.	Nickel (Ni)	0.02
3.	Mercury (Hg)	0.06
4.	Cadmium (Cd)	0.03
5.	Chromium (Cr)	0.05
6.	Copper (Cu)	0.05
7.	Silver (Ag)	0.10
8.	Selenium (Se)	0.04
9.	Aluminum (Al)	0.20
10.	Manganese (Mn)	0.05

Table 3: Significance of intervals of Contamination factor/Pollution Index (C_f /PI)

C_f /PI	Significance
< 0.1	Very slightly contamination
0.10-0.25	Slightly contamination
0.26-0.50	Moderate contamination
0.51-0.75	Severe contamination
0.76-1.00	Very severe contamination
1.1-2.0	Slight pollution
2.1-4.0	Moderate pollution
4.1-8.0	Sever e pollution
8.1-16.0	Very severe pollution
> 16.0	Excessive pollution

Source: Adopted from Lacatusu, (2000)

Results and Discussion

As shown in the Table 4, the Owon river has majority of the metals below the world permissible level except Pb, Cr, and Cu, with values 0.24, 2.04 and 0.22 mgL^{-1} which are slightly above the WHO standard limit of 0.1, 0.05 and 0.05 mgL^{-1} for Pb, Cr, and Cu respectively. Moreover, the pollution indices for the Owon river was found to be 0.57 mgL^{-1}, this values shows that the river is ranked under Severe contamination according Table 3 in this present study.

Table 4: Mean Heavy metal Concentration (mgL^{-1}) in samples

S/N	Sample	River	Pb	Ni	Hg	Cd	Cr	Cu	Ag	Se	Al	Mn
1	A1	Owon	0.24	0.08	0.002	0.02	2.04	0.22	0.002	0.02	0.08	0.0012
2	A2	Yemoja	0.29	0.06	0.001	0.016	1.84	0.26	0.002	0.04	0.092	0.0012
3	B1	Egudu	0.30	0.28	0.002	0.013	1.00	0.58	0.001	0.02	0.025	0.001
4	B2	Ekuruwa	0.31	0.22	0.001	0.009	1.78	0.48	0.002	0.03	0.024	0.0014
5	C1	Lapata	0.22	0.12	0.002	0.016	0.40	0.40	0.01	0.03	0.039	0.0011
6	C2	Ogbere	0.26	0.03	0.08	0.0001	0.013	2.04	0.60	0.002	0.045	0.0012
7	D1	Ereru	0.36	0.22	0.002	0.016	0.78	0.20	0.001	0.002	0.055	0.001
8	D2	Ome	0.32	0.14	0.002	0.005	1.84	0.42	0.002	0.002	0.044	0.0012
9	E1	Erigba	0.30	0.22	0.001	0.008	2.42	0.42	0.002	0.05	0.054	0.0014
10	E2	Etiri	0.40	0.128	0.002	0.016	2.02	0.35	0.002	0.042	0.056	0.0012
		WHO	**0.10**	**0.02**	**0.06**	**0.03**	**0.05**	**0.05**	**0.10**	**0.04**	**0.20**	**0.05**

Table 5: Contamination factor of the rivers from the study area

Metals	**Contamination factor (Cf)**									
	Owon	**Yemoja**	**Egudu**	**Ekuruwa**	**Lapata**	**Ogbere**	**Ereru**	**Ome**	**Erigba**	**Erigba**
Pb	2.400	2.900	3.000	3.090	2.180	2.640	3.680	3.260	3.030	4.040
Ni	4.000	3.000	14.00	11.00	6.000	4.000	11.00	7.000	11.00	6.400
Hg	0.030	0.027	0.033	0.016	0.030	0.000	0.030	0.030	0.010	0.030
Cd	0.667	0.530	0.433	0.300	0.530	0.430	0.530	0.160	0.260	0.530
Cr	40.80	36.80	20.00	35.60	8.000	40.80	15.60	36.80	48.40	40.40
Cu	4.400	5.200	11.60	9.600	8.000	12.00	4.000	8.400	8.400	7.000
Ag	0.020	0.020	0.010	0.020	0.010	0.020	0.010	0.020	0.020	0.020
Se	0.500	1.000	0.500	0.750	0.750	1.250	0.050	0.050	1.250	1.050
Al	0.400	0.460	0.125	0.120	0.190	0.220	0.270	0.220	0.270	0.280
Mn	0.024	0.024	0.020	0.028	0.022	0.024	0.020	0.020	0.020	0.020
pollution Index	0.57	0.56	0.53	0.55	0.46	0.01	0.4	0.42	0.63	0.67

A similar case was observed in Yemoja River except that Ni concentration more than the WHO. Furthermore, all other rivers follow the same pattern of having the mean concentration values of Hg, Cd, Ag, Se, Al and Mn below WHO (2011) standard except Pb, Cr, and Cu and Ni having a moderately higher values than that of the world health organization recommended safety limit.

As shown in in table 5, pollution indices from each of the rivers falls under four categories: no contamination (Ogbere), moderate contamination (Ereru, Ome) and severe contamination (Owon,Yemoja, Egudu, Ekuruwa, Erigba, Etiri).

Contamination Factor of Heavy Metals in Water from Sampling Rivers

The contamination factor of the individual heavy metals in the water samples were as follows; Pb (2.18-4.04), Ni (3.0-14.0), Hg (0.00-0.033), Cd (0.16667-0.6667), Cr (8.00-48.40), Cu (4.00-12.00), Ag (0.01-0.02), Se (0.05-1.25), Al (0.12-0.46) and Mn (0.020-0.028). These values when compared to the intervals of contamination and pollution intervals and interpretations as proposed by Lacatusu, (2000), revealed that Pb in the samples was found to be within the category of moderate pollution. Ni was in the range of moderate pollution-excessive pollution and Hg was within the range of non-contamination. Cd values were found to fall within of moderate pollution in all the rivers samples while Cr values were found within excessive pollution in all rivers' samples. Cu values fall within the range of very severe pollution. Ag values was found within the range of very slightly contamination in all the rivers' sample while Se value was found within the range of slightly pollution in all the samples. Al value was found to be very severe pollution. Mn was in the range of very slightly pollution and Hg was found within the range of non-contamination.

Conclusion

Pollution of rivers by heavy metals and the potential health risk have been studied in the Ijebu-North, Southwestern, Nigeria. These rivers include Owon, Yemoja, Egudu, Ekuruwa, Lapata, Ogbere, Ereru, Ome, Erigba and Etiri where several agricultural activities are being carried out. The Pb, Ni, Cr and Cu concentrations in all water samples from the rivers exceeded the WHO stipulated limit of 0.010 mgL^{-1}, 0.02 mgL^{-1}, 0.006 mgL^{-1}, 0.05 mgL^{-1} and 0.05 mgL^{-1} respectively for drinking water whereas Hg, Cd, Ag, Al and Mn concentrations in all the rivers' samples were found below the WHO recommended values of 0.006 mgL^{-1}, 0.03 mgL^{-1}, 0.10 mgL^{-1}, 0.20 $mgL^{-1}$and 0.05 mgL^{-1}respectively except for rivers Erigba and Etiri whose Se concentrations were found to be higher than the WHO recommended limit of 0.40 mgL^{-1}. It is evident from the present study that direct drinking of water from these water sources can be deleterious to the villagers/inhabitants as levels of some heavy metals were above the WHO stipulated limits. Generally, levels of Pb, Ni, Cr and Cu in water from all the rivers' samples exceeded WHO stipulated limits of 0.010 for Pb, 0.02 for Ni, 0.05 for Cr and 0.05 for Cu. Though there are probable sources that may account for the presence of heavy metals in these rivers, activities of subsistence farmers seem to contribute to this trend. Water sources around these communities are polluted and hence considered unfit for many domestic and agricultural uses, especially for drinking and feeding of live stocks. This is due to bio-accumulation that could occur in the food chain (Guo et al., 2013. Lead, cadmium, mercury and chromium are highly carcinogenic and could cause serious public health problems. Nickel, manganese and cobalt cause cells damages and affect carcinogenic processes. Heavy metal toxicity could be acute, while others could be chronic after long-term exposure which may lead to the damage of several organs in the body such as the brain, lungs, liver and kidney causing diseases in the body.

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