Available online www.unicrossjournals.com

UNICROSS JOURNAL OF SCIENCE AND TECHNOLOGY, UJOST

RESEARCH ARTICLE VOL. 3(3) SEPTEMBER, 2024 ISSN:2814-2233

Date Approved September 30, 2024 Pages 235 - 242

QUALITY ASSESSMENT OF WATER OBTAINED THROUGH NOVEL WATER-SOURCING METHOD BY SLUM-DWELLERS IN CALABAR, NIGERIA

Uttah, Emmanuel Chukwunenye[a]*, Uttah, Faustina Onyinye[a], Etta, Eme Effiong[a], Ekong, Mercy[b]

[a]Department of Animal and Environmental Biology, University of Cross River State, Calabar.

[b]Department of Microbiology, University of Cross River State, Calabar

***Corresponding author**

Abstract

The study was aimed at determining the quality of water from Novel Low-tide Creek-bed Drilling (NLCD) used by residents of Calabar, Nigeria. Physico-chemical parameters were determined using established standard protocols. Water samples were collected in triplicates and processed for heavy metals using Atomic Absorption Spectrophotometer (AAS)-(Perkin Elmer model 2380). With the parameters, the Simple Water Quality Index (SWQI) was calculated. The SWQI for NLCD 1, NLCD 2, and NLCD 3 were 34, 34.6, and 32.6 respectively, indicating extremely poor water quality. The Heavy Metal Index (HEI) of NLCD 1, 2, and 3 were 14.869, 12.739, and 13.802 respectively, indicating low level of heavy metal contamination in all three. The Heavy Metal Pollution Index (HPI) for all the three were in the > 100 classification, indicating high level heavy metal pollution or high risk of metal pollution, therefore unsafe for drinking. In conclusion, the NLCD water was unsafe for drinking. Public awareness of this unsafe water should made urgently.

Keywords: Water quality, Heavy Metal Evaluation Index, Heavy Metal Pollution Index, Calabar

1.0 Introduction

Harmless drinking water is a basic need for good health and it is a rudimentary right of humans (WHO, 2003). The global debate on potable water has been dominated largely by a desire to ensure that access to domestic water supplies is guaranteed for as much of the World's population as possible, and that is accompanied by adequate levels of sanitation (Ademoroti, 2006).

Due to the lack of water distribution infrastructure, people in the rural areas in developing countries may have no other options for drinking water than to resort to using natural bodies of water such as lakes, rivers, streams and underground water wells. This may explain why in 2022, globally, at least 1.7 billion people used a drinking water source contaminated with faeces (WHO, 2023). Presently, about 1.1 billion people currently live in slums or slum-like conditions in cities, with 2 billion more expected in the next 30 years (https://unstats.un.org/sdgs/report/2023). A slum household is a group of individuals living under the same roof lacking one or more of the following conditions: access to improved water, access to improved sanitation, sufficient living area, and durability of housing.

In 2018, Nigeria was ranked 31st globally on Population living in slums. In all, 53.9% of Nigeria's urban population live in slums. About 80 million Nigerians live in slums (www.sustainabledevelopment.un.org).
There is significant population of slum-dwellers in Calabar, and these live especially along the creeks. The slum dwellers perennially suffer scarcity of potable water. And this has led the Calabar slum dwellers to develop an ingenious, and novel method of sourcing water for domestic activities from the creek-bed. They dig into the creek bed for water for domestic use. Into this same creek, pipes from toilets and bathrooms empty human wastes. This study aims at carrying out a comprehensive assessment of the quality of water obtained from this novel water-sourcing method in the slums in Calabar, Nigeria.

2.0 Materials and methods

2.1 Description of the study area

Calabar is the capital of Cross River State, Nigeria. Cross River is a state in South South Nigeria", bordering Cameroon to the east, and located between Latitude 04°58'36"N and Longitude 08°20'18"E. It sits atop 406 square kilometers landmass, with the population of about 504,590, and Density of 1242/km. It shares boundaries with Akamkpa to the north, Odukpani to the west, and Akpabuyo Local Government to the east and the Atlantic Ocean to the south.

2.2 Indigenous Innovation for harvesting water:

The study area, which is the specific area where the innovative water harvesting was being carried out was between 0432999 N and 0543610 E. The study population lives beside the creek. The creek served a lot of purposes for the residents. Their toilets were piped into the same creek where human excrements were sent to. It was from the same creek that they harvested water for domestic use. The local population believed that the human wastes evacuated into the creek would be carried away when the tide receded.

During low tide, the indigenous population dug into the creek bed until they encountered water. They then placed clean basins to collect water from the creek bed. Alternatively, they fasten a pipe into the water bed until water rose up through the pipe into available container.

2.3 Collection of water samples for study

Sample bottles were autoclaved for 15 minutes to sterilize them at 121 °C under a pressure of 15 psi. Water samples were collected in triplicates into a sterile sample bottle.

2.4 Analysis

Samples were allowed to attain room temperature before the analysis were carried out.

2.4.1 Methodology for physico-chemical analysis

Physico-chemical parameters were assessed using standard protocols.
pH: was read using the pH meter (pH model SensION+ 30).
Turbidity: was determined using the turbidity meter
Total Dissolved Solids: was determined using the multifunctional conductivity meter (Metledo Toledo conductivity meter). Readings were displayed in mg/L.

2.4.2 Methodology for microbial analysis

Media preparation: This was prepared according to manufacturer instructions, then sterilized using autoclave and allowed to cool to 40^{o}C using a water bath.
Culture preparation: 1ml of the water sample was taken using a sterile syringe and dispensed into the empty sterile petri dish, then 15ml of the media was poured into the sterile petri dish and swirled gently to mix. The mixture was allowed to cool and solidify at room temperature. The culture was then be incubated at 37^{o}C for 24 hours. The culture was then harvested and the resulting colonies counted using a colony counter, and the results recorded in cfu/ml (colony forming units per ml).

2.4.3 Calculating Simple Water Quality Index

The water quality were assessed using the physico-chemical parameters of the water. The Simple Water Quality Index was used to assess this water quality with the following formula:

$SWQI = (\sum(W_i x S_i)) / \sum W_i$

Where:

W_i = Weightage of each parameter (usually 0.2 for 5 parameters)

S_i= Sub-index score for each parameter (scaled 0 – 100). Typical parameters and weightages are:

pH (Wi = 0.2), Turbidity (Wi = 0.2), TDS (Wi = 0.2),BOD (Wi = 0.2), Feacal coliform (Wi = 0.2). The Sub-index scores (Si) were calculated using: $Si = ((Xi – Xmin) / (Xmax – Xmin)) \times 100$

Where:

Xi = Measured value, X_{min} = Minimum acceptable value, and X_{max} = Maximum acceptable value

<u>Interpretation of SWQI values:</u>

From 0 to 24.99 indicates EXTREMELY POOR water quality

From 25 to 44.99 indicates POOR water quality

From 45 to 64.99 indicates FAIR water quality

From 65 to 84.99 indicates GOOD water quality

From 85 to 100 indicates EXCELLENT water quality

2.4.4 Calculation of Heavy Metal Evaluation Index (HEI)

$HEI = \sum \ (Hc / Hmax)$

Where, Hc is the concentration of each heavy metal as measured in water and Hmac is the maximum allowable concentration of the particular heavy metal in water.

2.4.5 Calculation of Heavy Metal Pollution Index (HPI)

$HPI = \underline{\sum WiQi / \sum} Wi$

$Qi = \sum [(Mi\text{-}Ii) / (Si\text{-}Ii)]$

Where: Qi is the sub-index of the ith parameter (heavy metal) and is given by Equation (4). Wi is the corresponding weighting while Mi, Ii, and Si are analytical, ideal and standard concentrations respectively of the heavy metal; and n is the number of heavy metals considered. This parameter combines the impact of n number of heavy metals and their individual impacts to assess water contamination

3.0 Results

The results of this research work are presented in two broad categorizations, namely:

(i) Water Quality evaluation using the Physico-chemical parameters. Simple Water Quality Index (SWQI) analysis using a total of 5 physico-chemical/Bacteriological parameters were carried out on the water samples. The parameter were pH, turbidity, Total Dissolved Solids (TDS), Biological Oxygen Demand (BOD), and Feacal coliform.

(ii) Public health indices of the heavy metal concentrations of the water. This involved the water quality assessment of how safe for drinking, both water sources were using two public health indices, namely, the Heavy Metal Evaluation Index (HEI) as well as the Heavy Metal Pollution Index (HPI).

3.1 Water quality evaluation using the Physico-chemical/ bacteriological parameters

Results of physico-chemical/ Bacteriological analysis and the Water Quality Index (WQI) were presented in Table 1. Four out of five parameters in the three sampled stations were beyond the WHO Maximum Permissible Limits. The SWQI were 34, 34.6, and 32.6 for NLCD 1, NLCD 2, and NLCD 3 respectively. The results indicated that the three sample stations had extremely poor water quality.

Table 1. Results of physico-chemical analysis and the Simple Water Quality Index of the water samples

S/N	Parameters	WHO	NLCD 1	NLCD 2	NLCD 3
1	pH	6.81-7.51	3.9	4.0	3.9
2	Turbidity	5-25	169	132	151
3	T.D.S	500-1500	96.3	105.8	109.3
4	BOD	<5.0	8	9	9
5	Total coliform	0-10	78	59	77
	WQI	NA	34	34.6	32.6
	Verdict	N/A	Extremely poor	Extremely poor	Extremely poor

Key units: pH (^oC), Turbidity (NTU: Nephelometric Turbidity Unit), T.D.S.(Mg/L), BOD (Mg/L), Total coliform (Cfu/ml).

3.2 Public health indices of the heavy metal concentrations

The results of heavy metal analysis of the water samples in comparison with the WHO Maximum Permissible Limits were presented in Table 2.

Table 2. Heavy metal concentrations of the sampled stations

Heavy metal	WHO	NLCD 1	NLCD 2	NLCD 3
As	13	12	12	10
Cr	70	65	70	50
Cd	0.7	0.6	0.7	3
Cu	2500	2600	2500	1500
Fe	500	480	450	300
Pb	17	17	18	8500
Hg	0.6	0.7	0.7	1
Ni	130	90	110	20
Zn	4500	4500	4800	3000

The Heavy metal Evaluation Index (HEI) were presented in Table 3. The HEI of the water samples were 14.869, 12.739, and 13.802 for NCLD 1, 2, 3 respectively and indicated low level of heavy metal contamination.

Table 3. Heavy metal Evaluation Index (HEI) of the NLCD water samples

Heavy metal	WHO MPL	NLCD 1	NLCD 2	NLCD 3
As	10	1.3	1.2	1.2
Cr	50	1.4	1.3	1.4
Cd	3	0.233333	0.2	0.233333
Cu	1500	1.666667	1.733333	1.666667
Fe	300	1.666667	1.6	1.5
Pb	8500	0.002	0.002	0.002118
Hg	1	0.6	0.7	0.7
Ni	20	6.5	4.5	5.5
Zn	3000	1.5	1.5	1.6
Overall HEI	N/A	14.869	12.739	13.802
Verdict	N/A	Medium	Medium	Medium

Results of Heavy Metal Pollution Index (HPI) calculation were presented in Table 4. The HPI of all the samples were more than 100 (> 100) and indicated high level heavy metal pollution, and high risk metal pollution and therefore unsafe for consumption.

Table 4. Heavy Metal Pollution Index (HPI) of the NLCD water samples

Heavy metal	NLCD 1	NLCD 2	NLCD 3
As	2.481649	2.290753	2.290753
Cr	0.534509	0.49633	0.534509
Cd	148.4747	127.2641	148.4747
Cu	0.011992	0.012482	0.011992
Fe	0.106053	0.101811	0.095448
Pb	5.726882	5.726882	6.2723
Hg	31.81601	37.11868	37.11868
Ni	0.506459	0.350625	0.428542
Zn	0.009545	0.009545	0.010181
HPI	189.6678	173.3712	195.2371
Verdict	High	High	High

4.0 Discussion

The NLCD water sources were evaluated to assess their suitability for drinking and for domestic uses. The physico-chemical parameters were beyond the WHO Permissible Limits and calculated SWQI of the physico-chemical parameters indicated extremely poor water quality. This suggests that the water was polluted and totally unsafe for human consumption, if not treated (Adelagun *et al*., 2021). The physico-chemical parameters of many water sources, especially the surface waters, in parts of Nigeria are poor (Abaje *et al*. (2009).

The Heavy Metal Evaluation Index criteria are classified as low (HEI<10), medium (HEI=10–20), and high (HEI>20) (Edet and Ofong 2002). The HEI of the NLCD were indicated that this water source had medium level of heavy metal contamination. The HPI of all the NLCD samples had high level heavy metal pollution, and high risk metal pollution making the water unsafe for drinking and domestic uses.

Heavy metals are toxic when their concentrations in solution are high and can be detrimental to human health. Zinc, Copper, Arsenic, Chromium and Iron are heavy metals. Most of the water samples were within the minimum permissible limit of the WHO. The heavy metal contamination may be as a result of general waste disposal into the creek.

The recommended pH standards for drinking water by WHO and NIS was 6.5 - 8.5. The pH value ranged from 3.9 to 4.0, which is acidic. Acidic water corrodes metal pipes and plumping systems but alkaline water is a lot healthier to drink (Shittu *et al.*, 2008). Daily drinking of alkaline water improved DNA aging markers on mice (Logozzi *et al*., 2020), reduced non-alcoholic fatty liver disease symptoms (Jackson *et al*., 2018), slightly improved stool in 60 human participants (Tanaka *et al.*, 2018), and showed significant difference in whole blood viscosity (measurement of how efficiently blood flows through your vessels) after strenuous workout (Weidman *et al*., 2016). Alkaline water also helps improve bone density in postmenopausal people with osteoporosis (Fasihi *et al*., 2021).

The turbidity of water is the measure of relative clarity of water. Turbidity describes the cloudiness of water caused by suspended particles such as clay and silts, chemical precipitates such as manganese and iron, and organic particles, such as plant debris and organisms (GCDWQ, 2024). As turbidity increases, it reduces the clarity of water to transmitted light by causing light to be scattered and adsorbed. Relatively, water is said to be suitable for consumption when its turbidity is below 5NTU. The turbidity of the water in this study was from 13.2 NTU to 16.9 NTU, which were outside the permissible limit of the WHO.

Total Dissolved Solids (TDS) are mostly inorganic matter and small amount of organic matter dissolved in water to form a solution. The Total Dissolved Solids from both water sources were within the minimum permissible limit of the WHO. TDSs in drinking water has been associated with natural sources, sewage urban runoff, industrial waste water and chemical used in the water treatment process, though it is of aesthetic value rather than a health hazards (Ballester and Sunyer, 2000). Alexandra *et al.,* (2017) from Ghana, found that the concentration of TDS in water samples to be above 172 mg/L and were associated with salty taste.

The HPI values of Cd and Hg were particularly quite high. Excessive levels of cadmium is a known carcinogen and is linked to kidney damage, lung diseases, and bone, and has preferential pattern of distribution in these organs (Suru, 2008; Hadzi *et al*., 2015). Mercury is toxic to the kidney and affects the nervous system causing symptoms such as irritability, nervousness, change in vision or hearing, and difficulties with memory (Jarup, 2003).

5.0 Conclusion

The physic-chemical characteristics of the two sources of water rendered them unsafe for domestic uses. The heavy metal concentrations of the boreholes were within safe ranges for domestic uses, while that of NCLD were quite unsafe with high risk of heavy metal pollution.

6.0 Recommendation

It is recommended that the poor ranges of physic-chemical parameters poor as recorded in this study that resulted in water quality index be addressed urgently. Safe and established protocols should be deployed in this regard, for example, using lime or soda ash addition or CO_2 for pH correction, and Coagulation/Flocculation (alum, ferric chloride) or sedimentation or filtration for turbidity reduction.

Acknowledgement

This work was supported by an Institution-Based Research (IBR) Grant 2024 from the Tertiary Education Trust Fund (TETFund) to the University of Cross River State, Calabar.

References

Abaje, I.B., Ati,O.F. and Ishaya, S. (2009). Nature of Potable Water Supply and Demand in Jema'a LGA of Kaduna State, Nigeria. *Research Journal of Environmental and Earth Sciences,* **1**(1):16-21.

Adelagun, R.O.A., Etim, E.E, and Oko, E.G. (2021). Promising Techniques for

Wastewater Treatment and Water Quality Assessment. Application of Water Quality Index for the Assessment of Water from Different Sources DOI: http://dx.doi.org/10.5772/intechopen.98696

Edet A, Ofong O (2002) Evaluation of water quality pollution indices for heavy metal contamination monitoring. A study case from Akpabuyo-Odukpani area, Lower Cross River Basin (southeastern Nigeria). *GeoJournal* **57**:295–304.

Fasihi, S., Fazelian, S., Farahbod, F., Moradi, F., and Dehghan, M. Effect of alkaline drinking water on bone density of postmenopausal women with osteoporosis. *Journal of Menopausal Medicine* **27**(2): 94-101. doi: 10.6118jmm.20036

Guidelines for Canada Drinking Water Quality (GCDWQ, 2024). Summary Tables. Published by Health Canada. www.canada.ca.

Hadzi, G.Y., Essumang, D.K., Adjei, J.K. (2015). Distribution and risk assessment of heavy metals in surface water from pristine environments and major mining areas in Ghana. *Journal of Health and Pollution* **5**(9):86-99.
https://unstats.un.org/sdgs/report/2023 (accessed May, 2024)

Jackson, K., Dressler, N., Ben-Shushan, R.S., Meerson, A., LeBaron, T.W., Tamir, S. (2018). Effects of alkaline-electrolyzed and hydrogen-rich water, in a high-fat-diet nonalcoholic fatty liver disease mouse model. *World Journal of Gastroenterology* 24(45):5095-5108. Doi: 10.3748/wjg.v24.i45.5095

Jarup, I. (2003). Hazard of heavy metal contamination. *British Medical Bulletin*. 2003:167-182.

Logozzi, M., Mizzoni, D., Di Raimo, R., Andreotti, M., Macchia, D., Speda, M., Fais, S. (2020). In vivo antiaging effects of alkaline water supplementation. *Journal of Enzyme Inhibition Med. Chem*. **35**(1): 657-664 doi: 10.1080/ 14756366.2020. 1733547
Suru, S.M. (2008). Onion and garlic extracts lessen cadmium-induced nephrotoxicity in rats. *BioMetals*, **21**: 623-633.

Tanaka, Y., Saihara, Y., Izumotani, K., and Nakamura, H. (2018). Daily Ingestion of alkaline electrolyzed water containing hydrogen influences human health, including gastrointestinal symptoms. *Med Gas Research* **8**(4): 160-166. doi: 10.4103/2045-9912.248267.

Weildman, J., Holsworth, R.E., and Fridman, G. (2016). Effect of electrolyzed high pH alkaline water on blood viscosity in healthy adults. *Journal of the International Society of Sports Nutrition* **13**: 45. doi: 10.1186/s12970-016-0153-8

WHO (2003). The Right to Water. Office of the High Commissioner for Human Rights (OHCHR), Centre on Housing Rights and Evictions (COHRE), Water Aid, Centre on Economic, Social and Cultural Rights.

WHO/UNICEF (2013): Progress on drinking water and sanitation. Geneva WHO/UNICEF Joint Monitori
ng Programme for water supply and sanitation.