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Evaluation of wholesomeness of sources of domestic water in Ajaokuta and Lokoja Municipality

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Abstract

Water quality has been linked to health outcomes across the world. This study evaluated the wholesomeness of sources of domestic water in Ajaokuta and Lokoja Municipality through assessment of the community practices regarding collection and storage of water, analysis of physicochemical and bacteriological quality and the determination of the human health risks associated with consumption of the water. Assessment of water quality was carried out on the quality of water in use from 9 different sources. Questionnaires were used to identify the community sources of water and storage activities. Many of the households reported they cover their containers and the majority (58%) do not treat their water before use. The physicochemical, bacteriological quality and trace metals' concentration of water samples from the different sources and household storage containers were majorly within the permissible range of both within permissible range of both the Nigeria Standards of water quality and World Health Organisation. E. coli and total coliform were not detected or within the permeable value all of water samples at the different sources The calculated non-carcinogenic effects using hazard quotient toxicity potential and cumulative hazard index of drinking water through ingestion pathway for both children and adult were less than unity, implying that consumption of the water could pose no significant non-carcinogenic health risk. Amongst the studied trace metals, only the maximum level of lead for both adults and children has the highest chance of cancer risks. We recommend that appropriate measures should be taken to maintain residual free chlorine at the distribution points, supply of municipal treated water should be more consistent in the municipality of Lokoja and Ajaokuta, monitoring and evaluation from other sources be carried out, and residents should be educated on hygienic practices of transportation and storage of drinking water from the different sources as certain water transportation and storage practices by community members can cause the risk of water contamination.

Key words: *Water quality, Contamination, Evaluation, Hygienic practices, Human health risks*

1. Introduction

One of the most important resources for industry, agriculture, and human nourishment is water. This outstanding resource serves as the foundation for and sustains social and economic progress (Taiwo *et al.*,

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2012). It is necessary for the preservation and upkeep of all living things, including plants, animals, and humans (Patil and Patil, 2010). Water quality and its overall state are determined by its chemical, physical, and biological makeup. In order to avoid sickness and enhance quality of life, it is essential to have access to clean water (Oluduro and Aderiye, 2007). Just like clean air, safe drinking water is a fundamental human right. Achieving universal access to safe and high-quality water is a fundamental human right, and the United Nations General Assembly (UNGA) has identified universal access to clean water and sanitation as one of the development goals to be met by 2030 (Arora and Mishra, 2019; Luvhimbi *et al.,* 2022).

In Nigeria, groundwater is a significant source of water for home and agricultural use. It is thought that groundwater is significantly purer and pollution-free than surface water. When water deviates from its pure form, its typical characteristics and function are impacted, leading to pollution. However, long-term groundwater pollution from home sewage, solid waste disposal, and industrial effluents leads to health issues (Raja *et al.,* 2002). These issues are far more severe in places with shallow groundwater tables, high industrialization, and dense populations. The majority of home water sources in the municipalities of Ajaokuta and Lokoja need to have their quality and wholesomeness thoroughly assessed in order to identify whether or not they are truly safe for human consumption. This evaluation should also take into account the water's mineral composition. However, it is possible for bacteria, NO^{3-}, arsenic, or other pollutants to contaminate water from many sources, such as well, borehole, or ground water. Testing and assessment of the waters from the various sources are crucial.

Therefore, it is essential to assess the wholesomeness of domestic water sources to identify potential risks and implement necessary measures to safeguard public health. This can involve regular testing and monitoring of water quality, identifying potential sources of contamination, implementing effective treatment and purification methods, and raising awareness among the public about the importance of clean and safe drinking water. For some of the health concerns and anticipated illness over a long use from contaminated and hard water, this work intends to examine the physical, chemical and microbiological properties of the groundwater and surface water obtained from Ajaokuta and Lokoja in Kogi State, and determines its suitability for drinking and other uses based on WHO standards for safe and drinking water for man's consumption and usage. By addressing the issue of wholesomeness of domestic water sources, we can ensure that communities have access to clean and safe water for their daily needs, promoting overall health and well-being.

2. Methodology

2.1. Study area

The study was conducted at Ajaokuta and Lokoja townships in Kogi State of Nigeria. Ajaokuta is a town located in Kogi State, Nigeria, known for the Ajaokuta Steel Company Limited (ASCL), which is the largest steel complex in Nigeria and the largest in Africa. The town is situated on the west bank of the Niger River with latitude: 6^0 40′6.59" N and longitude: 8^0 48′11.39" E, and population of 16039 (2006 Census) while Lokoja is the capital city of Kogi State in central Nigeria, located at the confluence of the Niger and Benue rivers with latitude: 7^0 48′7" N and longitude: 6^0 44′39" E and population of 237000 (2006 Census).

2.2. Study design

This study adopted a quantitative design comprising of field survey and water analysis.

For the field survey, a cross-sectional descriptive study was used, where data were collected at a particular time from a sample, for the purpose of describing the population represented by the sample at this particular time (Awotunde and Ugodulunwa, 2004). This descriptive cross sectional study of the population in Ajaokuta and Lokoja Metropolises to assess the knowledge and perception on the wholesomeness of domestic water available for usage in their immediate environment. While water analysis comprises physicochemical parameters, major and trace elements, and microbiological analyses.

2.3. Study population

Field survey: The survey was done to identify the selected households and their shared sources of water for usage. The townships were divided into 20 quadrants for sampling purposes. From each quadrant, 6 households were randomly selected where questionnaires were distributed and water samples collected for analysis.

Quantitative data collection: A structured interviewer-administered questionnaire was employed for data collection in the selected area. A total of 120 questionnaires were distributed each for Ajaokuta and Lokoja. Adults between the ages of 18 and 69 years were randomly selected to complete the questionnaire which includes questions concerning demographic and socio-economic statuses of the respondents, water sources, storages, treatments as well as perception of water quality and health. Table 1 shows the different districts names where the questionnaire were administered, and the number per district area.

Table 1: Distribution summary of questionnaire in different location

S/No	Location			
	Lokoja		Ajaokuta	
	Quadrant Area	Number of Questionnaire Distributed	Quadrant Area	Number of Questionnaire Distributed
1	Lokongoma	12	Kwara estate	12
2	Face 2	12	Rakaform	12
3	Marine	12	Imo estate	12
4	Zone 8	12	Beacon estate	12
5	Ganaja village	12	Feorgirole 1	12
6	200 unit	12	Feorgirol 2	12
7	Sango 1	12	African camp	12
8	Sango 2	12	Gongola estate	12
9	Felele	12	German camp	12
10	Natako	12	Geregu camp	12
	Total	120	Total	120

2.4. Sample /sampling techniques

Water sampling: Water samples for analysis was collected from the treated water supplied from household taps and storage containers, packaged water being sold, well and borehole water and rain water in the

Table 2: Sources of water sample collection and designations

S/No	Sources	Location	Designation
1	Borehole	Lokoja	LBH
2	Packaged or sachet	Lokoja	LPW
3	Well	Lokoja	LWW
4	Rain	Lokoja	LRW
5	Packaged water or sachet	Ajaokuta	APW
6	Borehole	Ajaokuta	ABH
7	Treatment plant	Ajaokuta	ATW
8	Well	Ajaokuta	AWW
9	Rain	Ajaokuta	ARW

metropolises from different locations and sites. Permission to collect water samples from the reservoir tank at households was obtained from the water treatment plant and other sources. Water samples were collected in 500 mL sterile polyethylene bottles. After collection, the containers were transported to the laboratory on ice in a cooler box. Each of the samples was tested for physico-chemical parameters, microbial parameters and trace metals' concentration. Table 2 shows the various sources of water samples collected from the different locations, sources from borehole water to water from treatment plant.

Physicochemical parameters' analysis: Onsite analysis of temperature, pH, Electrical Conductivity (EC) and Total Dissolved Solids (TDS) were performed immediately after sampling, following the standards protocols and methods of American Public Health Association (APHA) Association (1992).

2.5. *Analysis of major and trace elements*

Analysis of the major metals; Calcium (Ca), Sodium (Na), Potassium (K) and Magnesium (Mg) and the trace metals in water samples. The following trace element: Copper (Cu), Manganese (Mn), Iron (Fe), Chromium (Cr), Cadmium (Cd), Arsenic (As), Nickel (Ni), Zinc (Zn), Lead (Pb) and Cobalt (Co), will be tested (Edori and Kpee, 2016).

Microbiological water quality analysis: Analysis of microbial parameters was conducted within 6 h of collection as recommended by APHA. Viable Total coliform and *E. coli* were quantified in each sample. Test for *E. coli* concentration and count for the Most Probable Number (MPN) were performed.

2.6. *Human health risk assessment*

The HHRA was classified as either carcinogenic or non-carcinogenic based on the evaluation of the risk level for exposure to metal or metalloids. The present study evaluated the rate of pollutant ingestion in a human body through the oral consumption of drinking water using the USEPA guidelines by computing the Chronic Daily Intake (CDI), Hazard Quotient (HQ), Hazard Index (HI), and Carcinogenic Risk (CR).

2.7. *Hazard quotient*

The adverse effects resulting from exposure to non-carcinogenic pollutants were evaluated using a Hazard Quotient (HQ), as determined by the toxicant section of the United States Environmental Protection Agency (USEPA). The following equation was used to calculate HQ:

$$HQ=\frac{CDI}{RfD} \quad ...(1)$$

The Reference Dosage (RfD) for arsenic is 0.0003 mg/kg/day.

The Chronic Daily Intake (CDI) is computed using the following equation:

$$CDI=\frac{Cw\times IR\times EF\times ED}{BW\times AT} \quad ...(2)$$

Where, CDI is the daily dose of heavy metals (mg/l) to which consumers might be exposed. Cw (mg/l) is the concentration of heavy metals in the spring water, IR is the Ingestion rate, EF is the Exposure frequency, ED is

Table 3: Input parameters to characterise CDI value

Factor Parameter	Symbol	Units	Adult	Children
Exposure Duration	ED	Years	30	6
Exposure Frequency	EF	Days/Year	365	365
Averaging Time.	AT(EDx365)	Days	10950	2190
Body Weight	BW	Kg	70	15
Ingestion Rate	IR	L/Day	2.0	1.0

Source: Nawaz et al. (2023)

the Exposure duration, BW is the Body weight, AT is the Averaging Time. The input parameters used in evaluating CDI values are presented in Table 3.

2.8. Hazard index

The following equation is used to determine the HI of Arsenic associated with the HQ values, which is defined as the sum of the HQ of the investigated parameters.

$$HI = HQ1 + HQ2 + HQ3 + HQ4 + \ldots + HQn \quad \ldots(3)$$

HQ values show that there are no and considerable non-carcinogenic health impacts, respectively, if HQ < 1 and HQ > 1. HI < 1 denotes a minimal or non-existent risk of adverse non-cancer health, while HI > 1 denotes a high amount of such risk. There are four categories for chronic risk (HQ or HI): negligible (<0.1), low ($\geq$0.1 < 1), medium ($\geq$1 < 4), and high ($\geq$4) (USEPA, 2001).

2.9. Carcinogenic risk

By exposing people to carcinogenic substances, CR helps in estimating a person's lifetime risk of developing any sort of cancer.

The Slope Factor (SF) of heavy metals produced by cancer is multiplied by the CDI to determine the Cancer Risk (CR), as shown in the following equation:

$$CR = CDI \times SF \quad \ldots(4)$$

where, "SF" (1.5 mg/kg/day for As) is the slope factor of pollutants. The "CR" is identified from very low ($<1 \times 10^{-6}$) to very high ($>1 \times 10^{-3}$) (USEPA, 2001).

Validity of measurement: Validity is the extent to which an instrument can measure exactly what it was designed for (Onwumere, 2005). The face validity of the instrument will be ensured by experts in Health Science Department, National Open University of Nigeria and the standard Laboratory where tests will be carried out. The validity of the instrument will be determined by subjecting the instrument to face and content validity, which involved scrutiny of the instruments to ensure it measures the extent to which the instrument related to the knowledge and perception of respondents. Their major observations should address all objectives set out in the thesis, remove or rephrase ambiguous words or statements, items in a scale should be sufficient. They will review questionnaire and confirmed that the items measure the concepts of interest relevant to the study. Respondents will be given time to go through the questionnaire and the researcher will be present to clear any misunderstanding that may arise.

Reliability of measurement: Proper quality assurance procedures and precautions was taken to ensure the reliability of the results. Samples were carefully handled to avoid contamination. Glassware were properly cleaned, and reagents were of analytical grades. Deionized water was used throughout the study. For the other instrumentation determinations, this was correct to the instrument readings. For validation of the analytical procedure, repeated analysis of the samples against internationally certified/standard reference material of National Institute of Standard and Technology was used. The analytical results obtained were compared with recommended values.

2.10. Data collection

A self-administered method was used to collect data from study participants and close ended Questionnaires as well as focus group interviews was administered to the participants which gathered both qualitative and quantitative data. The researcher explained the purpose of the research to the participants The researcher was guarantee the confidentiality of the participants as their respective names and addresses were not be required.

2.11. Data analysis

In this study, the experimental results obtained was statistically analyzed using Microsoft excel and presented as descriptive statistics in the form of tables and graphs. The values were expressed as means which will be obtained from a set of observations. The significance of the difference among the concentrations of water quality parameters and heavy metals at different sampling locations was assessed with independent t-test. A

$p<0.05$ was considered statistically significant. The experimental data obtained were compared with the standards and guidelines for domestic water use (WHO, 2011; WHO, 2002).

Ethics approval and consent to participate: The ethical clearance for this study was obtained from the University Health, Safety and Research Ethics' Committee. Permission to conduct the study was obtained from the selected households. Respondents was duly informed about the study and informed consent was obtained from all of them. The basic ethical principles of voluntary participation, informed consent, anonymity and confidentiality of respondents was duly complied with during data collection, analysis and reporting.

3. Results (data anaylysis and presentation)

Table 4 above examines the bio-data of the respondents, which shows that 56% were male while 44% were female. Most of the respondents (32.5%) were of the age interval of 35 to 44 years, followed by 18 to 24 with the percentage of 28% and then 45 and above with percentage of 22%. Base on level of education, 47.5% are undergraduates, followed by postgraduate with percentage of 43.5%. The table also reviewed the employment status of the respondents; permanent employment (37%) followed by students (23%), self-employment (22%), temporary employment (18%).

Table 4: Socio-demographic characteristics of the respondents

Socio-Demographic Characteristics		Frequency	Percentage (%)	Mean	SD
Gender	Male	135	56	120.0	21.2
	Female	105	44		
Age	18-24	67	28	59.7	15.9
	25-34	42	17.5		
	35-44	78	32.5		
	45-above	52	22		
Level of education	No formal education	2	1	47.0	56.7
	Primary school	6	3		
	Secondary school	9	4		
	Undergraduate	114	47.5		
	Post graduate	104	43.5		
Employment status	Adult education	5	2	49.0	30.1
	Permanent employment	89	37		
	Temporary employment	43	18		
	Self-employment	53	22		
	Student	55	23		

Table 5 above examines the sources and storage of water outfits. The result shows the most respondents had water usage from water treatment plants (31%), packaged or sachet (23%) and borehole (21%). The result also shows that 74% of the respondents store their water in plastic containers, while 18% store water in metal containers. The respondents' duration or storage ranges from less than week (25%), 1-2 weeks (30%), less than a month (17%) and above a month (26%).

Most of the respondents (95%) have their containers covered. The result further show cleaning of containers carried out daily (23%), weekly (23%), two weeks (16), monthly (22%) and annually (11%).

Table 5: Sources and storage of water					
Variables		**Frequency**	**Percentage (%)**	**Mean**	**SD**
What are the sources of water available to you	Water from treatment plant	74	31	39.3	24.7
	Packaged or sachet water	55	23		
	Borehole	50	21		
	Well water	21	9		
	Rain water	29	12		
	Stream water	7	3		
Where do you store your water	Clay pot	5	2	48.0	73.9
	Metal container	44	18		
	Plastic container	177	74		
	Reservoir well	10	5		
	Others	4	2		
How long does your water stay in storage container	Less than a week	61	25	59.3	13.3
	1-2 weeks	73	30		
	Less than 1 month	41	17		
	More than a month	62	26		
	Others	2	1		
Are your storage vessels covered	Yes	229	95	80.0	129.0
	No	8	4		
	Others	3	1		
What are the frequency of cleaning your water storage container	Do not clean at all	2	1	34.3	21.8
	Everyday	55	23		
	Every week	54	23		
	Every two weeks	39	16		
	Every month	53	22		
	Biannually or annually	26	11		
	When the needs arises (others)	11	6		

Table 6 reveals the treatment and perception on quality of water. The result shows that 40% of the respondents treat water while 58% do not treat water The result also reviewed the method of treatment; 12% use chlorine, 22% use boiling, 18% use alum while 39% do not treat. The perceptions of respondents vary on susceptibility to sickness, 55% affirm while 45% in the negatives. The result further shows satisfactory with water use 50% while 45 are unsatisfactory.

Table 7 shows the physical and microbiological analysis of the water sample. pH value ranges from 6.72 to 9.09 with an average of 7.98, Electrical Conductivity (EC) had values of 50 to 740 microsiemens per centimeters (µS/cm). The water samples temperatures are between 23.5 °C (lowest) and 24.4 °C (highest), whereas TDS

Table 6: Water treatment and perception on quality

Variables		Frequency	Percentage (%)	Mean	SD
Do you usually treat your water before use	Yes	94	40	79.6	67.4
	No	139	58		
	Sometimes	6	2		
Which method of treatment do you usually use to make your water safe	Solar disinfectant	5	2	39.2	32.7
	Water filter ceramic	10	4		
	Chlorine or bleach	29	12		
	Boiling	53	22		
	Use of alum	44	18		
	No treatment	94	39		
Do you think you can get sick from the water you use	Yes	130	55	119	15.6
	No	108	45		
Are you satisfied with the water you use	Yes	120	50	79.6	60.6
	No	109	45		
	Somehow	10	5		

Table 7: Physical and bacteriological analysis of water samples

Location	Physical				Bacteriological	
	pH	Conductivity (µS/cm)	Temperature (^{0}C)	TDS (mg/L)	Total Coliform (cfu)	Thermo Tolerant Coliform or *E. coli* (cfu)
LBH	7.94	740	23.9	0.24	0	0
LPW	8.04	50	24	0.19	0	0
LWW	8.02	550	24.2	0.24	2	0
LRW	6.72	720	23.5	0.21	<5	1
APW	8.38	140	23.7	0.21	0	0
ABH	9.09	630	23.8	0.24	0	0
ATW	8.2	120	24.4	0.17	0	0
AWW	7.85	520	24.2	0.19	3	0
ARW	7.62	410	23.6	0.23	7	<2
References						
WHO (2017)	6.5-8.5	1000	Ambient	500	0	0
NSDWQ (2017)	6.5-8.5	1000	Ambient	500	10 Maximum	0

Source: WHO (2017) and NSDWQ (2015)

varied between 0.17 and 0.24 mg/L. The total coliform and *E. coli* have values of 0 to 7 colony forming units (cfu) and 0 to <2 cfu, respectively.

Table 8 shows the analysis of metals in water. The values ranges mg/L for Ca-14.825-31.025, K-0.650-3.300, Mg-2.876-5.807, Na-7.70-50.25, Ni-0.004-0.135, Pb-0.010-0.034, Fe-0.132-0.177, Cu-0-0.07, Cr-0.12-0.098, Cd-0.012-0.137, Mn-0.020-0.220 and Zn-0.049-0.383.

Table 8: Metal analysis of water different sources

Location	Major Metals (mg/L)				Minor Metals (mg/L)							
	Ca	K	Mg	Na	Ni	Pb	Fe	Cu	Cr	Cd	Mn	Zn
LBH	31.025	2.250	5.807	18.38	0.135	0.016	0.177	0.02	0.072	0.035	0.028	0.359
LPW	13.425	0.650	2.276	25.25	0.043	0.010	0.132	0.03	0.080	0.017	0.047	0.049
LWW	13.052	1.820	2.876	50.25	0.033	0.012	0.172	0.02	0.092	0.032	0.031	0.251
LRW	22.202	0.790	3.891	9.05	0.107	0.011	0.137	0.02	0.098	0.012	0.041	0.115
APW	14.825	1.325	5.181	35.75	0.031	0.031	0.172	0.07	0.012	0.012	0.220	0.383
ABH	30.725	3.300	5.768	17.70	0.004	0.014	0.142	0.05	0.014	0.033	0.021	0.061
ATW	18.250	2.175	3.923	48.00	0.117	0.034	0.164	0	0.065	0.137	0.021	0.019
AWW	18.022	2.010	4.786	30.10	0.023	0.023	0.175	0.02	0.021	0.121	0.020	0.089
ARW	30.128	1.550	5.101	7.70	0.097	0.015	0.139	0.03	0.015	0.112	0.022	0.332
References												
WHO (2017)	100	1-2	20	40	0.07	0.01	0.05-0.3	2.0	0.05	0.003	0.05	3.0
NSDW (2017)	150	1.0	20	40	0.01	0.01	0.3	1.0	0.01	0.003	0.1	5.0

Source: WHO (2017) and NSDWQ (2015)

Table 9: Total hazard quotient and health risk index (HI) for trace metals in the water samples

Location	Metals										HI
			Ni	Pb	Fe	Cu	Cr	Cd	Mn	Zn	
LBH	HQ	Adults	1.93E-01	1.31E-01	7.23E-03	1.43E-02	6.86E-01	2.00E-01	5.72E-02	3.42E-02	1.32E+00
		Children	4.50E-01	3.05E-01	1.69E-02	3.34E-02	1.60E+00	4.67E-01	1.33E-01	7.98E-02	3.09E+00
LPW		Adults	6.15E-02	8.17E-02	5.39E-03	2.15E-02	7.63E-01	9.72E-02	9.60E-02	4.67E-03	1.13E+00
		Children	1.43E-01	1.91E-01	1.26E-02	5.00E-02	1.78E+00	2.27E-01	2.24E-01	1.09E-02	2.64E+00
LWW		Adults	4.72E-02	9.81E-02	7.03E-03	1.43E-02	8.77E-01	1.83E-01	6.33E-02	2.39E-02	1.31E+00
		Children	1.10E-01	2.29E-01	1.64E-02	3.34E-02	2.05E+00	4.27E-01	1.48E-01	5.58E-02	3.06E+00
LRW		Adults	1.53E-01	8.99E-02	5.60E-03	1.43E-02	9.34E-01	6.86E-02	8.38E-02	1.10E-02	1.36E+00
		Children	3.57E-01	2.10E-01	1.31E-02	3.34E-02	2.18E+00	1.60E-01	1.95E-01	2.56E-02	3.17E+00
APW		Adults	4.43E-02	2.53E-01	7.03E-03	5.01E-02	1.14E-01	6.86E-02	4.49E-01	3.65E-02	1.02E+00
		Children	1.03E-01	5.91E-01	1.64E-02	1.17E-01	2.67E-01	1.60E-01	1.05E+00	8.52E-02	2.39E+00
ABH		Adults	5.72E-03	1.14E-01	5.80E-03	3.58E-02	1.33E-01	1.89E-01	4.29E-02	5.82E-03	5.33E-01
		Children	1.33E-02	2.67E-01	1.35E-02	8.34E-02	3.11E-01	4.40E-01	1.00E-01	1.36E-02	1.24E+00
ATW		Adults	1.67E-01	2.78E-01	6.70E-03	0.00E+00	6.20E-01	7.84E-01	4.29E-02	1.81E-03	1.90E+00
		Children	3.90E-01	6.48E-01	1.56E-02	0.00E+00	1.45E+00	1.83E+00	1.00E-01	4.22E-03	4.43E+00
AWW		Adults	3.29E-02	1.88E-01	7.15E-03	1.43E-02	2.00E-01	6.92E-01	4.09E-02	8.48E-03	1.18E+00
		Children	7.67E-02	4.38E-01	1.67E-02	3.34E-02	4.67E-01	1.61E+00	9.53E-02	1.98E-02	2.76E+00
ARW		Adults	1.39E-01	1.23E-01	5.68E-03	2.15E-02	1.43E-01	6.41E-01	4.49E-02	3.17E-02	1.15E+00
		Children	3.23E-01	2.86E-01	1.32E-02	5.00E-02	3.34E-01	1.49E+00	1.05E-01	7.38E-02	2.68E+00
RFD			2.00E-02	3.50E-03	7.00E-01	4.00E-02	3.00E-03	5.00E-03	1.40E-02	3.00E-01	

Table 9 shows the Hazard Quotient (HQ) and Health risk Index (HI) for trace metals in the water samples HQ ranges from Ni-1.33E-02 to 4.50E-01 (Children) and 5.72E-03 to 1.93E-01 (Adults), Pb-1.91E-01 to 6.48E-01 (Children) and 8.17E-02 to 2.78E-01 (Adults), Fe-1.26E-02 to 1.69E-02 (Children) and 5.39E-03 to 7.23E-03 (Adults), Cu-3.34E-02 to 1.17E-01 (Children) and 1.43E-02 to 5.01E-02 (Adults), Cr-2.67E-01 to 2.18E+00 (Children) and 1.14E-01 to 9.34E-01 (Adults), Cd-1.60E-01 to 1.83E+00 (Children) and 6.86E-02 to 7.84E-01 (Adults), Mn-9.53E-02 to 1.05E+00 (Children) and 4.09E-02 to 4.49E-01 (Adults), Zn-4.22E-03 to 8.52E-02 (Children) 1.81E-03 to 8.52E-02 and 1.81E-03 to 3.65E-02 (Adults). The HI varied from 1.24E+00 to 4.43E+00 (Children) and 5.33E-01 to 1.90E+00 (Adults).

Table 10 shows the Cancer risk associated with the levels of Ni, Pb, Cr and Cd in the water sample for different age groups. The values varied for: Ni-2.43E-04 to 8.19E-03 (Children) and 1.04E-04 to 3.51E-03 (Adults), Pb-5.67E-06 to 1.93E-05 (Children) and 2.43E-06 to 8.27E-06 (Adults), Cr-4.00E-04 to 3.27E-03 (Children) and 1.72E-04 to 1.40E-03 (Adults), Cd-3.04E-04 to 3.47E-03 (Children) and 1.30E-04 to 1.49E-03 (Adults).

Table 10: Cancer risk associated with the levels of Ni, Pb, Cr and Cd in the water sample

Location		Metals				
			Ni	Pb	Cr	Cd
LBH	CR	Adults	3.51E-03	3.89E-06	1.03E-03	3.80E-04
		Children	8.19E-03	9.07E-06	2.40E-03	8.87E-04
LPW		Adults	1.12E-03	2.43E-06	1.14E-03	1.85E-04
		Children	2.61E-03	5.67E-06	2.67E-03	4.31E-04
LWW		Adults	8.59E-04	2.92E-06	1.32E-03	3.48E-04
		Children	2.00E-03	6.80E-06	3.07E-03	8.11E-04
LRW		Adults	2.78E-03	2.67E-06	1.40E-03	1.30E-04
		Children	6.49E-03	6.24E-06	3.27E-03	3.04E-04
APW		Adults	8.07E-04	7.54E-06	1.72E-04	1.30E-04
		Children	1.88E-03	1.76E-05	4.00E-04	3.04E-04
ABH		Adults	1.04E-04	3.40E-06	2.00E-04	3.59E-04
		Children	2.43E-04	7.94E-06	4.67E-04	8.36E-04
ATW		Adults	3.05E-03	8.27E-06	9.30E-04	1.49E-03
		Children	7.10E-03	1.93E-05	2.17E-03	3.47E-03
AWW		Adults	5.99E-04	5.59E-06	3.00E-04	1.32E-03
		Children	1.40E-03	1.30E-05	7.00E-04	3.07E-03
ARW		Adults	2.52E-03	3.65E-06	2.15E-04	1.22E-03
		Children	5.89E-03	8.50E-06	5.00E-04	2.84E-03
CSF			9.10E-01	8.50E-03	5.00E-01	3.80E-01

4. Discussion

This study provides information about the quality of water in a selected area in Lokoja and Ajaokuta municipality taking into consideration the physicochemical, microbiological and trace metals' parameters of the treated water in use.

Many participants in the study have their primary source of water from treatment plant, borehole, packaged containers while very few have water from rain and well. This implies that getting water for household use would involve collecting the water and then into the storage containers. This observation is not restricted to the study area, as a similar situation has been observed in other municipalities (Luvhimbi *et al.*, 2022; Nawaz *et al.*, 2023). The passage of water through multiple containers before use can increases the risk of contamination. Residents of the study area store their drinking water in plastic buckets, ceramic vessels, jerry cans and other containers. Almost all the respondents (95%) claim that their water storage vessels are covered and that their water usually stays for within a week in the storage containers (55%) from Table 5. Covering of water storage containers reduces the risk of water contamination from dust or other airborne particles. In this study (58%) use water directly from source without any form of treatment. This is because many residents in Lokoja and Ajaokuta municipality believe that the water they drink is of good quality and thus do not need any further treatment (Edokpayi *et al.*, 2018). The few who treat their water before drinking mostly use the boiling method. While boiling and other home-based interventions like solar disinfection of water have been reported to improve the quality of drinking water; drinking vessels, like cups, have also been implicated in water re-contamination of treated water at the point of use in the study of Rufener *et al.* (2010). The Centres for Disease Control and Prevention (CDC) recommends that containers for drinking water should be fitted with a small opening with a cover, through which water can be collected while the container remains closed, without having to dip any potentially contaminated object into the container (CDC, 2012).

The pH of the analyzed samples from the study area ranged from 6. to 9.09. Most of the samples were within the values recommended by NSDWQ (6.5 to 8.5) and comparable to results from previous similar studies (Luvhimbi *et al.*, 2022). Also, the electrical conductivity of all water samples from this study ranged from 50 µS/cm to 740 ìS/cm which complied with the recommended value of WHO: < 1000 µS/cm (WHO, 2011). The presence of dissolved solids such as calcium, chloride, and magnesium in water samples is responsible for its electrical conductivity (Meide and Ayenew, 2016).

Total dissolved solids are the inorganic salts and small amounts of organic substance, which are present as solution in water. Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulphates, etc. These minerals produced unwanted taste and colour in water. A high TDS value indicates that water is highly mineralised. The recommended TDS value set for drinking water quality is < 500 mg/L WHO (2011). In this study, the TDS values ranged from 170 mg/L to 240 mg/L. Hence, the TDS of all the samples complied with the guidelines and consistent with previous studies (Alhasan and Udoji, 2012; Aruf *et al.*, 2024).

The water samples temperatures were within the recommended room temperature of 25 °C (WHO, 2011) ranging between 23.5 °C (lowest) and 24.4 °C. The analysis of magnesium (2.276 to 5.807 mg/L) and calcium (14.8 to 31.025 mg/L) concentrations showed that they were within the permissible range recommended for drinking water by NSDWQ (2015) and WHO (2011). All living organisms depend on magnesium in all types of cells, body tissues and organs for variety of functions while calcium is very important for human cell physiology and bones. Similar studies in Ethiopia and Turkey also showed acceptable levels of these metals in drinking water (Meide and Ayenew, 2016; Aruf *et al.*, 2024). Likewise, the levels of potassium (0.65 to 3.30 mg/L) and sodium (7.70 to 50 mg/L) were within the permissible limit of WHO and NSDWQ and may not cause health related problems. Sodium is essential in humans for the regulation of body fluid and electrolytes, and for proper functioning of the nerves and muscles, however, excessive sodium in the body can increase the risk of developing a high blood pressure, cardiovascular diseases and kidney damage (Smyth *et al.*, 2014). Potassium is very important for protein synthesis and carbohydrate metabolism, thus, it is very important for normal growth and body building in humans, but, excessive quantity of potassium in the body (hyperkalemia) is characterized with irritability, decreased urine production and cardiac arrest (Pohl *et al.*, 2013). Metals like copper (Cu), cobalt (Co) and zinc (Zn) are essential requirements for normal body growth and functions of living organisms, however, in high concentrations, they are considered highly toxic for human and aquatic life (Edokpayi *et al.*, 2018). Elevated trace metal (loids) concentrations could deteriorate water quality and pose significant health risks to the public due to their toxicity, persistence, and bio accumulative nature (Budi *et al.*, 2024).

In this study, the concentrations of Manganese, Cobalt, Nickel and Copper all complied with the recommended concentration by NSDWQ for domestic water use. Iron (Fe) is an essential element for human health, required for the production of protein haemoglobin, which carries oxygen from our lungs to the other parts of the body. Insufficient or excess levels of iron can have negative effect on body functions (Luvhimbi *et al.*, 2022). The recommended concentration of iron in drinking water is $\leq$ 0.2 mg/L (NSQDW, 2015). In this study, the concentration of iron in the samples ranged from 0.132-0.334 mg/L. A high concentration of Fe in water can give water a metallic taste, even though it is still safe to drink. The levels of Pb, and Zn were in the range of 0.01-0.034 m/L and 0.049-0.383 m/L, respectively. The levels recorded complied with the NSDWQ (2015) and WHO (2011) guidelines for drinking water. Similar results were reported by Mohod and Dhote (2013). Lead is not desirable in drinking water because it is carcinogenic and can cause growth impairment in children having interference with Vitamin D metabolism, and are toxic to the central and peripheral nervous systems (Jarvis and Fawell, 2021). In addition, health impacts are indicated when metals are above the permitted limits; Cadmium (Cd) is toxic to the kidney, Chromium (Cr), Copper (Cu) results in Gastrointestinal disorder, Magnesium affects consumer acceptability while Manganese (Mn) affects Neurological disorder (NSDWQ, 2015).

The Hazard Quotient (HQ) takes into consideration the oral toxicity reference dose for a trace metal that humans can be exposed to (Onyele and Anyanwu, 2018). Health related risk associated with the exposure through ingestion depends on the weight, age and volume of water consumed by an individual. HQ for all analyzed trace metals in both children and adults were less than one unit (Table 9), indicating that there are no potential non-carcinogenic health risks associated with the consumption of the water from the study area either by children or adults. The calculated average cumulative health risk index (HI) for children and adult varied from 1.24E+00 to 4.43E+00 (Children) and 5.33E-1 to 1.90E+00 (Adults) respectively. HQ across metals serve as a conservative assessment tool to estimate high-end risk rather than low end risk in order to protect the public. This served as a screen value to determine whether there is major significant health risk (Onyele and Anyanwu, 2018). The results in this study signifies that the population of the investigated area are not susceptible to non-cancer risks due to exposure to trace metals in drinking water. Similar observation has been reported by Bamuwamye *et al.* (2022) after investigating human health risk assessment of trace metals in Kampala (Uganda) drinking water. It should be noted that the hazard index values for children were higher than that of adult, suggesting that children were more susceptible to non-carcinogenic risk from the trace metals.

Drinking water with trace metals such as Pb, As, Cr and Cd could potentially enhance the risk of cancer in human beings. Long term exposure to low amounts of toxic metals might, consequently, result in many types of cancers. Using Ni and Pb carcinogens, the total exposure risks of the residents in Table 10. For trace metals, an acceptable carcinogenic risk value of less than 1×10^{-6} is considered as insignificant and the cancer risk can be neglected; while an acceptable carcinogenic risk value of above 1×10^{-3} is considered as harmful and the cancer risk is worrisome (Luvhimbi *et al.*, 2022; Nawaz *et al.*, 2023). Amongst the studied trace metals, only the maximum levels of lead for both adults and children had the highest chance of cancer risks highest for Ni-8.19E-03 for Children and Cd-1.49E-03 for Adults.

The water from the various sources tested negative for both total coliform and *E. coli* hence complied with regulatory standards of NSDWQ (2015) and WHO (2011) The results could probably be due to the use of chlorine as a disinfectant in the treatment plant. Using disinfectants, pathogenic bacteria from the water can be killed and water made safe for the user. Similar studies have also reported that treated water in urban water treatment plants contains no total coliforms and *E. coli* (Adedeji *et al.*, 2017). In contrast, there were couple of samples from rain and well water and E. *coli* was also detected from the rain waters. There had been report on considerable levels of total coliform and *E. coli* (Onyango *et al.*, 2018; Otorkpa, 2019). The reason alluded to this include lack of disinfectant, no residual chlorine in the treated water, high prevalence of open defecation and unhygienic practices in proximity to water sources (Ajayi and Adejumo, 2011). Suspected contamination is possible from the rain and the proximity of sewage to the well was observed not far apart with total coliform of around 5 and 2 cfu in Lokoja and 4 and 2 cfu in Ajaokuta, MPN/100 mL with most of the sites exceeding the WHO guidelines of 10 MPN/100 mL (WHO, 2011). All the samples tested negative for *E. coli*, this complies with the WHO guideline of 0 MPN/100 mL.

5. Conclusion

Water quality has been linked to health outcomes across the world. This study evaluated the wholesomeness of water from different sources for drinking and other domestic uses by the municipalities of Ajaokuta and Lokoja; assessed the community practices regarding collection and storage of water and determined the human health risks associated with consumption of the water. Assessment of water quality was carried out on physicochemical and bacteriological quality of water in use on 9 different sources. Questionnaires were used to identify the community sources of water and storage activities. Many of the households reported they cover their containers and the majority (58%) do not treat their water before use. While *E. coli and* total coliform were not detected or within the permeable value many of water samples at the different sources

Trace metals' levels in the drinking water samples were within permissible range of both the Nigeria Standards of water quality and World Health Organisation. The calculated non-carcinogenic effects using hazard quotient toxicity potential and cumulative hazard index of drinking water through ingestion and dermal pathways were less than unity, implying that consumption of the water could pose no significant non-carcinogenic health risk.

The physicochemical, bacteriological quality and trace metals' concentration of water samples from the different sources and household storage containers were majorly within the permissible range of both WHO and NSDWQ drinking water standards. HQ for both children and adults were less than unity, showing that the drinking water poses less significance health threat to both children and adults. Amongst the studied trace metals, only the maximum level of lead for both adults and children has the highest chance of cancer risks.

We recommend that appropriate measures should be taken to maintain residual free chlorine at the distribution points, supply of municipal treated water should be more consistent the municipality of Lokoja and Ajaokuta, and residents should be educated on hygienic practices of transportation and storage of drinking water from the different sources as certain water transportation and storage practices by community members can cause the risk of water contamination.

Recommendations

- A more consistent supply of treated municipal water to the Municipality and training of residents on hygienic practices of transportation and storage of drinking water from the source to the point of use.
- Cleaning of vessels or containers for water are necessary and within short period of time because water can be contaminated in the distribution networks due to the adherence of bacteria onto biofilms or accidental point source contamination by broken pipes, installation and repair works.
- A frequent and periodic testing and monitoring of water quality be conducted and result reviewed.

References

Adedeji, O.H., Olayinka, O.O. and Oladimeji, O. (2017). Physicochemical and microbiological examination of hand-dug wells, boreholes and public water sources in selected areas of Ibadan, Nigeria. *Journal of Applied Sciences and Environmental Management*, 21(3): 576-584.

Ajayi, A.O. and Adejumo, T.O. (2011). Microbiological assessment and some physico-chemical properties of water sources in Akungba-Akoko, Nigeria. *Journal of Toxicology and Environmental Health Sciences*, 3(13): 342-346.

Alhassan, M.M. and Ujoh, F. (2012). Assessment of the chemical quality of potable water sources in Abuja, Nigeria. *British Journal of Applied Science & Technology*, 2(2): 146-172.

Arora, N.K. and Mishra, I. (2019). United Nations sustainable development goals 2030 and environmental sustainability: Race against time. *Environmental Sustainability*, 2(4): 339-342.

Aruf, M., Muhammad, A., Sulaiman, M., Usman, H.M., Panda, S.L. and Idris, I.M. (2024). Water quality assessment and health implications: A study of Kano metropolis, Nigeria. *Journal of Science and Technology*, 9(6): 33-52.

Association, A.P.H. (1992). *Standard Methods for the Examination of Water and Waste Water,* 16th Edition, American Public Health Association, Washington.

Awotunde, P.O. and Ugodulunwa, C.A. (2004). Research methods in education. Fab Anieh (Nig) Ltd., Jos.

Bamuwamye, M., Ogwok, P., Tumuhairwe, V., Eragu, R., Nakisozi, H. and Ogwang, P.E. (2022). Human health risk assessment of heavy metals in Kampala (Uganda) drinking water.

Budi, H.S., Catalan Opulencia, M.J., Afra, A., Abdelbasset, W.K., Abdullaev, D., Majdi, A., ... and Mohammadi, M.J. (2024). Source, Toxicity and carcinogenic health risk assessment of heavy metals. *Reviews on Environmental Health*, 39(1): 77-90.

CDC. (2012). gov/drinking water

Edokpayi, J.N., Rogawski, E.T., Kahler, D.M., Hill, C.L., Reynolds, C., Nyathi, E., ... and Dillingham, R. (2018). Challenges to sustainable safe drinking water: A case study of water quality and use across seasons in rural communities in Limpopo Province, South Africa. *Water*, 10(2): 159.

Edori, O.S. and Kpee, F. (2016). Physicochemical and heavy metal assessment of water samples from boreholes near some abattoirs in Port Harcourt, Rivers State, Nigeria. *American Chemical Science Journal*, 14(3): 1-8.

Jarvis, P. and Fawell, J. (2021). Lead in drinking water—An ongoing public health concern?. *Current Opinion in Environmental Science & Health*, 20: 100239.

Luvhimbi, N., Tshitangano, T.G., Mabunda, J.T., Olaniyi, F.C. and Edokpayi, J.N. (2022). Water quality assessment and evaluation of human health risk of drinking water from source to point of use at Thulamela Municipality, Limpopo Province. *Scientific Reports*, 12(1): 6059.

Meride, Y. and Ayenew, B. (2016). Drinking water quality assessment and its effects residents health in Wondo genet campus, Ethiopia. *Environmental Systems Research*, 5(1): 1-7.

Mohod, C.V. and Dhote, J. (2013). Review of heavy metals in drinking water and their effect on human health. *International Journal of Innovative Research in Science, Engineering and Technology*, 2(7): 2992-2996.

Nawaz, R., Nasim, I., Irfan, A., Islam, A., Naeem, A., Ghani, N., ... and Ullah, R. (2023). Water quality index and human health risk assessment of drinking water in selected urban areas of a Mega City. *Toxics*, 11(7): 577.

Nigerian Standard for Drinking Water Quality (2015). Standards organisation of Nigeria governing council ICS 13.060.20 NSDWQ.

Oluduro, A.O. and Aderiye, B.I. (2007). Efficacy of moringa Oleifera seed extract on the microflora of surface and underground water.

Onwumere, F.C. (2005). Method and an apparatus for forming a one-piece introducer. US Patent No. 6,837,873.

Onyango, A.E., Okoth, M.W., Kunyanga, C.N. and Aliwa, B.O. (2018). Microbiological quality and contamination level of water sources in Isiolo County in Kenya. *Journal of Environmental and Public Health*, 2018(1): 2139867.

Onyele, O.G. and Anyanwu, E.D. (2018). Human health risk assessment of some heavy metals in a rural spring, Southeastern Nigeria. *Afr. J. Environ. Nat. Sci. Res.*, 1(1): 15-23.

Otorkpa, O. (2019). Overview of major bacterial contaminants of drinking water in Nigeria: A review. *International Journal of Pathogen Research.*

Patil, V.T. and Patil, P.R. (2010). Physicochemical analysis of selected groundwater samples of Amalner Town in Jalgaon District, Maharashtra, India. *Journal of Chemistry*, 7: 111-116.

Pohl, H.R., Wheeler, J.S. and Murray, H.E. (2013). Sodium and potassium in health and disease. *Interrelations between Essential Metal Ions and Human Diseases*, 29-4.

Raja, S., Yaccone, F.S., Ravikrishna, R. and Valsaraj, K.T. (2002). Thermodynamic parameters for the adsorption of aromatic hydrocarbon vapors at the gas water interface. *Journal of Chemical & Engineering Data*, 47(5): 1213-1219.

Rufener, S., Mäusezahl, D., Mosler, H.J. and Weingartner, R. (2010). Quality of drinking-water at source and point-of-consumption—drinking cup as a high potential recontamination risk: A field study in Bolivia. *Journal of Health, Population, and Nutrition*, 28(1): 34.

Smyth, A., O'Donnell, M.J., Yusuf, S., Clase, C.M., Teo, K.K., Canavan, M., ... and Mann, J.F. (2014). Sodium intake and renal outcomes: A systematic review. *American Journal of Hypertension*, 27(10): 1277-1284.

Taiwo, A.M., Olujimi, O.O., Bamgbose, O. and Arowolo, T.A. (2012). Surface water quality monitoring in Nigeria: Situational analysis and future management strategy. *Water Quality Monitoring and Assessment*, 13: 301-320.

USEPA (2001). Supplemental guidance for developing soil screening levels for superfund sites. *OSWER*, 9355: 4-24, Office of Soild Waste and Emergency Response.

World Health Organization (2002). *Guidelines for Drinking Water Quality*, 3rd Edition, 1.

World Health Organization (2011). Chemicals of health significance as described by World Health Organization guidelines (WHO) for drinking-water quality in 3rd Edition (2008) and 4th Edition (2011).

World Health Organization. (2017). Guidelines for drinking-water quality: Fourth edition incorporating the first addendum. World Health Organization, Geneva.

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