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EFFECT OF HUMAN ACTIVITIES ON SURFACE AND GROUNDWATER SOURCES IN CROSS RIVER STATE, SOUTH-SOUTH NIGERIA

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Abstract

Surface water and groundwater in Akamkpa and Lemna both in Cross River State, Nigeria are degraded due to the heavy human activities such as solid waste disposal (landfill) and mining that take place in these areas. Results from selected sampling points show that the water sources are highly unfit for consumption during the dry seasons with water quality index(WQI) values as high as 292.85 and of very poor quality in the wet season with WQI values of between 73.69 and 94.43. Electrical conductivity (EC) showed the highest variability with a standard deviation value of 151.26552 and 3.630427 for surface water and groundwater respectively, while total alkalinity and total suspended solids showed the least variability with values of 0.957427 and 0.0816497 for surface water and groundwater respectively.

keywords: mining activities, human activities, surface water, groundwater, landfill, and leachate

1. Introduction

Water is one of the earth's most important, renewable, and widely distributed resources of which groundwater constitutes about 97.2% (Kowalkowski et al., 2007). Human activities can affect water resources in many ways. Proper management and protection of the quality of surface and groundwater sources have been a major problem in Nigerian cities. The water of good quality is vital to man's existence as human physiology requires it in sufficient quantity to function optimally.

Due to the rapid growth of population, industrialization, and urbanization, they have been intense human activities and interference with nature leading to over-exploitation and severe pollution stress on natural water bodies. Improper disposal of hazardous waste still remains the most severe drinking water contamination problem. As wastes bio degenerate, leachates are developed which could become a pollution source for surface and groundwater (Ocheri et al., 2014). Leachates from landfill sites eventually either infiltration to groundwater aquifers or flow to natural water courses. Runoff from mining areas may contain sediments at the river bottom that are contaminated with high concentrations of heavy metals (Soares et al., 1999).

The task of ensuring water sources is safe for consumption is challenging, due to the fact that contamination of groundwater and surface water from natural and human activities cannot be ruled out. The Safe Drinking Water Act defines the term "water contaminant" as the presence of any physical, chemical, biological, or radiological substance or matter in water. The importance of water quality continues to be emphasized due to its role in epidemics and contribution to endemic disease from pathogens. Disease may also result from the consumption of water containing toxic levels of chemicals. Arsenic, fluoride, and nitrate are three chemicals that pose the greatest health threat to man.

Water provided for direct consumption and ingestion via food should be of a quality that does not represent a significant risk to human health. A 'zero-risk' scenario for public supplies is not achievable and evidence points to the need to define tolerable risks. Temperature, color, turbidity, odor, and taste are the most important physical properties of water in relation to the water supply. Physical, chemical and bacteria analysis is the most important determinant tests for water quality analysis. Global water quality criteria have been widely established for a number of traditional water quality variables such as pH, dissolved oxygen, biochemical oxygen demand for periods of five or seven days (BOD5 and BOD7), chemical oxygen demand (COD) and nutrients. Such criteria guide decision makers, especially in countries with rivers affected by severe organic pollution in the establishment of control strategies to decrease the potential for oxygen depletion and the resultant low BOD and COD levels. Water Quality Index (WQI) is one of the most effective arithmetic tools for a country to describe the health of water resources and create a baseline for measuring and assessing water quality. Many studies have been carried out concerning water indexes in various countries such as Canada, the United States, Egypt, United Kingdom and India in assessing the overall status of their water bodies.

Cross River State is a fast-growing state, thus there is increased demand of water for consumption. Though treated pipe borne water is supplied to the population, boreholes and surface water sources like streams, rivers etc. which are adversely affected by human activities are still in use by many. The question is, what are the effects of human activities on these water sources and how suitable are the sources for human consumption?

Two locations with human activities capable of polluting water sources namely, Akamkpa, where heavy mining activities are carried out and Lemna where the landfill for the solid waste generated in Calabar metropolis are disposed is situated, were investigated in this research.

Akamkpa is richly blessed with a lot of mineral resources. It is estimated that the area has thirty-six operating quarry sites (Berger et al., 2021). These has potential negative impact as groundwater and surface water sources in these areas can easily be degraded by contaminated runoff from effluent discharges. This can have far reaching impact on the health and life of the people living in these areas.

Calabar with an area of 157 square miles (406 km^2) and a population of 371,022people as at 2006 census *Wikipedia*, (2019), has a general dump site located in Lemna.The loss of leachate from this dumpsite and subsequent contamination of ground and surface water sources can be a major environmental problem.

Understanding the cause and source of pollution is complex and as such research on this area is challenging. To address this problem, water quality index (WQI) which is a good water quality monitoring tool, developed in recent years as an effective baseline to measure the general chemical, physical and biological characteristic of water is be employed. WQI is one of the most efficient tools used by authorities of various nations to describe the suitability for consumption of water resources and create a baseline standard for water quality.

2. Materials and methods

Due to rapid growth of population, industrialization, and urbanization, there has been intense human activities and interference with nature leading to an over-exploitation and severe pollution of natural water bodies.

Drinking water sources from Okom-Ita in Akamkpa local government and Lemna in Calabar municipal of Cross River State, Nigeria

was collected and analyzed for their quality. These arears were chosen due to the prevalence of human activities capable of polluting natural water bodies. Four sampling points were selected and their water samples were analyzed to determine the effect of human activities on water. Thirteen (13) parameters were analyzed in the laboratory which are pH, Total Dissolve Solid, total hardness, Calcium, magnesium, dissolve oxygen, biochemical oxygen demand, sulfate, nitrate, Chloride, total suspended solid, electrical conductivity and total alkalinity using a unique rating known as water quality index to determine the quality of water for human consumption.
Water sources and their labels

3. Study design

Sampling points were selected from major drinking water sources from the available surface water bodies and ground water (borehole) sources around the study area to determine the quality of water consumed as well as the effect of both industrial stone quarrying and landfill on the water sources. The samples were collected in both dry and wet seasons of the year to determine the variability in water quality. Table 3.2. shows the sampling points, location and their respective labels for ease of identification.

Table 3.2Sampling Point, Location and Sample Labels

Area	Location	Season	Sources	Approximated distance from pollution source	SAMPLE LABEL
Calabar	Lemna	Dry	Borehole	300m	B1
			Surface water	847m	S1
		Wet	Borehole	300m	B2
			Surface water	847m	S2
Akamkpa	Okom-ita	Dry	Borehole	600m	B3
			Surface water	1.600m	S3
		Wet	Borehole	600m	B4
			Surface water	1.600m	S4

4. Sampling method and procedure

After identifying the sampling points within the study area, water sample were collected from surface water and boreholes in each of the location.A clean sterile bottle was used to collect the water samples, without allowing the bottle head make contact with the tap nozzle to prevent possible contamination. The samples collected were properly stored inside a cooler to maintain same temperature and transported immediately to the laboratory for the physicochemical analysis. All water samples analysis were done using the standard analytical techniques.

a. Water quality index

Water quality index is a concept where a few essential parameters are selected and compounded into numerical rating for the evaluation of the water quality. It is aimed at turning complex water quality data into simple, understandable and useable information to the public.

Calculation of water quality index (WQI) using the Weighted Arithmetic Index method is as shown in equation (1)

$$\text{WQI} = \frac{\sum Q_1 W_1}{\sum W_1} \quad (1)$$

where W_1 relative unit weight and Q_1 is the quality rating of ithparameter for a total of n water quality parameters

The quality rating $Q1$is calculated as stated in equation (2),

$$\text{Q}_1 = \frac{(Q_{actual} - Q_{ideal}) \times 100}{V_{Standard} - V_{ideal}} \quad (2)$$

where $V\ actual$ = Actual value of water quality parameter obtained from laboratory.

$V\ ideal$ = Recommended WHO standard of the water quality parameter.

Vstandard = value of water quality

parameter obtained from standard table

[Note: $V\ standard$ for Ph =7 and for other parameters, it is equating to zero but for DO. V ideal = 14.6 mg/l].

The relative unit weight (wi) is calculated by finding the value inversely proportional to the recommended standard and value (si) for the corresponding parameter. The rating of the water quality using the above method is shown in Table 1.

Table 1: Rating of Water Quality for various WQI values.

WQI	Rating of Water Quality
0-25	Excellent
26-50	26-50 Good
51-75	Poor
76-100	Very poor
Above 100	Unsuitable for Drinking

Parameter Selection: The parameters used for the indices of water quality in this study are those used for the Global Drinking Water Index Development and Sensitivity Analysis. These parameters have been carefully selected to accurately reflect the major acceptability and health issues relating to water quality. In addition, factors including detection level and general ability for researchers and stakeholders to accurately measure the parameters in most part of the world have been considered. The parameters are presented in Table 2

Table 2: The Measured Values of the Water Quality Parameters and WHO Guideline.

S/n	**Parameter**	**S/n**	**Parameter**	**S/n**	**Parameter**
1	pH	6	Dissolve oxygen (DO)	11	Total alkalinity
2	Total dissolve solid	7	Biochemical oxygen demand (BOD)	12	Electrical conductivity
3	Total hardness	8	Sulphate	13	Chloride
4	Calcium	9	Nitrate		
5	Magnesium	10	Total suspended solid		

b. Standard Physicochemical Parameters for Drinking Water Quality

Standard permissible values and guideline for drinking water quality as describe by World Health Organization (WHO)

Table 3: Standard permissible values and WHO standard

S/N	Parameters	Standard permissible values	WHO Standard
1	pH	6.0	9.2
2	Total dissolve solid	2000	500
3	Total hardness	600	500
4	Calcium	100	200

5	Magnesium	30	0.5
6	Dissolve oxygen	5.0	6
7	Biochemical oxygen demand	5.0	6.0
8	Sulphate	150	400
9	Nitrate	6.3	50
10	Chloride	1000	600
11	Total suspended solid	10.66	1500
12	Electrical conductivity	0.139	250
13	Total alkalinity	600	200

5. Results

5.1 Laboratory Water Quality Test Results for Wet Season

Laboratory test results of water sample obtained from four different sample locations at wet season of the year 2017 in Cross River State are as shown in table 3.

Table 3: Laboratory water quality test for wet

S/n	Parameters	Dump Site (B2)	Dump Site (S2)	Quarry Site (B4)	Quarry Site (S4)
1	pH	4.06	6.04	5.76	6.12
2	Total dissolve solid	51.72	16.44	51.78	10.32
3	Total hardness	2.05	3.06	2.83	2.80
4	Calcium	0	1.71	1.50	1.42
5	Magnesium	2.05	1.35	1.33	1.38
6	Dissolve oxygen	2.06	2.25	2.36	2.80
7	Biochemical oxygen demand	6.65	6.16	5.77	6.85
8	Sulfate	4	5	0	5
9	Nitrate	6.0	4.4	4.6	2.9
10	Chloride	8.30	15.30	7.00	6.30
11	Total Suspended solid	0.2	1.7	0.2	1.2
12	Electrical conductivity	86.2	27.4	86.3	16.72
13	Total alkalinity	$2.4*10^{-13}$	$1.6*10^{-15}$	$1.7*10^{-15}$	$1.6*10^{-15}$

a. Water quality index analysis

Water quality index analysis was computed using micro soft excel to estimate the suitability of water for drinking purpose in various study areas are as shown in table 4.

Wet season

Table 4: Water quality index analyses

	Ph	TDS	TH	Ca	Mg	Do	BOD	SO_4	NO_3	Cl	TSS	E.C	TA	W_1	Q_1	W Q I
WS2	6.04	16.44	3.06	1.71	1.35	2.25	6.16	5	4.4	15.3	1.7	27.4	1.6	8.06	385.65	93.48
WS4	6.12	10.32	2.8	1.42	1.38	2.8	6.85	5	2.9	6.3	1.2	16.72	1.6	8.06	105.67	94.45

WB2	4.06	51.72	2.05	0	2.05	2.06	6.65	4	6	5	0.2	86.2	2.4	8.06	412.03	73.69
WB4	5.76	51.78	2.83	1.50	1.33	2.36	5.77	0	4.6	7	0.2	86.3	1.7	8.06	403.14	73.74

5.2 Laboratory water quality test results for dry season

Different Laboratory analysis was carried out on different water samples during the dry season and different results were gotten to ascertain if ground water from these research areas were safe for human consumption using WHO standard for safe drinking water in comparison. The result of the laboratory analysis is shown in table 5. Laboratory test results of water sample gotten from four different sample locations at dry season of the year 2019 in Cross River State.

Table 5: Laboratory water quality test results for dry season

S/n	Parameters	Dump Site (B1)	Dump Site (S1)	Quarry Site (B3)	Quarry Site (S3)
1	pH	4.46	6.24	5.73	6.50
2	Total dissolve solid	53.38	198	48.36	24.06
3	Total hardness	2.12	36.85	2.64	6.52
4	Calcium	0.26	1.96	1.64	2.82
5	Magnesium	2.46	10.45	1.26	0
6	Dissolve oxygen	1.72	1.91	2.57	2.66
7	BOD	5.57	5.24	6.29	6.51
8	sulphate	5	81	0	2
9	Nitrate	0.1	0.2	0.2	0.3
10	Chloride	5.00	15.30	7.00	6.30
11	Total Suspended solid	0.3	3.2	0.1	0.9
12	Electrical conductivity	89.3	330	80.6	40.1
13	Total alkalinity	$2.4*10^{-13}$	$1.7*10^{-15}$	$1.6*10^{-15}$	$1.8*10^{-15}$

a. Water Quality Index Analysis

Water quality index analysis was done using micro soft excel 2012 to determine the suitability of water for drinking purpose in various study area

Dry Season

Table 6: Water quality index analyses

	pH	TDS	TH	Ca	Mg	Do	BOD	SO_4	NO_3	Cl	TSS	E.C	TA	W_1	Q_1
DS1	6.24	198	36.85	1.96	10.45	2.57	5.24	81	0.2	6.3	3.2	330	1.6	8.06	435.9
DS3	6.5	24.06	6.52	2.82	0	2.66	6.51	2	0.3	6.3	0.9	40.1	1.6	8.06	292.85
DB1	4.46	53.38	2.11	0.26	2.46	1.58	5.57	5	0.1	8.3	0.3	89.3	1.8	8.06	551.05
DB3	5.73	48.36	2.64	1.64	1.26	1.62	6.29	0	0.2	7	0.1	80.6	1.7	8.06	342.9

5.3 Mean and standard deviation for surface water

Table 8: Mean, standard deviation and WHO standard for surface water

S/n	Parameters (x)	S1	S2	S3	S4	Mean $(\bar{x})$	Standard deviation	WHO Standard
1	pH	6.24	6.04	6.50	6.12	6.225	0.2009146	9.2
2	Total dissolve solid	198	16.44	24.06	10.32	62.205	90.704303	500
3	Total Hardness	36.85	3.06	6.52	2.80	12.31	16.449299	500
4	Calcium	1.96	1.71	2.82	1.42	1.9775	0.6034553	200
5	Magnesium	10.45	1.35	0	1.38	3.295	4.8132214	0.5
6	Dissolve Oxygen	1.91	2.25	2.66	2.80	2.405	0.4041864	6
7	BOD	5.24	6.16	6.51	6.85	6.19	0.693157	6.0
8	Sulphate	81	5	2	5	23.25	38.525965	400
9	Nitrate	0.2	4.4	0.3	2.9	1.95	2.0566964	50
10	Chloride	15.30	15.30	6.30	6.30	8.55	5.1961524	600
11	TSS	3.2	1.7	0.9	1.2	1.75	1.0214369	1500
12	EC	330	27.4	40.1	16.72	103.555	151.26552	250
13	Total Alkalinity	$1.7*10^{-15}$	$1.6*10^{-15}$	$1.8*10^{-15}$	$1.6*10^{-15}$	1.6	0.0957427	200

The standard deviation of Electrical conductivity, Sulphate, Total dissolve solid, Total hardness and Magnesium from the mean is high indicating that the people are at risk of taking unsafe water

5.4 Mean and standard deviation for ground water

Table 9: Mean, standard deviation and WHO standard for ground water

S/n	Parameters (x)	B1	B2	B3	B4	Mean $(\bar{x})$	Standard deviation	WHO Standard
1	Ph	4.46	4.06	5.73	5.76	5.0025	0.87286	9.2
2	Total dissolve	53.38	51.72	48.36	51.78	51.31	2.11158	500

	solid							
3	Total Hardness	2.12	2.05	2.64	2.83	2.41	0.38427	500
4	Calcium	0.26	0	1.64	1.50	0.85	0.84007	200
5	Magnesium	2.46	2.05	1.26	1.33	1.775	0.57968	0.5
6	Dissolve Oxygen	1.72	2.06	2.57	2.36	2.1775	0.36989	6
7	BOD	5.57	6.65	6.29	5.77	6.07	0.49152	6.0
8	Sulphate	5	4	0	0	2.25	2.62995	400
9	Nitrate	0.1	6.0	0.2	4.6	2.725	3.02806	50
10	Chloride	5.00	8.30	7.00	7.00	6.825	1.36228	600
11	TSS	0.3	0.2	0.1	0.2	0.2	0.08164	1500
12	EC	89.3	86.2	80.6	86.3	85.6	3.63042	250
13	Total Alkalinity	$2.4*10^{-13}$	$2.4*10^{-13}$	$1.6*10^{-15}$	$1.7*10^{-15}$	2.025	0.43493	200

6. Discussion

The results for groundwater and surface analysis showed the farther the groundwater and surface water source from any pollution source, the better the quality of the quality of water obtained from the location. The standard deviation of Electrical conductivity, Sulphate, Total dissolve solid, Total hardness and Magnesium from the mean is high indicating that the people are at risk of taking unsafe water. WQI values are above one hundred (100). The quality of water from these sources improves in the wet season though still very poor in quality with WQI values ranging from 73.69 to 94.43. this could be as a result of the flushing effect of rain water prevalent in the wet season.for surface water, EC showed the highest variability with a standard deviation value of 151.26552 while total alkalinity showed the least variability with a value of 0.957427. For ground water, EC showed the highest variability with a value of 3.630427 while total suspended solid showed the least variability with a value of 0.0816497.

7. Conclusion

The results showed that the water sources are highly unfit for drinking during the dry seasons as WQI values are above one hundred (100). Generally, the quality of water from these sources improves in the wet season though still very poor in quality with WQI values ranging from 73.69 to 94.43. this could be as a result of the flushing effect of rain water prevalent in the wet season.

Water sources, especially drinking water and potential pollution sources should be situated as far apart as possible as results showed that water pollution is directly proportional to the distance of water source from a pollution source.

References

Adelana, E.A., and Daniel. Y.P. ;(2005). Hydrochemical and electrical resistivity assessment of the impact of solid waste on groundwater at Oke-Alfa refuse dumpsite Lagos, Nigeria. Environmental Science and Engineering Technology, Vo.12, No.1, pp.5936-5946.

Bayode, S., M. Olurunfemi., and J.S.Ojo. 2012. Assessment of impact of some waste dumpsite on groundwater quality in some parts of Akure metropolis southwestern Nigeria. Pacific Journal of Technology, Vol.13, No.2, pp.528-536.

Berger, J., Minning, E., & Contractors, A. (2021). *Akamkpa Has 36 Quarries*. 1–6.

Beskow P. R., Lee S. and Lee Y., (2007), Assessment of Spatial–Temporal Patterns of Surface and Ground Water Qualities and Factors Influencing Management Strategy of Groundwater System In An Urban River Corridor Of Nepal, Journal of Environmental Management 86, 595–604.

Eni, O.O.and Ahmed S.D., (2010). Investigation of heavy metals in groundwater and surface water in the Federal Capital City of Abuja. Proceedings Annual Conference of the Nigerian Association of Hydrogeologists on Water Resources Development and Climate Change.p8.

Kowalkowski, T., Cukrowska, E. M., Mkhatshwa, B. H., & Buszewski, B. (2007). Statistical characterisation of water quality in Great Usuthu River (Swaziland). *Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering*, *42*(8), 1065–1072. https://doi.org/10.1080/10934520701418557

Ocheri, M. ., Odoma, L. ., & Umar, N. . (2014). Groundwater Quality in Nigerian Urban Areas: A Review. *Global Journal of Science Frontier Research*, *14*(3). http://journalofscience.org/index.php/GJSFR/article/view/1293

Soares, H. M. V. M., Boaventura, R. A. R., Machado, A. A. S. C., & Esteves Da Silva, J. C. G. (1999). Sediments as monitors of heavy metal contamination in the Ave river basin (Portugal): Multivariate analysis of data. *Environmental Pollution*, *105*(3), 311–323. https://doi.org/10.1016/S0269-7491(99)00048-2

Wikipedia, (2019). Wikipedia, the free encyclopedia; https://en.wikipedia.org/wiki/Akamkpa

Pruss, D.A and World Health Organization (WHO), (2000), Water Supply & Sanitation Sector Assessment Part II, WHO Press, Geneva.

World Health Organization (WHO), (2006), Guidelines for safe recreational water environments, WHO Press, Geneva.

Wikipedia, (2019). Wikipedia, the free encyclopedia;https://en.wikipedia.org/wiki/Calabar.