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Assessment of Major Water Sources in Onicha Local Government Area of Ebonyi State Nigeria Using Water Quality Index.

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Abstract
This study assessed the water quality index (WQI) of three major water sources of Stream, Borehole and Hand dug well in Onicha Local Government Area of Ebonyi State, Nigeria. It adopted standardmethod in analysing the physicochemical and microbiological properties of the water samples while utilising the weighted arithmetic water qualityindex (WAWQI) method in the calculation of the water quality index. The water samples were collected from Abaomege and Anumocha Abaomege communities in the study area. The study revealed that the borehole water source had the best water quality in the study area with a WQI value of 7.58 representing an excellent water quality status. This was followed by the stream water source with a WQI of 39.43 representing a good water quality status while the hand dug well water quality status was unfit for drinking with a WQI of 169.17. The study therefore recommended that water sources be treated adequately to an acceptable level before consumption.
Keyword: Water, Quality, Assessment, Water Sources, Water quality Index.

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I. INTRODUCTION

Water is a precious resource needed to sustain life. It is abundantly available on earth with over 70% of the earth's surface covered with water. However, the quantity and quality available for human consumption remains a global challenge. The increasing global population and rapid industrialization has resulted to high demand for water from the already inadequate fresh water sources. More people live in areas where there are water shortages. It is estimated that around 1.2billion people live in areas of physical water scarcity (UNDESA 2014). The high demand for water in areas where there is insufficient water quantity leads to water scarcity. According to UN-WATER 2018, water scarcity is water unavailability due to physical shortages or inaccessibility to water sources due to inadequate infrastructure to provide regular water supply.

Water scarcity leads to an increase in health problems to vulnerable people due to exposure to poor quality water, poor hygiene, and sanitary practices especially in Sub-Saharan Africa where there is a lack of infrastructural development (Hunter, MacDonald and Carter 2010, Mmom andMmom 2011, Tarrass and Benjelloun 2012,).

Water quality determination is key to maintaining good health especially in communities with poor water facilities. The knowledge of the quality status of water enables users and decision makers to become aware of actions to take in improving the water quality when it is poor. Water quality index is a dimensionless number that provides the quality status of water in a particular location with reference to the established rating method. This study therefore aims to determine the water quality index of water sources in Onicha LGA of Ebonyi State, Nigeria.

II. MATERIALS AND METHODS

Study Area

The study area (Onicha LGA) is in Ebonyi State, Nigeria. It lies approximately latitude 6°11'N and Longitude 7°82'E. Onicha LGA is one of the thirteen LGAs in Ebonyi State with a population of 236609 according to the 2006 national population census. Onicha LGA is also located in the southern part of the state, particularly in Ebonyi South Senatorial zone. The headquarters of the LGA is in Isu town. The people of Onicha LGA are predominantly of the Igbo ethnic group.The LGA enjoys two climatic periods of rainy and dry seasons just like the rest of the state. The average temperature in the area is 28 degC. Farming is the major occupation of the people with such crops as yam, rice, cassava, maize grown in large quantities within the study area.

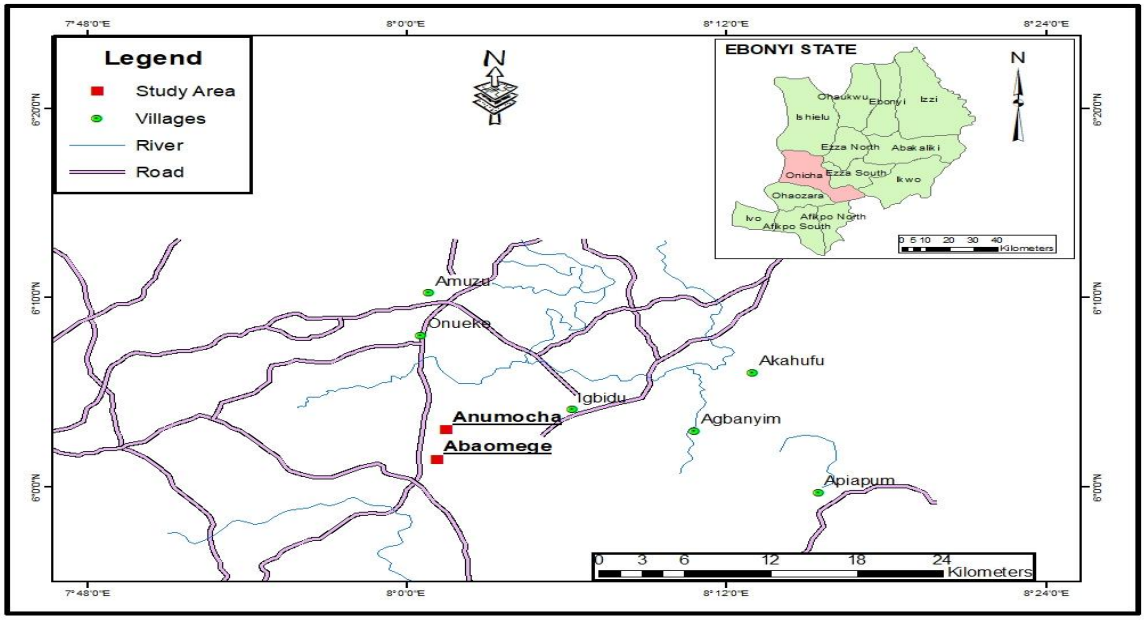

Figure 1: Onicha LGA showing communities

Sample and Sampling Method

The samples were collected from three major water sources in the study area. While stream and hand dug well samples were collected from Abaomege community, borehole sample was collected from Anumocha Abaomege community. Both communities are within the Onicha LGA.Physicochemical and microbiological analysis of the water samples were conducted to determine the water quality index. The parameters that were analysed includes pH, Electrical Conductivity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Hardness (TH), Arsenic (As), Zinc (Zn), Copper (Cu), Lead (Pb), Iron (Fe), Heterotrophic plate count (HPC) and Total Coliform (TC).The physical parameters like the pH, TDS and TSS were analysed in-situ. Other parameters like the heavy metals of Zinc, Lead, Arsenic, Copper, and Iron were analysed using the Atomic Adsorption spectroscopy. The microbiological parameters such as Total Coliform count were analysed using the Most Probable Number (MPN) – multiple tube technique for coliform enumeration.

Water Quality Index Determination

The Water Quality Index (WQI) provides a single number that makes it easy to understand water quality status. It states the overall water quality at a certain location and time using the measured values of selected water quality parameters. This study therefore adopted the use of the weighted arithmetic water quality index (WAWQI) method as was expressed by the following authors in their studies; Tiwari and Mishra (1985), Singh (1992), Patel and Desai (2006),Das, Panigrahi and Panda (2012) and Oni and Fasakin (2016). The World Health Organization (WHO) and the National Standard for Drinking Water Quality (NSDWQ) standards were used in the WQI calculation in this study. The overall WQI is expressed by the following equation:

$WQI = \sum QnWn / \sum Wn$.Therefore,

$Wn = K/Sn$

Where Wn = Unit weight for nth parameter

n = Number of water quality parameters

Sn= Standard permissible value for nth parameter (NSDWQ/WHO)

k = Proportionality constant.

$Qn = 100[Vn - Vio] / [Sn - Vio]$

Qn = Quality rating for the nth water quality parameter

Vn = Estimated value of the nthparameter at a given water sampling station
Sn = Standard permissible value of the nthparameter (NSDWQ/WHO)
Vio = Ideal value of nth parameter in pure water (i.e., 0 for all other parameters except the parameters pH and Dissolved oxygen(7.0 and 14.6 mg/l respectively)
The unit weight was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameter.
Therefore, the water quality index rating and status is stated as given below:

Table 1.0: WQIRating and Status

Water Quality Index Rating	Water Quality Status
0-25	Excellent
25-50	Good
51-75	Poor
76-100	Very poor
>100	Unfit for drinking

III. RESULTS AND DISCUSSION

The result of the water quality index calculation for the three water sources of stream, hand dug well, and borehole are shown in tables 2.0, 3.0 and 4.0 respectively. The WQI value for the stream water source is 39.43. Stream is a surface water source which is open to indiscriminate use by all living organisms including humans and animals.Anthropogenic activities impact surface water quality especially in rural areas (Khatri and Tyagi2015).Animals and humans alike use this water source for drinking and humans extend the usage for domestic activities withwaste products usually dumped intothe surface water sources, thereby contaminating it. Defecation from both humans and animals into surface water sources are common especially in rural areas, leading to increase in the spread of microbiological contaminants into thewater source (GwimbiGeorgeand Ramphalile 2019). According to WHO2017, total coliform bacteriaare excreted in the faeces of humans and animals which can occur in both sewage and natural waters.They are an indication of faecal contaminationin water sources (NSDWQ 2007).Similarly, HPC organisms can grow in water and on surfaces in contact with water. TC and HPC measurements are also used to assess the cleanliness and integrity of water systems and the presence of biofilms (WHO 2017).Microbiological contamination can also be found in ground water sources.

The hand dug well water source presented a WQI value of 169.17 as shown in table 3.0. Physicochemical parameters like Zinc, Iron, Total hardness, and Lead all exceeded the NSDWQ/WHO standard. According to the NSDWQ, there are no known health impacts from Zinc and Iron. However, the daily zinc requirement for adult men is between 15 to 20mg/day, while for Iron is between 10 to 50mg/day according to WHO 2017. Above the acceptable limits of 3mg/L for zinc and 0.3mg/L for Iron in drinking water, meant acceptability concerns for water regulatory bodies and consumers. Lead contributed significantly to the high WQI value for the hand dug well water source in the study area. This finding is consistent with several studies conducted on water quality which revealed presence of lead in water sources across Ebonyi State where the study area is located (Iroha, Ude, Okoronkwo, Ovia, Okafor andAkuma 2020, Iganga, Aneke, Ejikeme and Nweli 2015, Onuorah, Nwoke and Odibo 2018).The presence of heavy metalslike lead and Arsenic in water sources above the recommended limit is considered a health risk. Lead is carcinogenic. It is toxic to the human nervous system and equally affects mental developments in infants (NSDWQ 2007).

Table 2.0: Water Quality Index for Stream Water Source

Parameter	Sn	1/Sn	∑1/Sn	K=1/∑(1/Sn)	Wn=K/Sn	Vo	Vn	Vn/Sn	Vn/Sn * 100=Qn	Wn*Qn

pH	6.5 - 8.5	0.117647	204.90598	0.00488029	0.000574	7	6.65	0.23	23	0.013205
Cond.	1000	0.001	204.90598	0.00488029	4.88E-06	0	15	0.015	1.5	7.32E-06
Zn	3	0.333333	204.90598	0.00488029	0.001627	0	65.08	21.69333	2169.333	3.52899
Fe	0.3	3.333333	204.90598	0.00488029	0.016268	0	0.498	1.66	166	2.700425
Pb	0.01	100	204.90598	0.00488029	0.488029	0	0.00625	0.625	62.5	30.50179
Cu	1	1	204.90598	0.00488029	0.00488	0	0.0205	0.0205	2.05	0.010005
Arsenic	0.01	100	204.90598	0.00488029	0.488029	0	0.000425	0.0425	4.25	2.074122
TH	150	0.006667	204.90598	0.00488029	3.25E-05	0	187.195	1.247967	124.7967	0.00406
TDS	500	0.002	204.90598	0.00488029	9.76E-06	0	1.1265	0.002253	0.2253	2.2E-06
TSS	500	0.002	204.90598	0.00488029	9.76E-06	0	0.8005	0.001601	0.1601	1.56E-06
TC	10	0.1	204.90598	0.00488029	0.000488	0	121	12.1	1210	0.590515
HPC	100	0.01	204.90598	0.00488029	4.88E-05	0	216.9	2.169	216.9	0.010585
		204.906			1				**WQI**	**39.43**

Table 3.0: Water quality Index for Hand Dug Well Water Source

Parameter	Sn	1/Sn	∑1/Sn	K=1/∑1/Sn	Wn=K/Sn	Vo	Vn	Vn/Sn	Vn/Sn * 100=Qn	Wn*Qn
pH	6.5 - 8.5	0.117647	204.90598	0.00488029	0.000574	7	6.5	0.333	33.3	0.019119
Cond.	1000	0.001	204.90598	0.00488029	4.88E-06	0	30	0.03	3	1.46E-05
Zn	3	0.333333	204.90598	0.00488029	0.001627	0	61.58	20.52667	2052.667	3.339201
Fe	0.3	3.333333	204.90598	0.00488029	0.016268	0	0.312	1.04	104	1.691833
Pb	0.01	100	204.90598	0.00488029	0.488029	0	0.03185	3.185	318.5	155.4371
Cu	1	1	204.90598	0.00488029	0.00488	0	0.028	0.028	2.8	0.013665
Arsenic	0.01	100	204.90598	0.00488029	0.488029	0	0.0017	0.17	17	8.296488
TH	150	0.006667	204.90598	0.00488029	3.25E-05	0	97.8885	0.65259	65.259	0.002123
TDS	500	0.002	204.90598	0.00488029	9.76E-06	0	0.172	0.000344	0.0344	3.36E-07
TSS	500	0.002	204.90598	0.00488029	9.76E-06	0	0.5005	0.001001	0.1001	9.77E-07
TC	10	0.1	204.90598	0.00488029	0.000488	0	75.5	7.55	755	0.368462
HPC	100	0.01	204.90598	0.00488029	4.88E-05	0	128.9	1.289	128.9	0.006291
		204.906			1				**WQI**	**169.17**

Table 4.0: Water Quality Index for Borehole Water Source

Parameter	Sn	1/Sn	∑1/Sn	K=1/∑1/Sn	Wn=K/Sn	Vo	Vn	Vn/Sn	Vn/Sn * 100=Qn	Wn*Qn
pH	8.5	0.117647059	204.905980 4	0.00488028 7	0.0005741 5	7	6.85	0.1	10	0.00574151 4

Cond.	1000	0.001	204.9059804	0.004880287	4.8803E-06	0	18	0.018	1.8	8.78452E-06
Zn	3	0.333333333	204.9059804	0.004880287	0.00162676	0	72.535	24.17833333	2417.833	3.933240225
Fe	0.3	3.333333333	204.9059804	0.004880287	0.01626762	0	0.623	2.076666667	207.6667	3.378243138
Pb	0.01	100	204.9059804	0.004880287	0.4880287	0	0	0	0	0
Cu	1	1	204.9059804	0.004880287	0.00488029	0	0	0	0	0
Arsenic	0.01	100	204.9059804	0.004880287	0.4880287	0	0	0	0	0
TH	150	0.006666667	204.9059804	0.004880287	3.2535E-05	0	212.92	1.419466667	141.9467	0.00461827
TDS	500	0.002	204.9059804	0.004880287	9.7606E-06	0	0.3555	0.000711	0.0711	6.93977E-07
TSS	500	0.002	204.9059804	0.004880287	9.7606E-06	0	0.135	0.00027	0.027	2.63536E-07
TC	10	0.1	204.9059804	0.004880287	0.00048803	0	53	5.3	530	0.258655213
HPC	100	0.01	204.9059804	0.004880287	4.8803E-05	0	77	0.77	77	0.003757821
		204.9059804			1				**WQI**	**7.58**

In table 4.0, borehole water source indicated a WQI value of 7.58. It was the best of the three water sources, presenting a better water quality than the stream and hand dug well water sources. The borehole water source showed total hardness, total coliform and Zinc exceeding the acceptable limit. Hardness in water is predominantly caused by metallic ions of calcium and magnesium cations (WHO 2017). It is the measure of the capacity of water to react to soap with hard water requiring more soap to produce lather. According to NSDWQ 2007, just like Zinc, total hardness does not present any health impact. Though total coliform exceeded the acceptable limits, it does not present any significant negative impact on the result of the WQI due to the unit weight calculation. Ojukwu, Chukwu-Okeah and Mmom (2021), Noori (2020). Table 5.0 shows a summary of the WQI status for the three water sources. Hand dug well showed the least water status with "unfit for drinking". This is followed by the stream water source with a status of "good" while borehole water source presented an "excellent" status. WQI shows a single value that describes the water quality status of a given water source. It supports decision making by stakeholders on the actions to take concerning water consumption. Therefore, it is recommended that water sources be treated before consumption to maintain good health condition of users.

Table 5.0: Water Quality Index Summary for the Water Sources

Water Source	WQI Value	WQI Status
Stream	39.43	Good
Hand dug Well	169.17	Unfit for drinking
Borehole	7.58	Excellent

IV. CONCLUSION

The study determined that the borehole water source presented the best water quality in the study area with an excellent WQI status. This was followed by the stream water source and hand dug well with WQI status of good and unfit for drinking respectively. WQI is a description of the water quality of a given water source using a single value to enable effective decision-making concerning water usage. The study therefore recommends treatment of all water sources to an acceptable level before consumption.

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