Worldwide Journal of Variegated Studies in Multidisciplinary Research www.wjvsmr.org
Volume 0001, Issue 0001, August 2024 ISSN: 1595-8752

UNDERGROUND WATER ASSESSMENT USING WATER QUALITY INDEX METHOD. CASE STUDY: AFFISERE QUARTER IN UGHELLI, DELTA STATE, NIGERIA

Roland Owemiwe[1], Eze Q. Okoro[2]
[1](Novena University Ogume , Del state, Nigeria)
[2](University of Nigeria, Nsukka, Nigeria)

ABSTRACT ***:*** *This study assessed the quality of selected hand dug wells in Affisere quarter of Ughelli town, Delta State, Nigeria using Water Quality Index (**WQI**). Eight wells were randomly selected in Affisere quarter of Ughelli North Local Government Areal and were tested for nine (9) parameters of National Sanitation Foundation (NSF) using standard analytical procedures. WQI results indicated that the quality of the selected well water samples were medium except for sample 4 that was extremely bad. The findings also revealed that all the samples except samples 3, 4 and 6 had high coliform levels (about 91 coliform/100cm^3). This was an indication of faecal contamination substantiating the proximity of some of the wells to septic systems. The nitrate levels in all the samples exceeded the Maximum Contaminant Level (MCL) of WHO, EPA, APHA and the Nigerian Drinking Water Standards. Based on the results obtained, the quality of the well water samples was therefore not suitable for human consumption without adequate treatment. Regular monitoring of groundwater quality, abolishment of unhealthy waste disposal practices and introduction of modern techniques is highly recommended.*

KEYWORDS - *water quality, water quality index, hand dug wells, national sanitation foundation*

I. INTRODUCTION

This demand for water has led to the use of ground water not only for its wide spread occurrence and availability but also for its constituent good quality which makes it ideal supply of drinking water [UNESCO, 2000]. The supply of fresh water to Nigerians has been inadequate and forced inhabitants to resort to drinking water from wells [Dawodu, 2007]. People around the world have used ground water as a source of drinking water and even today more than half the world's population depends on ground water for survival [UNESCO, 2000]. Groundwater has long been considered as one of the purest forms of water available in nature and meets the overall demand for rural and semi-rural people. This was considered as the major source of water for human activities (consumption inclusive) especially in the rural area.

However, the large scale industrial growth has caused serious concerns regarding the susceptibility of groundwater contamination due to discharge of waste materials. Waste materials near factories are subjected to reaction with percolating rain water and therefore reach the aquifer system and as such degrade the groundwater quality. Contaminants also find their way into ground water through activities like seepage of municipal landfills, septic tank effluents etc.

Furthermore, it is of prime importance to have prior information on the quality of water resources available which will aid planning developmental projects. Ramakrishnaiah and Sadashivaiah (2010) reported that once ground water is contaminated, its quality cannot be restored. It therefore becomes imperative to protect it in other to prevent water borne diseases such as typhoid, cholera, diarrhea and dysentery which are potentially communicable [Okeke, 2003].

Water quality index is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers [Yisa and Jimoh, 2010]. It thus, becomes an important parameter for the assessment and management of surface water. WQI is defined as a rating reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of the suitability of surface water for human consumption [Atulegwu and Njoku, 2004]. Water Quality Index (WQI) provides a single number (like a grade) that expresses the overall quality of water at certain location and time based on several water quality parameters.

The study area is situated in the north central part of Delta State between latitudes N5˚31'30" and longitude E6˚00'. It is located within the equatorial region having two climate regimes: the wet season, which begins in April aand last till October and the dry season which begins in November to March.

This work assesses groundwater quality of hand dug wells within Affisere quarter of Ughelli town, Delta state using the National Sanitation Foundation (**NSF**) Water Quality Index (**WQI**). Nine parameters that include pH, Turbidity, Temperature, Total suspended solids, Phosphate, Nitrates, Biochemical Oxygen Demand, and Faecal coliform count were assessed and used to calculate the NSF Water Quality Index. Results were also compared to the APHA(1998), WHO (2001) standards for drinking water; and the Nigerian Standard for drinking water quality [(2007); NIS 554].

II. LITERATURE REVIEW

The attempts to categorize water according to its degree of purity date back to the mid-twentieth Century (Horton, 1965; Landwehr, 1974). Horton selected 10 most commonly measured water quality variables for his index including Dissolved Oxygen (DO), pH, Coliform, specific conductance, alkalinity and chloride. The index weight ranged from 1to 4 and the index score was obtained with a linear sum aggregation function. The function consisted of the weight sum of the sub-indices divided by the sum of the weights and was multiplied by two coefficients M1 and M2 , reflecting temperature and obvious pollution respectively.

Horton's pioneering effort has been followed up by several works to formulate various WQI's and their use has been strongly advocated by agencies responsible for water supply and control of water pollution Bhargave D.S 1983, Bolton 1978, Deutsch (2003).

Turgut (2005) made an attempt to design a rudimentary social accounting system which would measure the costs and impact of pollution control efforts and applied that index on an illustrative basis to data on several streams in Alabama, USA. Like Horton's index, it had decreasing scale, with values expressed as a percentage of perfect water quality corresponding to 100%.

Another multiplicative water quality index specifically designed for decision making was developed by Ajayi (2011), using index method introduced by Brown et al (1970), has also introduced to changes to Delphi method.

Lately, Brown and co-workers presented a WQI similar to Horton's index (Brown et al 1972). He proposed multiplicative form the index where weights to individual parameters were assigned based on a subjective opinion based on the judgment and critical analysis of the author. The weight assigned reflected parameters significance for a use and had considerable impact on the index. Later on, similar indices have been formulated by different authors.

Various researchers have considered similar approaches which brought changes to the methodology depending on the usage and parameters under consideration. Prati et al (1971) considered 13 different parameters of equal weight in their system. Sidhu and Warner (2003). Values of these parameters are rated from 0 to 13 with values more than 8 denoting heavy pollution. Afia Zia (2006).

III. METHODOLOGY

Eight wells were randomly selected in Affisere quarter of Ughelli town, Delta State, Nigeria. The locations of the sampling points were spread within the length and breadth of the community. All samples were collected same day and kept in two litres rubber bottles, which was previously washed with 10% HNO_3 and 1:1 HCl for 48 hours. The rubber bottles were labeled and immediately few drops of HNO_3 were added in order to prevent loss of metals, bacterial and fungal growth. Temperature, turbidity, and pH of water samples were also measured at the time of collection.

The eight well water samples, collected in triplicates were analyzed for nine parameters: pH, Turbidity, temperature, Total suspended solids, phosphate, nitrates, Biochemical oxygen demand, and Faecal coliform count. Water quality index was calculated from the point of view of suitability of the water for human consumption as seen below. The Water Quality Index (WQI) was calculated using the National Sanitation Foundation (NSF) water quality index. This index has been widely field and applied to data from a number of different geographical areas all over the world to calculate WQI for various water bodies.

Mathematical expression for NSF WQI is given by

$$\text{NSF WQI} = \sum_{i-1}^{p} W_i Q_i \quad \text{.....................} (1)$$

where Q_i is the sub-index for i_{th} water quality parameters;
W_i is the weight in terms of importance associated with i_{th} waters quality parameter; and
p is the number of water quality parameters.

IV. RESULTS AND DISCUSSION

The physico-chemical properties obtained for each sample are presented in Table 1.

Table 1. Results of the Physico-Chemical Properties for the Eight Well Samples Investigated

Sample	Dissolved Oxygen (%sat)	Faecal Coliform (count /100cm^3)	pH	Biological Oxygen Demand (mg/l)	Temperature (^{0}C)	Nitrates (mg/l))	Phosphate (mg/l)	Turbidity (NTU)	Total Suspended Solids (mg/l)
1	5.51	24	5.84	4.42	28.30	4.20	0.015	27.00	18
2	6.40	59	6.66	2.94	29.32	1.10	0.006	4.38	14
3	4.92	0	6.1	1.71	29.20	0.002	0.001	3.25	3
4	5.08	0	5.81	3.84	27.60	3.10	0.003	16.96	8
5	6.31	8	6.5	3.42	31.00	1.20	0.002	6.10	15
6	5.12	0	6.3	2.30	29.00	1.02	0.003	2.30	4
7	5.68	5	6.34	2.32	28.00	0.05	0.0015	0.32	0
8	5.88	91	6.76	4.20	30.42	1.50	0.002	8.81	15
Source: Authors Fieldwork, 2013									

From Table 1, the coliform count/100 cm3 of the investigated samples revealed that apart from sample 3, 4 and 6 which showed zero count, others have coliform count as high as 91/100 cm3 count which could probably due to contamination of faecal origin. These values are above the minimal contaminant level (MCL) recommended value of 0/100 cm3 sample. Another plausible reason for this occurrence may be due to the fact that most of the wells were unprotected without lids and concrete linings. The sampling environments were located very close to septic systems and refuge dump sites. Hence such samples which had high coliform count were not fit for drinking because its potential risk of cholera, diarrhoea and other associated diseases.

The pH results showed that only sample 1 and 2 were below the tolerable limit of the Nigerian Drinking Water Standards, APHA and WHO standards of 6.5 - 8.5. This means that they were slightly acidic, soft and corrosive. Drinking water with a pH level above 8.5 indicated that the water was hard. Hardness did not pose a health risk, but could cause aesthetic problems, such as difficulty in getting soap and detergent to foam and lowering efficiency of electric water heaters. All the samples were highly turbid.

Table 2. Weighted mean for the nine WQI parameters

Factors	**Weight (W_i)**
Dissolved Oxygen	0.17
Feacal coliform	0.16
pH	0.11
Biochemical Oxygen Demand	0.11
Temperature Change	0.10
Phosphate	0.10
Nitrate	0.10
Turbidity	0.8
Total Suspended Solid	0.7

Table 3: Results of the samples and their Water Quality Indexes (WQI)

Samples	**WQI**	**Quality**
1	50.88	Medium
2	61.31	Medium
3	52.91	Medium
4	44.03	Bad
5	61.07	Medium
6	55.33	Medium
7	63.21	Medium
8	59.11	Medium

Table 4: Water Quality Index Legend

Range	Quality
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very Bad

The results exceeded the Nigerian Drinking Water Standard Maximum Permissible Limit of 5 NTU, APHA's MCL of 0.5 NTU, and Environmental Protection Agency MCL of 1 NTU with sample 1 having as high as 17 NTU. High turbidity indicated high risk to disease causing microorganisms such as viruses, parasites and some bacterial and carriers of variety of materials such as pesticides, heavy metals. The suspended particles absorb heat from the sunlight, making turbid waters become warmer, and so reducing the concentration of oxygen in the water. The nitrate level of the investigated samples was low. They fall below the MCL for the Nigerian Drinking water standards, WHO, and APHA which was 10 mg/l NO3-N or 50 mg/l NO3. Temperature in all the samples was found to be high. High temperature in drinking waters leads to low oxygen because the rate of dissolution of gases in water decreases with increasing temperature and low oxygen in water affects the taste and other aesthetic property of water. Dissolved

Oxygen in all the samples exceeds 2 mg/l or 1.5 % Sat which was the MCL of the Nigerian Drinking Water Standard and the WHO. Oxygen is necessary in sufficient quantity to give the taste required in water. Total Suspended Solids in the samples did not exceed the 500 mg/l U.S. EPA and secondary standard. This was probably because there are no activities such as construction that will allow the quick influx of sediment into groundwater via overland flow.

The suspended particles clouding the water may be due to such inorganic substances as clay, rock flour, silt, calcium carbonate, silica, iron, manganese, sulfur, or industrial wastes. Again, the clouding may be caused by organic substances such as various microorganisms, finely divided vegetable or animal matter, grease, fat, oil, and others.

Phosphorous levels in the well samples were negligible with none exceeding 0.1 which is far below the MCL of the Nigerian Drinking Water Standard and the World Health Organization (WHO).

The overall WQI indexes according to the NSF WQI legend showed in Table 4 and revealed that only sample 4 was bad and all other samples were of medium quality.

V. CONCLUSION

From the information deduced from this study using water quality index, sample 4 was found to be bad while other were within the medium range. This was due to the environments in which these well samples were situated, some were very close to septic systems and 90% of the wells were without cover, equally some of them do not extend above the ground. These water samples were not fit for drinking without proper treatment.

References

1. Akintola F.A. (1982). Geology and geomorphology of Nigeria in maps, Hodder and Stoughton, London, pp. 45.

2. Afia Zia, Hamidullah shah, Saleemullah, Mohammad Noman and Shaffisiddiqi, (2006). Evaluation of heavy metals and pathogenic micro-organisms in drinking of Peshawar valley. Asian Environ. Technol 10: 08-09

3. Ajayi, A (2011). Physiochemical properties of ground and surface water. Department of science laboratory Technology, Delta state polytechnic, otefe-oghara pp 31-33.

4. APHA (1998). American Public Health Association, standard methods for the examination of water and wastewater, 20th ed., 1220 pp.

5. APHA, AWWA, WEF (1998). Standard Methods for the Examination of Water and Waste waters, 20th Edition American Public Health Association, Washington, D.C. 233 pp.

6. Atulegwu P.Uand J.D Njoku (2004) The impact of biocides on the water quality, Int. Res. J. Eng. Sci. Technol., 1, p. 47-52.

7. Bhargave D.S. 1983. Use of water quality index for river classification and zoning of Ganga River, Environmental poll. Serv. B: chem.. phys. 6, 51-76

8. Brown et al (1970), (1972). The water quality index, national sanitation foundation (NSF), Environmental monitoring and Assessment pp38, 59.

9. Deutsch (2003), Effect of iron on drinking water, the royal society of chemistry, UK. pp 30

10. Dawodu M.O. and A. Ipaiyeda. (2007). Evaluation of groundwater and stream quality characteristics in the vicinity of a batter factory in Ibadan, Nigeria, Res.J.Applied Sci., 2, 1071-1076.

11. Fasunwon O., Olowofola J., Akinyemi O., Fasunwon B., and O. Akintokun (2008). *Contaminants Evaluation as Water Quality Indicator in Ago-Iwoye, South-western, Nigeria*, African Physical Review, 2, p. 12.

12. Nigeria Industrial Standard. (2007). *Nigerian Standard for Drinking Water Quality* NIS 554, 14.

13. Okeke C.O., and A.H. Igboanua (2003). *Characteristics and quality assessment of surface water and groundwater recourses of Akwa Town, Southeast*, Nigeria. J. Niger. Assoc. Hydrol. Geol., 14, p. 71-77.

14. Okuo J.M., Okonji E.I., and F.R. Omeyerere. (2007). *Hydrophysico-chemical assessment of the Warri coastal aquifer, southern Nigeria*, J. Chem. Soc. Nig., , 32, p. 53-64.

15. Ramakrishnaiah C.R., Sadashivaiah C., and G. Ranganna (2009). *Assessment of water quality index for the groundwater in Tumkur Taluk*, Karnataka State India, 6(2), p. 523-530

16. Suleiman F.B. (2006). *Analysis of Some Sachet Water Samples in Katsina, Nigeria*, Chem Class Journal of Chemical Society of Nigeria, Zaria Chapter, 3, p. 42-44.

17. Tyagi P.D., Buddhi R., Chaudhary K.C., and Sawhney R.L. (2002). *Degradation of ground water quality in industrial area in India*, Ind. J. Environ. Protect., 20, p. 174-181.

18. UNESCO (2000). *Groundwater UNESCO environmental development briefs no*. 2, 14

19. WHO (2001) *Guidelines for Drinking Water Quality. Addendum: Microbiological agents in drinking water*. World Health Organization, Geneva, 2001

20. Yisa J., and Jimoh T. (2010). *Analytical Studies on Water Quality Index of River Landzu.* American Journal of Applied Sciences, 7(4), p. 453-458.