WASH IMPLICATIONS OF UNPROTECTED LANDFILL ON GROUNDWATER QUALITY: A CASE STUDY OF UMUERIM, NEKEDE, IMO STATE, NIGERIA

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ABSTRACT

WASH related infections in Nigeria at large can be attributed partially to incessant and unlicensed disposal of hazardous waste in unprotected sanitary landfills. However, the contaminant plume of this potential point source of waste depletes the quality of groundwater sources, thus rendering it unsafe for consumptive purposes. Empirically, the WASH drive towards accessing quality water per capita has provided a push for the evaluation of water quality for boreholes located around a waste disposal site along Umuerim, Nekede, Owerri-West Local Government area of Imo state, Nigeria. The objective of this study is to monitor the physicochemical properties of boreholes over a period spanning five years, as well as developing the water quality index in the study area. In this collaborative work between The Federal Polytechnic Nekede, Owerri, Imo State Ministry of Environment and Umuerim Community, representative sample volumes of 225 cl of water were continuously collected from each of three different boreholes within the vicinity of the dump site. The water samples collected were tested for pH, phosphate, temperature, conductivity, nitrate, turbidity, E-coliform, DO, and BOD. From the test results obtained, the Water Quality Index (WQI) of an overall representative sample evaluated using National Sanitation Foundation Water Quality Index (NSFWQI) is 65.769, which represents water of medium quality. When the individual test results were rated with WHO and Federal Environmental Protection Agency (FEPA) standards for potable water, the values obtained indicate that the water was of a poor quality and can be attributed to leachate infiltration from the landfill. Thence, further treatment is recommended to ensure potability. Imo State Ministry of Environment and Federal Polytechnic Nekede, Owerri should collaborate and proffer an appropriate waste disposal method, a protected sanitary landfill for waste disposal. However, efforts at sensitizing the community on affordable water treatment options for the various households are already yielding results.

Keywords: aquiferous zone, borehole, dissolved oxygen, dump site, leachate, landfills, plumes, potability, quality index, WASH.

1 INTRODUCTION

Water is an integral aspect of life. It is only a satisfactory supply that must be made uncommittedly available to all. Man's daily activities revolve around water which include domestic, pharmaceutical, and diverse industrial and agricultural activities. As an outstanding priority, acceptable water quality must be met for consumptive purposes. Water quality encompasses its distinctive features such as chemical, radiological, physical and biological characteristics [1]. It is a measure of the conditions of water relative to the requirements of one or more biotic species. However, the paucity of good quality water in the globe remains a major contributing factor to high morbidity and mortality rates especially among children [2]. World Health Organization (WHO) recommends minimum daily water consumption of 2.7–3.7 l per capita per day. Current events have revealed that people manage water with far less than recommended standard [3].

Undoubtedly, this could be because of non-renewal of water sources, drought, desertification and contamination of water sources. Incessant and unlicensed disposal of solid waste in unauthorized sanitary landfill pose prompt pollution hazard to groundwater sources [4]. Several locations in Nigeria have experienced this challenge including Umuerim Nekede

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area of Imo State. The groundwater of this zone of interest is unduly exposed to this point pollution source. WASH related infections in this zone can be attributed partially to these unsafe practices. WASH is the acronym for water, sanitation and hygiene [5].

The contaminant plumes percolate into the aquifer through leachate infiltration and successfully disperse transversely within the aquiferous zone [6]. In line with World Health Organization (WHO), about 80% of all the world's diseases are caused by water. The use of befoul water and poor sanitary conditions result to increased vulnerability to water – borne diseases including diarrhoea, which leads to deaths of more than 70,000 citizens annually [7].

Assiduous research shows that 73% of this sickness along enteric disease burden is associated with WASH [6]. Interestingly, the contaminant alters the water quality and from experience, the aquifer is present at about 25 m beneath the earth surface. The landfill site is an abandoned borrow pit and extends to nearly 20 m depth. Several boreholes in this area are drawing from this threatened aquifer with resultant exposure to several water-borne challenges. Due to the growing concern that quality water has become scarce in the area taking cognizance of the future generation, it became imperative to evaluate water quality of this zone. The objective of this study is to monitor the physicochemical properties of boreholes by sampling over a period spanning five years (2014–2018). These selected physicochemical properties of the average values would then be transformed into water quality index using National Sanitation Foundation Water Quality Index Method.

2 METHODOLOGY

The methodology used to carry out this groundwater quality monitoring in the pollution prone zone is The National Sanitation Foundation Water Quality Index.

2.1 Study area

The study area covers the dump site located in Nekede along the Federal Polytechnic Nekede-Ihiagwa road, Imo State Nigeria with chainage(4+473), taking Naze junction as the starting point (0+000). It is bounded by longitude 60° 50'E and 70° 04'E and latitude 50° 23'N and 50° 30'N. The landfill site is an abandoned borrow pit and extends to nearly 20 m in depth. The dump site is shown in Fig. 1.

Figure 1: Dump site in Nekede along Ihiagwa road.

2.2 Sample collection

The water samples were collected from three different boreholes around the dumpsite. The first sample was collected 10 m away from the dumpsite, while, the second and third samples were collected 20 m and 30 m away from the dumpsite respectively. Water samples were collected with sterilized plastic containers. These samples were collected in the months of July and September during peak rains. This is the time that will yield more leachate in the landfill. Sampling data, place and time were recorded on the sample containers and were taken to the laboratory for analysis in accordance with the standard methods for examination of water and wastewater [10].

2.3 The National Sanitation Foundation Water Quality Index method

National Sanitation Foundation Water Quality Index method classified water quality into nine quality parameters according to the degree of purity by using the most commonly measured water quality variables [8]. The water quality data are recorded and transferred to a weighting curve chart where the numerical values of Qi are obtained. Mathematically, NSFWQI is expressed below:

$$\text{NSFWQI} = \sum_{i=1}^{n} W_i I_i \tag{1}$$

where NSFWQI is National Sanitation Foundation Water Quality Index, I_i is sub-index for i^{th} water quality parameters, W_i is the weight associated with i^{th} water quality parameters, n is the number of water quality parameters.

3 RESULTS AND DISCUSSION

3.1 Results

Table 1 below was used for water quality rating as per National Sanitation Foundation Water Quality Index method according to WHO and FEPA recommended standards for potability.

Table 1: Water quality rating as per National Sanitation Foundation Water Quality Index method. *(Source: Liou et al. [4].)*

WQI Value	Rating of water quality	Grading
91 – 100	Excellent water quality	A
71 – 90	Good water quality	B
51 – 70	Medium water quality	C
26 – 50	Bad water quality	D
0 – 25	Very bad water quality	E

3.2 Discussion

Water quality index of a water body is established from various important physicochemical parameters. From Table 2, the final index value after the analysis is 65.769 which falls within the index assessment range of 51–70 or Category C (Table 1).The various physicochemical parameters for calculation of water quality index are presented in column 2 of Table 2.

The result shows that the average temperature for borehole water is 27.1°C, which is above acceptable limits. Turbidity value was found to be 10 NTU quite above the limit set by WHO and FEPA standards, as can be seen in Table 3. The turbidity affects clarity of water and presents an unpleasant look of the water. It is also indicative of the presence of microorganisms. Total dissolved solids had average value of 350 mg/l. The TDS content of eater affects its palatability and is also related to hardness. It has been observed that TDS concentration below 1,000 mg/l is usually acceptable to consumers [7].

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Table 2: Average test values and interpolated Q values of water quality parameters.

Test parameters	Average test result (5 years)	Interpolated q-values	Weighting factors	NSFWQI
DO	0.52 mg/l	98.60	0.17	16.762
Phosphate	0.15 mg/l	96	0.10	9.600
BOD	11.2 mg/l	29.60	0.11	3.256
E – Coliform	184 cfu/100 ml	38.28	0.16	6.125
TDS	350 mg/l	70	0.07	4.9
Nitrate	0.52 mg/l	95.92	0.10	9.592
pH	5.86	42.6	0.11	4.686
Temperature	27.1°C	12.48	0.19	1.248
Turbidity	10NTU	76	0.10	7.6
Total				65.769

Note: The weighting factors are predefined standard factors for each test parameters.

Table 3: Comparison of experimental results with WHO and FEPA Standards.

Parameters	Units	Average test result (5 years)	WHO STD	FEPA
DO	mg/l	0.52	100	NS
Phosphate	mg/l	0.15	NS	>50
BOD	mg/l	11.2	5	NS
E – Coliform	cfu/100 ml	184	MNBD	NS
TDS	mg/l	350	NS	NS
Nitrate	mg/l	0.52	10	10
pH		5.86	6.5–8.5	6.5–8.5
Temperature	°C	27.1	27	25
Turbidity	NTU	10	≤ 5	5

NS – not specified; ND – not detected; MNBD – must not be detected.

Average value was obtained by calculating the mean for the three (3) samples:

$$\text{NSFWQI} = \sum_{i=1}^{n} W_i I_i = 65.769.$$

The pH expresses the extent of acidity or alkalinity of a sample. It was found to have an average value of 5.86. This is an indication of weak acidity. The soil type may be such that it permits dissolution of materials which bring about slight acidity in the sample. The pH was found to be lower than the WHO and FEPA range of 6.5–8.5 for borehole waters. Nitrate was determined to be 0.52 mg/L. The presence of nitrates in a water sample could be due to inorganic fertilizers, plants, animal decomposition and hazardous wastes which may have percolated the soils over time [11].

The presence of phosphate in a water source could be attributed to discharges related to contaminant plumes [12]. The average value of dissolved Oxygen (DO) was 0.52 mg/L. This parameter is important for the sustenance of aquatic lives [12].

The results of parameters in borehole water after collection are presented in Table 2. For the parameters discussed, the average results show a rise in temperature (27.1°C), Turbidity (10 NTU), and total dissolved solids (350 mg/L). This may be attributed to the fact that the particles in the water had no opportunity for settlement. The average values of nitrate (0.52 mg/L) and Phosphate (0.15 mg/L) which expressed lower concentrations were within acceptable limits. The reason for this is also not clear but it could be that soluble particles that are chemical in nature could be well distributed in the body of water and possibly interact with the water molecules.

However, the BOD value obtained was way higher than the standard WHO values and this is further supported by the low DO value. This is an indication that biological activity is on-going within the aquiferous zone.

The implication therefore is that borehole water collected during the rainy season presented a better water quality monitoring for drinking. The overall water quality index obtained for the boreholes indicates a medium water quality, using NSFWQI rating [9]. This value is corroborated by the unacceptable values of the parameters obtained in the tests conducted.

4 CONCLUSION

Water quality index is a good means of predicting the condition of any water source at a particular time. The most definitive of contaminant distributions requires the installation of monitoring wells and the collection and analysis of water samples. Monitoring usually continues over a period of several years and requires several sampling rounds. A water analysis would typically include the major cations and anions (routine analysis) and packages of organic and metal analyses, depending on the type of contamination involved. The study was aimed at developing WQI to monitor the current water quality in the bid to continuously monitor that unprotected landfill. Most of the individual quality parameters fell below acceptable standards set by the WHO and FEPA. Assessment of WQI is necessary for control and treatment of contaminated water supplied to homes from boreholes within the affected area. From this study, it is therefore established that the borehole waters should be subjected to some level of treatment prior to use for drinking purpose.

RECOMMENDATIONS

Achieving Sustainable Development Goal in terms of safe drinking water in the zone before 2025 requires assiduous strategies. Considering the peculiarities of the location, there are no alternative water supply options since the nearby surface water source has not been adequately harnessed.

Development and implementation of an appropriate waste disposal system in the area will help to prevent leaching of contaminant plumes into the groundwater sources. Strengthening the capacity of National and Sub-national bodies to develop and implement WASH policies, strategies and guidelines will underpin the drive towards safeguarding family health. Sensitization of local dwellers on low cost sanitary systems is needed to eliminate open waste disposal of any nature. Sensitization of households on practical materials and guidance for water disinfection techniques will go a long way to reduce WASH related infections.

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