

ASSESSING THE NUTRIENT CHARACTERISTICS AND COLIFORM STATUS OF SHALLOW HAND DUG WELL WATER IN OKPUNO-AWKA, SOUTHEASTERN NIGERIA

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Abstract

Shallow hand dug well water is the most essential source of water supply for human consumption in Okpuno-Awka area. This study was carried out to qualitatively assess the natural water sources in the Okpuno-Awka area of southeastern Nigeria with a view of measuring the impact of physico-microbial contaminants from Okpuno-Awka dumpsite leachates. Water samples were collected from forty (40) shallow hand dug wells across the study area and analyzed using various physical and microbial parameters. The results of physicochemical parameters of the hand dug wells revealed a pH range of 5.4 to 6.9 while Electrical Conductivity varied between 84 and 369 $\mu\text{S}/\text{cm}$ sequentially for each sampled point. The Total Dissolved Solids (TDS) for hand dug well samples ranged from 104 to 789mg/l. On the other hand, the results of the microbial parameters show concentration values of between 28.9mg/l and 21.51 mg/l for biochemical oxygen demand (BOD), 48mg/l and 20.11mg/l for chemical oxygen demand (COD) and 53 mg/l and 29 mg/l for total viable count (TVC) in the surface waters and groundwater respectively. The results indicate that all the measured physical parameters are within the WHO (2012) acceptable limits for drinking water. The waters sources in the study area are also classified as fresh waters based on the proportion of TDS. All the nutrients' parameters, except for the Phosphate, have values which are within the WHO desirable limits. The highest concentrations of Coliform were recorded in the dumpsite leachate samples. Better wastewater management methods are desirable to improve water quality in the study area.

Keywords: nutrient, coliform, physicochemical, water, contaminant.

1. INTRODUCTION

In several regions in Southern Nigeria like the Okpuno-Awka area, shallow had dug well water remains the most significant source of water supply for human consumption. This is ascribed to the accessibility of these water sources along with the inconsistent and insufficient supply or not having piped water in such areas (Ifediegwu et al., 2019). Having a steady and drinkable water supply is crucial for the development of a stable society, fostering economic growth and maintaining public health. Despite the fact that portable water is crucial to human living, 1.1 billion people worldwide depend

on contaminated drinking water from hand dug wells and surface waters. Additionally, approximately 2.4 billion individuals globally lack proper hygiene (WHO, 2008). According to WHO and UNICEF (2004), in sub-Saharan Africa, not less than 44% of the entire population (approximately 320 million people) lack access to portable and adequate water supply.

Even though shallow hand dug well water seem to be merely adequate for drinking and household use, such water frequently demonstrates significant seasonal fluctuations in microbial and physicochemical quality, especially during rainy seasons being attributed to serious deterioration (Jain, 1998). Although the exact causes of contamination are unknown, they are frequently attributed to faecal pollution from on-site hygiene facilities like pit toilets or the presence of faeces in the surrounding area, which clearly connect to surface flow to cause faecal contamination. Indicator bacteria, such as *Escherichia coli* and faecal coliforms, are frequently used in wealthy nations to assess faecal pollution and potential declines in water quality, and this technique is now being expanded to underdeveloped nations.

Diseases spurred via drinking of tainted water, and not maintaining hygiene, are the main cause of death among children globally, after respiratory disorders (WHO, 2011). Over five million people die each year from diarrheal sickness, which is still a leading cause of death for children. In underdeveloped nations, diarrheal illness is thought to be responsible for 80% of all illnesses (UNESCO, 2007; WHO, 2008).

Thus far, in Southern Nigeria, studies (e.g., Onwuka et al., 2019; Onwuka et al., 2004; Ovwah and Hymore, 2001; Omotoyinbo, 2007; Nnodo and Illo, 2002) has focused on microbial and physicochemical analyses of portable water sources from urban areas. According to these researches, several shallow hand dug well waters that supply some urban areas in Southern, Nigeria are neither lined, nor covered, and are mostly sited very close to waste dumps and pit toilets, therefore making the water extremely vulnerable to microbial contamination (Omotoyinbo, 2007). This research investigates the impact of leachate migration on surface water, and groundwater quality near the closed landfill with the aim of evaluating microbial and physicochemical quality of shallow hand dug wells water in Okpuno-Awka area, Southern, Nigeria.

2. METHODOLOGY

2.1. Location of the study area

The study area lies between latitudes 6°11'00" and 6°17'00" N and longitudes 7°02'00" and 7°07'00" E. It covers an estimated land area of approximately 72.82/km. Figure 1 is a map of Anambra State showing the study area. Awka has a relatively higher population since it houses Okpuno-Awka town and is the Anambra State headquarter. The study area is rightly located in the humid tropical rainforest belt with two distinct

well-defined seasons, the wet (raining) and dry seasons. The wet season begins from April to July and then a short break known as August break; a short-wet season form mid-August to early November, and the dry season however, begins from late November to early March all year round. The area is generally characterized by flat topography due to the underlying geology with very few elevated points ranging from 120m to 213 m above sea level. The Araka River is the largest river passing through the study area. It originates in Abagana through Amawbia, where it flows northwards through the study area to the Ajali River. The study area is part of Niger Delta Basin whose rocks are Upper Cretaceous in age (Reyment, 1965). Okpuno-Awka is mainly underlain by Imo Formation that is made up of blue-grey clays, shallow-marine shale and sandstone, limestone and calcareous sandstone (Figure 2). It is estimated to be approximately 1,000m thick and is dated to the Paleocene to lower Eocene period (Reyment, 1965; Ekwenye et al., 2020).

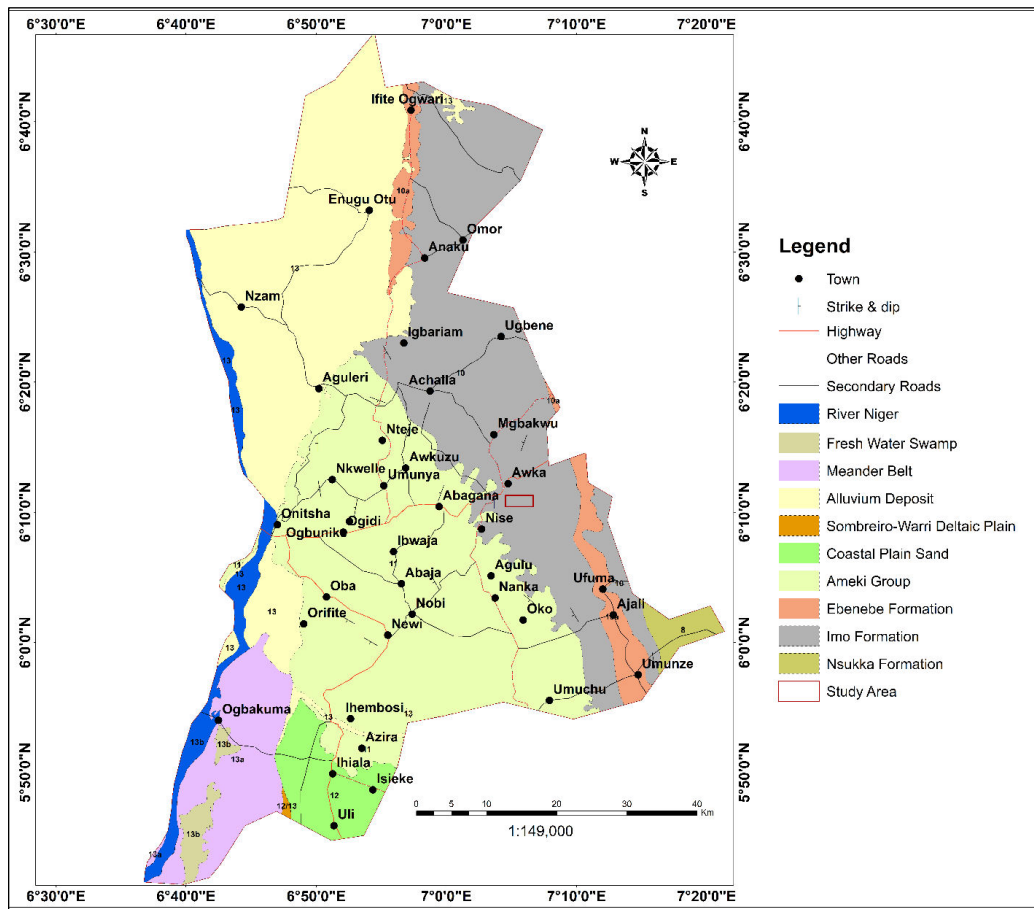


Figure 1: Map of Anambra State showing the study area.

2.2 Geology of the study area

The study area falls within the Niger Delta Basin whose rocks are Upper Cretaceous in age. Lithological units mapped in the area are (from the oldest to the youngest), Imo Formation (Paleocene) and Nanka Formation (Eocene). Figure 2 below shows the geologic map Awka and environs. The type locality of these formations has been described by Reymont 1965.

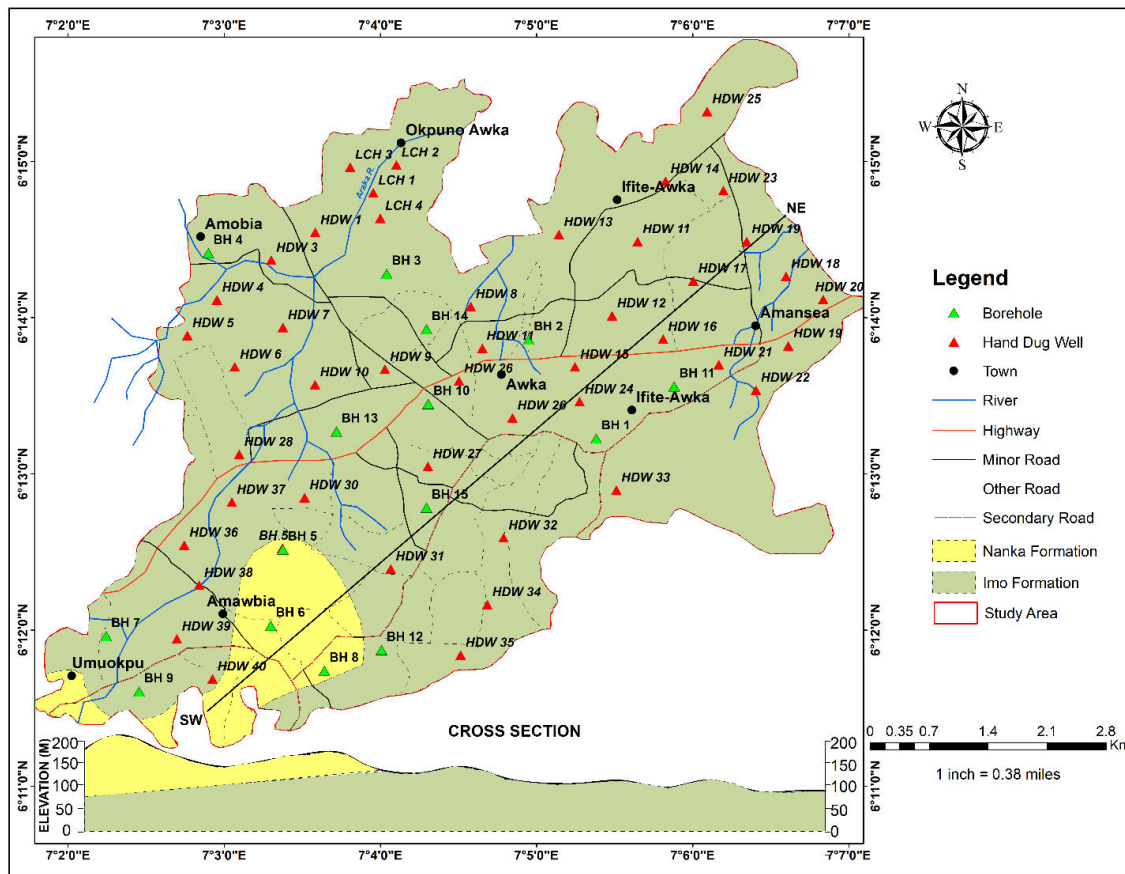


Figure 2. Geological map of the study area showing the sampled points

2.3 Water sample collection

Water samples were collected from shallow hand dug wells in 1litre polythene bottles which were labelled accordingly, pre-washed thoroughly with dilute nitric acid and rinsed three times with the water to be sampled at time of sampling before being filled to brim. The collected samples were acidified with concentrated hydrochloric acid for cation analyses. Acidification was done to prevent precipitation of unstable metals that easily change their form when exposed to different environmental conditions and also to prevent adsorption of some metals onto the surface of the container. For collection,

preservation and analysis of samples, the standards established by APHA (2005) were adhered to. The samples were stored in an ice box and transported to University Nigeria's Water laboratories for chemical analyses within 24 hours of sampling.

2.4 Analysis of Physicochemical Parameters

Physicochemical properties of water samples including pH, temperature, electrical conductivity, turbidity, dissolved oxygen, biological oxygen demand, and total dissolved solids were assessed. The pH, electrical conductivity, total dissolved solids and temperature were measured using Hanna environmental probe (H Series). The turbidity was determined by nephelometry method (Association of Official Analytical Chemists, 1985).

Dissolved oxygen (DO) levels of the samples was investigated using a DO meter (Hanna H19146-04). Thereafter, the sample was then incubated in darkness at 25°C for 5 days and the DO₅ readings taken. The disparity between the initial DO (DO₁), and the DO₅ gave the BOD of the sample (Association of Official Analytical Chemists, 1985). To evaluate the total suspended solids (TSS), constant weight of the filter paper (dried in an oven at 150°C for one hour) was taken and used for filtering a specific volume of the water sample. The filter paper was then cooled in a desiccator for one hour. The final weight of the filter paper was determined and the findings documented (ASTM, 2012). The determination of total hardness was performed according to ASTM, (2012). A precise volume of sample was measured into 250 ml dried conical flask. 2 ml ammonia buffer solution and 1 tablet of total hardness indicator were introduced into the sample and mixed. The solution was then titrated with 0.02 N EDTA solution to a blue colour end point from which the total hardness values were calculated and documented. Salinity levels in the sample were assessed according to ASTM (2012). A specific volume of the sample was introduced into a 250 ml dried conical flask. 2-3 drops of K₂CrO₄ were added to the flask, mixed and titrated with 0.1N AgNO₃ to a brick – red end enabling calculation of values which were then recorded. Nitrate analysis was performed using ASTM (American Society for Testing and Materials International, 2012) method using a uv-vis spectrophotometer (DR/3800) at a wavelength of 500 nm. Nitrite concentration in the sample was determined via the same spectrophotometer but at wavelength of 507 nm. The concentration of sulphate and phosphate in the water samples were analyzed by spectrophotometer (DR/3800) at wavelength of 450nm. Analysis program number for sulphate and phosphate was chosen and the wavelength configured to 450nm. The spectro UV -Vis 2500 spectrophotometer was utilised for the determination of Oil and Grease content within the water samples according to ASTM method at the wavelength of 425nm. Bicarbonate levels were measured by titration employing phenolphthalein and methyl orange as indicator. Cations concentrations were estimated (Na⁺, K⁺, Mg²⁺ and Ca²⁺) via Single channel emission, Flame Photometer (JENWAY -PPF7).

2.5 Nutrients and coliform analysis

For these analyses, membrane filtration method was used to examine Total Bacteria Count, Total Coliform Count and Total Viable Fungal. In membrane filtration method, known volumes of water were filtered through each of two membrane filters consisting of a cellulose compound with a uniform pore diameter of 0.45 μm in situ within 60 s after sampling in accordance with internationally recognized standards techniques (American Public Health Association (APHA), 2005). The bacteria were retained on the surface of the membrane filter. Both membranes were incubated in situ in a potable incubator for preliminary period at relatively low temperature of 30°C and then changed to a higher temperature, one at 35°C or 37°C and one at 44°C. Acid producing colonies were counted after a total incubation time of 18 hours.

3. RESULTS AND DISCUSSION

Statistical summary of physicochemical, nutrients and coliform properties of shallow hand dug well water in Okpuno-Awka is presented in Tables 1 and 2. Also, the results obtained from laboratory analyses were compared with those of the WHO (2017) and NIS (2007). The results indicated that approximately 38% of the water quality parameters possessed a broader range of standard deviation which reveals that water quality from the analyzed shallow hand dug wells might be influenced by its proximity to waste dumps or pit toilets, therefore making the water extremely vulnerable to contamination.

3.1 Physicochemical characteristics of the shallow hand dug wells

The physicochemical ion concentrations in the waters are well below the maximum desired limits of the WHO and NIS (Table 1). However, majority of the samples have pH values of the allowable limits of 6.5 - 8.5, making the waters slightly acidic in composition. The slightly acidity nature of the waters could be associated to the leaching of dissolved constituent from Okpuno-Awka dumpsite, leakage from septic tanks and use of chemical fertilizer in the area. The EC varies from 84 $\mu\text{S}/\text{cm}$ to 369 $\mu\text{S}/\text{cm}$ with mean of 267 $\mu\text{S}/\text{cm}$ and standard deviation of 100.45 $\mu\text{S}/\text{cm}$. The TDS varies from 104 mg/l to 786 mg/l. Freeze and Cherry (1979) describe waters with TDS values less than 1,000 mg/l as freshwater and those with TDS values more than 1,000 mg/l as saline. Clearly, freshwater bodies exist in the study area.

Table 1. Statistical summary of analyzed physicochemical parameters in Okpuno-Awka Shallow Hand Dug Wells

Parameters		Total Samples	No.	Min.	Max.	Mean	STD	WHO (2017)	NIS (2007)
Physical	pH	40		5.4	6.9	6.0	0.409	6.5–8.5	6.5–8.5
	EC (µS/cm)	40		84	369	267	100.45	600–1000	1000
	TDS (mg/L)	40		104	786	563	209	1000	1000
Chemical	Ca ²⁺ (mg/L)	40		16.5	32.2	25.5	3.623	75	-
	Mg ²⁺ (mg/L)	40		14.9	49.1	26.3	7.571	50	0.20
	Na ⁺ (mg/L)	40		32	280	98	44.989	200	200
	HCO ₃ ⁻ (mg/L)	40		21.6	91.8	31.85	15.656	250	-
	Cl ⁻ (mg/L)	40		63	125	90.5	13.242	200–300	250
	SO ₄ ²⁻ (mg/L)	40		68.13	103.94	89.23	8.223	250	100
	PO ₄ ⁻ (mg/L)	40		2.160	7.314	6.177	1.269	75	75
	NO ₃ ⁻ (mg/L)	40		4.96	10.64	8.28	1.064	50	50

3.2 Nutrients Characteristic of the Water Samples

While nutrients are vital for plant growth, an excess of nutrients in water can lead to numerous adverse health and environmental consequences. Excessive amounts of nutrients—such as nitrogen and phosphorus—in water can set off a chain of events known as *eutrophication*. Algae thrive on the nutrients, multiplying, spreading, and giving the water a green hue. Algae blooms can cause unpleasant odours, block sunlight, and sometimes release toxic substances. As algae die and decompose, bacteria consume the oxygen dissolved in the water, depriving fish and other aquatic species essential oxygen supply. If oxygen level drops too low, the water becomes hypoxic, making it impossible for life to thrive and creating a "dead zone".

Results of the analyzed nutrient and coliform characteristic of the water parameters obtained from the study area summarized in Table 2.

Table 2. Showing the nutrients characteristics and coliform status of the water samples from the study area

ID	Nitrate-Nitrogen (mg/l)	Phosphate (mg/l)	Total Bacteria Count x10 (cfu/100ml)	Total Coliform Count x10 (cfu/100ml)	Total Viable Fungal x10 (cfu/100ml)	Sample Location
LCH 1	18.64	10.304	56.3	0.85	2.24	Okpuno-Awka
LCH 2	18.2	10.347	47.7	1.09	1.96	Okpuno-Awka
LCH 3	17.32	9.217	58.0	1.10	1.99	Okpuno-Awka
LCH 4	17.92	9.043	64.9	0.60	2.21	Okpuno-Awka
HDW 1	7.13	6.137	50.1	0.60	0.19	Okpuno-Awka
HDW 2	8.6	6.791	42.5	0.70	0.06	Amobia
HDW 3	8.42	7.228	52.9	0.50	0.05	Amobia
HDW 4	8.62	6.254	40.3	0.80	0.06	Amobia
HDW 5	8.22	5.724	10.5	0.10	0.01	Amobia
HDW 6	9.4	7.314	36.1	0.30	0.91	Amobia
HDW 7	8.16	5.698	16.5	0.20	1.21	Amobia
HDW 8	8.42	6.324	26.9	0.80	0.01	Awka
HDW 9	8.54	6.334	22.3	0.90	0.91	Awka
HDW 10	5.94	4.264	13.2	0.90	0.34	Awka

HDW 11	8.4	2.324	10.7	1.00	1.64	Awka
HDW 12	7.62	6.843	11.3	0.70	1.6	Awka
HDW 13	7.52	5.043	26.9	0.30	1.02	Ifite-Awka
HDW14	9.64	6.431	56.5	0.50	1.01	Ifite-Awka
HDW 15	7.46	2.16	37.1	0.40	1.66	Awka
HDW 16	8.43	6.672	51.8	1.02	0.91	Amansea
HDW 17	8.51	7.368	22.4	0.98	0.24	Amansea
HDW 18	8.32	6.264	10.9	0.22	0.5	Amansea
HDW 19	8.12	5.364	19.7	0.32	0.34	Amansea
HDW 20	9.3	6.318	12.4	0.27	0.49	Amansea
HDW 21	8.46	5.348	31.2	0.95	0.24	Amansea
HDW 22	8.62	6.318	38.1	1.00	0.05	Amansea
HDW 23	8.24	6.454	12.3	0.13	0.81	Ifite-Awka
HDW 24	8.3	6.865	29.9	0.20	0.91	Ifite-Awka
HDW 25	8.56	5.168	14.9	0.10	0.68	Ifite-Awka
HDW 26	8.64	6.564	11.8	0.26	0.86	Awka
HDW 27	8.15	5.397	10.0	0.30	0.99	Awka
HDW 28	9.66	6.644	17.3	0.29	0.09	Amawbia
HDW 29	8.26	5.634	20.3	0.40	0.08	Awka
HDW 30	8.43	6.312	19.9	0.60	0.91	Amawbia
HDW 31	8.14	6.64	28.5	0.45	1.02	Amawbia
HDW 32	5.64	4.304	41.3	0.32	1.21	Ifite-Awka
HDW 33	8.2	2.347	36.2	0.12	1.33	Ifite-Awka
HDW 34	7.32	6.217	30.1	0.45	0.99	Ifite-Awka
HDW 35	7.92	4.043	29.4	0.22	0.81	Ifite-Awka
HDW 36	10.64	5.434	40.7	0.31	0.61	Amawbia
HDW 37	5.80	6.112	43.1	0.29	0.58	Amawbia
HDW 38	4.96	4.623	29.5	0.16	0.61	Amawbia
HDW 39	8.12	5.057	19.9	0.31	0.99	Amawbia
HDW 40	7.94	5.008	20.7	0.28	0.21	Amawbia

Nitrate-Nitrogen (NO₃-N)

Various farming practices contribute to elevated nitrate levels in ground and surface water (Nas and Berktay, 2006). Methemoglobinemia, also known as blue baby syndrome can occur due to reaction of nitrite and iron interaction with red blood cells, impairing oxygen transport (Onyekwelu and Aghamelu, 2019). Children under a certain age are particularly vulnerable to the effects of nitrate contaminated water. The range of Nitrate-Nitrogen prescribed by WHO is 45 mg/l. Concentrations of NO₃-N in the dumpsite leachate samples spanned from 17.32 mg/l (LCH3) to 18.64 mg/l (LCH1). Shallow hand dug wells are comprised of NO₃-N concentrations ranging from 5.64 mg/l to 10.64 mg/l. High Nitrate-Nitrogen observed at the dumpsite leachates could be as result of organic wastes dumped at the dumpsite. The spatial variation of NO₃-N in the leachate and water samples of the study area is given in Fig. 3.

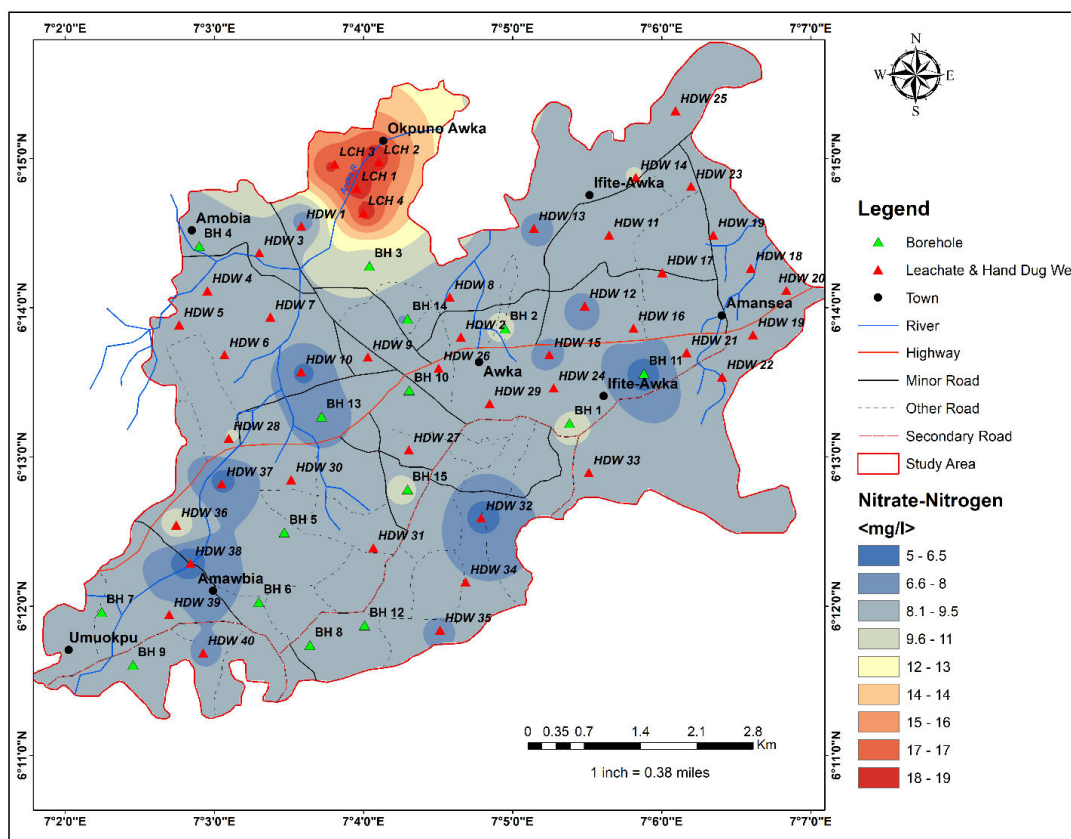


Figure 3. Spatial distribution of Nitrate-Nitrogen in water

Phosphate (PO_4^{2-})

Phosphate rich industrial and sewage waste can contaminate water sources. Excessive fertilizer is the primary source of phosphate in surface waters with runoff. Increased phosphate levels can result in muscle damage, respiratory issues and kidney failure (Nyamangara et al., 2013). The standard limit for phosphate is 0.1 mg/l (WHO, 2008). The values of PO_4^{2-} observed in the leachate samples spanned between 9.043 mg/l to 10.347 mg/l with highest value recorded at LCH2 while shallow hand dug wells vary from 2.16 mg/l to 7.368 mg/l. Among the leachate, and shallow hand dug well samples analyzed, Okpuno-Awka leachate (LCH2) recorded highest PO_4^{2-} concentration which may be as result of decomposition of organic materials in the dumpsite. The spatial variation of PO_4^{2-} in the leachate and water samples of the study area is given in Fig. 4.

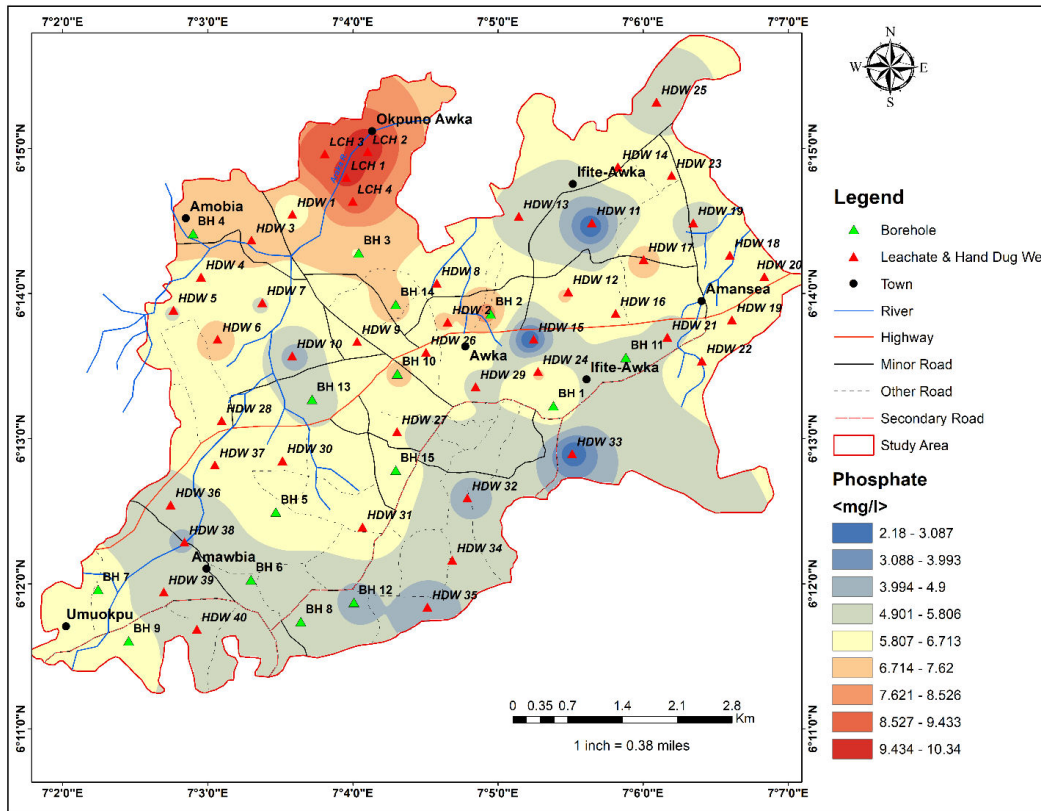


Figure 4. Spatial distribution of Phosphate in water

Total Bacterial Count (TBC)

Total bacterial counts are bacteria that are always resident in the digestive tracts of animals and humans, and are found in their wastes (WHO, 2008). The concentration of total bacterial count (TBC) varied from 47.7×10 (cfu/100ml) (LCH 2) to 58.0×10 (cfu/100ml) (LCH 3) and in shallow hand dug well samples, TBC fluctuated between 10×10 (cfu/100ml) (HDW 27) to 56.5×10 (cfu/100ml) (HDW 14) (Figure 5). Shallow hand dug well samples showed significantly lower values in comparison to dumpsite leachate water samples. High concentration of TBC in the dumpsite leachate water samples suggests inadequate disposal of sewage and wastewater from households, septic tanks and latrines at the dumpsite.

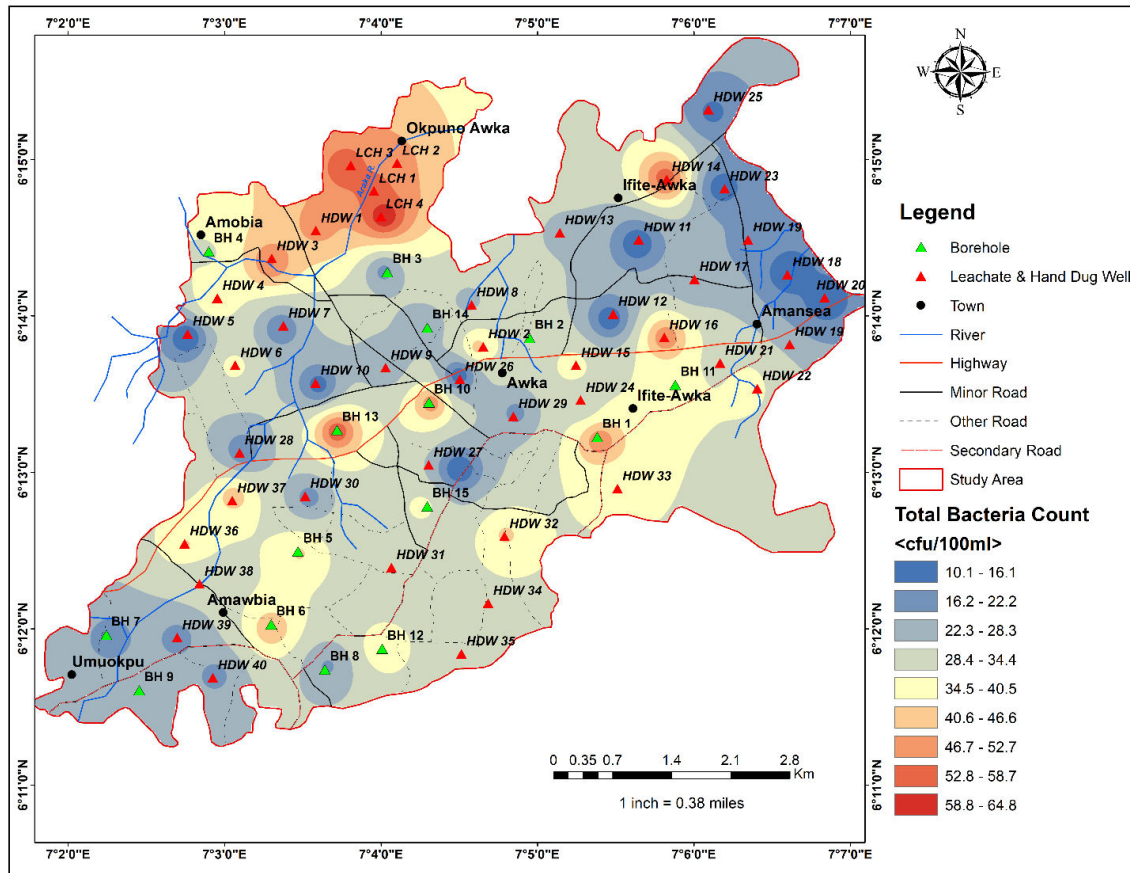


Figure 5. Spatial distribution of Total Bacteria Count in water

Total Coliform Count (TCC)

The detection of this indicator organism in drinking water sources signals potential water-borne issues, posing a significant risk to human health and a matter of serious concern. In the study area, the values of total coliform count obtained from the dumpsite leachate samples varied from 0.60×10 (cfu/100ml) (LCH 4) to 1.10×10 (cfu/100ml) (LCH 3), while in shallow hand dug well samples, Total Coliform Count measured between 0.10×10 (cfu/100ml) (HDW 5) to 1.02×10 (cfu/100ml) (HDW 16) (Figure 6). The high concentrations of TCC in the dumpsite leachate sample is likely linked to the co-disposal of domestic sewage, coloured organic matter (humic substances) and industrial wastes at the dumpsite.

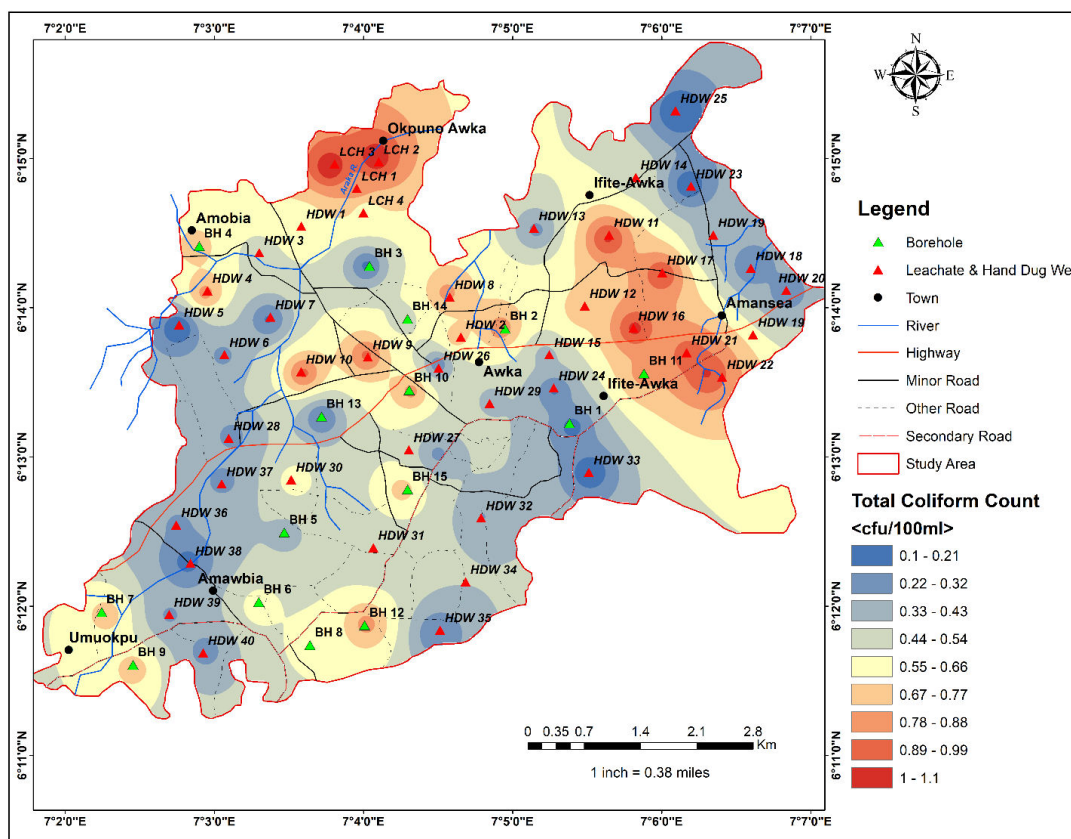


Figure 6. Spatial distribution of Total Coliform Count in water

Total Faecal Coliform (TFC)

This provides a quantitative assessment of microbial presence such as bacteria, yeast and mold in a sample. A high concentration of TFC in water is usually attributed to poor quality. In the study area, the analysis of total faecal coliform (TFC) revealed a substantial difference in TFC between the samples in which dumpsite leachate sample ranged from 1.96×10 cfu/ml (LCH 2) to 2.24×10 cfu/ml (LCH 1) (Figure 7) whereas, shallow hand dug well samples vary between 0.01×10 cfu/ml (HDW 5 and HDW 8) to 1.66×10 cfu/ml (HDW 15). These values are lower than the 0.50×10 cfu/ml recommended by World Health Organization (WHO, 2017) and Nigeria Industrial Standard (NIS, 2007) allowable limit for safe drinking water. Large amounts of total faecal coliform (TFC) in the leachate samples suggests the presence of organic materials such as latrine waste, leftover food from hotels and various animal feeds dumped at the site. The spatial variation of total faecal coliform in the leachate and water samples of the study area is given in Fig. 7.

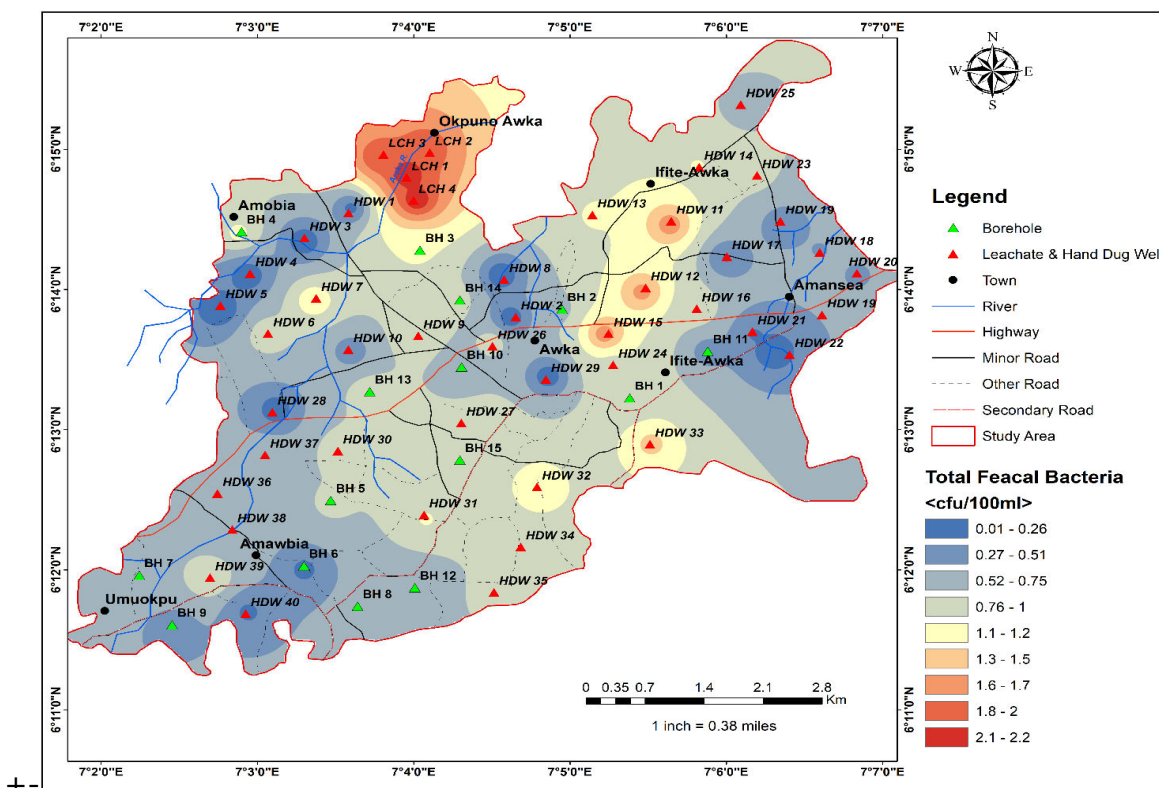


Figure 7. Spatial distribution of TFC in water

CONCLUSION

The following have been established by this study:

1. The Okpuno-Awka dumpsite produces leachates which contain micro-organisms that have been released to the surrounding surface and groundwater.
2. The groundwater in the area are slightly acidic to neutral with electrical conductivity values revealing that the area is centrally made up of fresh water.
3. The coliform content of the leachates may have affected the quality of the natural water sources within the Okpuno-Awka metropolis.
4. The groundwater are not suitable for consumption because of the proven high coliform content and activity in them.

Therefore, to avoid any form of health risks associated with the intake of such contaminated water, it is recommended that the water should be treated properly before use. Also, there is need for an immediate action by the government to line the dumpsite at the base to stall any further infiltration of leachates into the ground and surface waters.

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