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Water resources utilization in Yenagoa, Central Niger Delta: Environmental and health implications

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This study examined the groundwater in relation to the surface water quality analysis in Yenagoa Local Government Area (LGA), Bayelsa State, Central Niger Delta. Groundwater samples were collected from the boreholes in the randomly selected communities namely Igbogene, Akenfa, Edepie, Swali, Biogbolo and Amarata and surface water samples from a point in Epie Creek that flows through the selected communities. These water samples were subjected to laboratory analyses for pH, conductivity, colour, total dissolve solids (TDS), total hardness, alkalinity, nitrate, sulphate, calcium, lead, copper, Total hydrocarbon content (THC), total coliform and faecal coliform. Descriptive and inferential statistics were used to analyze and explain the results obtained. The result showed that the pH in the study area was slightly alkaline with a mean of 7.3. The conductivity level of groundwater in the area was not significantly varied but it was very high in Igbogene and Biogbolo communities with 35 and 31 µS/cm, respectively. The mean values of considered parameters in groundwater were generally lower than that of surface water but the values in both were lower than the standard of World Health Organization (WHO). The results also showed that 78.3% agreed that water from both groundwater and surface water is used for domestic purpose while 18.3% for agricultural purpose. The study revealed that there is a positively direct and strong relationship between water treatment and occurrence of diseases. It is recommended that residents be educated more on groundwater and surface water management and laws should be promulgated as well as adoption of participatory management approach.

Key words: Water resources, water quality, utilization, health, Yenagoa.

INTRODUCTION

The principal goal of water management globally is to assess and manage the water resources that are available and this is not in exemption of the developing countries. Where groundwater is the main resource, management requires information on both its quantity and quality (Mogheir and Singh, 2002).

Groundwater continues to serve as a reliable source of water for a variety of purposes, including industrial and domestic uses and irrigation. The use of generally high quality groundwater for irrigation (which is largely indifferent to water quality) dwarfs all other uses (Burke, 2002). In many developing country settings, reliance has turned to dependency and the establishment of perceptions of access and use that are intensely 'private', irrespective of the legal status of the groundwater. However, groundwater and the aquifers that host it are inherently vulnerable to a wide range of human impacts.

Thus, it is understood that ground water has its standard quality and has a tendency to be altered or polluted. The pollution of groundwater can occur naturally, from environmental changes or from certain circumstances and activities carried out by man in relation to

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the location of the ground water. Christopherson (2002), stated that pollution can enter ground water from industrial injection wells(wastes pumped into the ground), septic tanks outflow, seepage from hazardous-waste disposal sites, industrial toxic wastes sites, agricultural residues (pesticides, herbicides, fertilizers) and urban waste landfills. All of the sources mentioned above are basically man-made. In groundwater pollution, the main contaminants of concern include petroleum hydrocarbon, chlorinated organic compounds such as trichloroethylene, heavy metals such as lead, zinc and chromium, and inorganic salts (Philip et al., 1994). Many of these industrial operations release various toxic heavy metals in their effluents. Heavy metals, arsenic and arsenical compounds, barium, chromium, lead, cadmium, manganese, zinc and other harmful materials are known to cause serious health effects (Nwankwoala et al., 2011). Such health problems includes but not limited to acute and chronic respiratory problems, gastro-intestinal tract infection, cardiovascular system disorder, nervous system and blood forming organisms malformation cases of skin and lung cancer (Horsfall et al., 2001). These harmful heavy metals and compounds have been found in traces as well as substantial amount in ground water. The presence of these substances is due to industrial activities and solid waste disposal sites located within such areas. Various households and industrial waste material are found in many urban wastes open dumps and garbage sites. Usually they are not properly located and managed, and as such the liquid residue (leachates) percolates into the soil, after heavy rainfall or long-term decomposition resulting in the pollution of ground water.

The effect of the contact and consumption of contaminated and polluted groundwater has become a cause for concern. This resultant effects of serious health issues and diseases to man, plant and animal developmental/growth problem is on the increase. Therefore, this has prompted the need for a study on the spatial analysis of quality of groundwater in Yenagoa LGA of Bayelsa State, Nigeria. The study therefore focused on the use of certain water variables to evaluate the spatial variations in the quality of groundwater in the study area. Nevertheless, the study suggested participatory ways to improve and maintain good quality of water in the study area.

Study area description

The study area is Yenagoa Local Government Area (LGA) in Bayelsa State of Nigeria. Yenagoa LGA is geographically located within latitudes 4°49'N and 5°23'N and also within longitudes 6°10' E and 6°33'E (Figure 1). Yenagoa City is the capital of Bayelsa State and Yenagoa LGA. The city is located on the banks of Ekole Creek and Nun River; the latter being one of the major river courses making up the Niger Delta’s river. Yenagoa is the northernmost city of the state’s significant population centre.

The study area is located within the lower delta plain believed to have been formed during the Holocene of the Quaternary period by the accumulation of sedimentary deposits. The major geological characteristic of the state is sedimentary alluvium. The study area is situated within the lower floodplain of the Niger Delta. The terrain is poorly drained with a gentle syncline to the Gulf of Guinea in a southwestern direction. The majority of the communities within the local government area are completely surrounded by wetlands, generally less than 5 m above sea level. The main features of the drainage in the study area include the meandering of the distributaries of the River Niger which makes the place to be prone to flooding.

METHODS OF STUDY

This study involved the collection of water samples from boreholes and surface water within Yenagoa metropolis. Water samples were collected from across the study area (Figure 1) into a well-labeled polyethylene bottles. Meanwhile, the bottles were properly rinsed with the borehole water to be sampled before the main water sample was collected in order to avoid contamination. Water samples were then subjected to laboratory analyses on both the cations and anions. The considered cations include Calcium (Ca^{2+}), while the anions included Cholride (Cl^-), Nitrate (NO_3^-) and Sulphate (SO_4^{2-}). Properties such as electrical conductivity (EC) pH, temperature and total dissolve solids (TDS) were also considered for the analysis. Analyses of groundwater samples were carried out using standard methods as suggested by the American Public Health Association (1989). Cations were analysed using an Atomic Absorption Spectrophotometer (Perkin – Elemer AAS 3110) and the anions using the Colorimetric method with the UV- Visible Spectrophotometer WPAS 110. Standard solutions and blanks were commonly run to check for possible errors in the analytical procedures. Generally, the processes controlling the chemistry of the groundwater were identified by the systematic study of hydro-chemical data. Global Positioning Systems (GPS) was used to record the latitudes and longitudes of each sampled borehole. The location readings enabled the mapping of the boreholes in their respective locations.

RESULTS

Table 1 present the physico-chemical characteristics of groundwater in Yenagoa in relation to the World Health Organization (WHO) standard. It was discovered that pH of the ground water was slightly acidic in Akenfa and Edepie while it was slightly alkaline in the remaining sampled communities. The pH fell within the standard of WHO (2006). The conductivity level of ground water in the area was not significantly varied but it was higher in Igbogene and Biogbolo communities with 35 and 31 µS/cm conductivity level respectively than in other areas. Total dissolved solid (TDS) was highest in Igbogene with 66 mg/L while the least (48 mg/L) was experienced in Akenfa. The TDS in Yenagoa was generally low. These

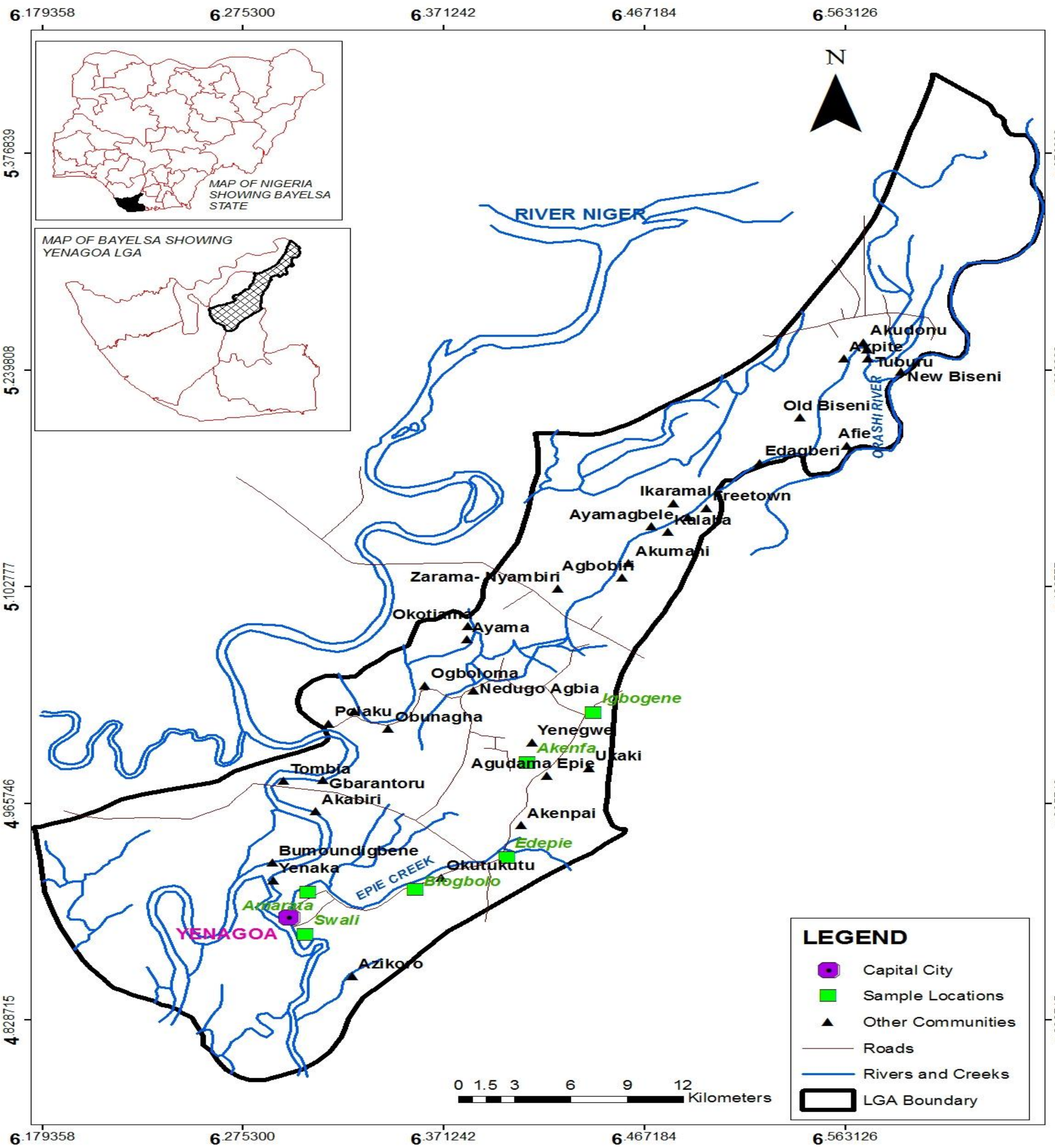

Figure 1. Map of Yenagoa showing sample locations (Inset: Map of Niger Delta showing the study area).

values are indications of the inland nature of the aquifers and their remoteness from the influence of any saline intrusion. The hardness of the borehole water samples ranged between 34 and 154 mg/L. The highest was observed in Amarata with 154 mg/L and the least in Edepie with 34 mg/L. The hardness was 137 and 133 mg/L in Igbogene and Akenfa, respectively. The hardness still generally was lower than the WHO standard. The levels observed could be attributed to the leaching of hardness enhancing species like magnesium and calcium, which abound in the soil systems around the study area. The alkalinity of the water samples

Table 1. Physico-chemical and microbiological quality of groundwater samples.

S/N	Parameter	Units	Igbogene	Akenfa	Edepie	Swali	Biogbolo	Amarata	WHO limits
1.	pH		7.8	6.8	6.9	7.5	7.6	7.7	6.0 – 8.5
2	Conductivity	µS/cm	35	23	26	24	31	23	-
3	TDS	mg/L	66	48	55	50	61	63	500
4	Colour	Pt-Co	0.2	0.3	0.8	0.4	0.6	0.5	5.0
5	Total hardness	mg/L	137	133	34	68	51	154	500
6	Alkalinity	mg/L	25.3	22.4	28.0	20.4	21.6	30.2	128-136
7	Chloride (Cl)	mg/L	4.3	3.2	5.6	1.5	1.8	2.4	250
8	Nitrate (NO_3)	mg/L	0.03	0.005	0.01	0.02	0.08	0.05	10
9	Sulphate (SO_4)	mg/L	0.002	0.009	0.004	0.006	0.050	0.005	25
10	Lead (Pb)	mg/L	0.001	0.013	0.013	0.00	0.01	0.02	0.05
11	Iron (Fe)	mg/L	0.003	0.073	0.005	0.035	0.055	0.001	0.3
12	Copper (Cu)	mg/L	0.016	0.092	0.002	0.105	0.077	0.006	1.0
13	Calcium (Ca)	mg/L	0.023	0.011	1.22	0.54	0.056	0.95	25
14	THC	cfu/ml	15000	30000	400000	10000	200000	30000	400
15	Total coliforms	cfu/100 ml	200	100	500	400	800	100	<10
16	Faecal coliforms	cfu/100 ml	30	27	65	30	85	70	0

Table 2. Sources of water.

Source	Igbogene		Akenfa		Edepie		Swali		Biogbolo		Amarata		Total	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Ground water	16	80.0	18	90.0	18	90.0	16	80.0	20	100.0	19	95.0	107	89.2
Rainfall	1	5.0	1	5.0	1	5.0	0	0.0	0	0	1	5.0	4	3.3
Surface water	3	15.0	1	5.0	1	5.0	4	20.0	0	0	0	0	9	7.5
Total	20	100.0	16	100.0	20	100.0	20	100.0	20	100.0	20	100.0	120	100

N.B: F- Frequency, % - Percent.

ranged between 20.4 and 30.2 mg/L and the highest was observed in Edepie. Similarly, the alkalinity level of ground water in the study area was lower to WHO standard (2006). The range for the chloride concentration in the study area was between 1.5 and 5.6 mg/L. The concentration was 4.3 mg/L in Igbogene while it was 3.2, 5.6 and 1.5 in Akenfa, Edepie and Swali, respectively. The nitrate concentration was generally low in Yenagoa. The concentration ranged between 0.005 and 0.08 mg/L. The sulphate concentration level in Igbogene was 0.002 mg/L, Akenfa 0.009 mg/L, Edepie, 0.01 mg/L and Amarata with 0.005 mg/L. These values were generally less than WHO (2006) which is 10 mg/L. Calcium was also generally low in the water samples in Yenagoa. It is therefore observed that Igbogene borehole had a value of 0.023 mg/L, 1.22 mg/L in Edepie and 0.56 mg/L in Amarata.

The concentration of heavy metals (Lead, Iron, and Copper) in groundwater samples revealed that they were generally moderate. Lead ranged between 0.00 and 0.02 mg/L while Iron ranged between 0.001 and 0.073 mg/L and Copper which ranged between 0.0016 and 0.105. Total Hydrocarbon (THC) was quite high in the study area whereby the highest was discovered in Edepie with 400,000 cfu/100 ml. The concentration of THC in Yenagoa was generally higher than the WHO standard. The total coliform was highest in Biogbolo with 800 cfu/100 ml and the least in both Akenfa and Amarata with the concentration of 100 cfu/100 ml. Mean while, these values were higher than the WHO standard. The fecal coliform in the water samples in the study area were generally high.

Sources of water in the study area

The result of the analysis from the respondents in the study area reveals the sources of water that people depended upon. Table 2 and Figure 2 reveal that 80% of total respondents depended on ground water in Igbogene while 5 and 15% depended on rainfall and surface water respectively in the same community. In Akenfa and

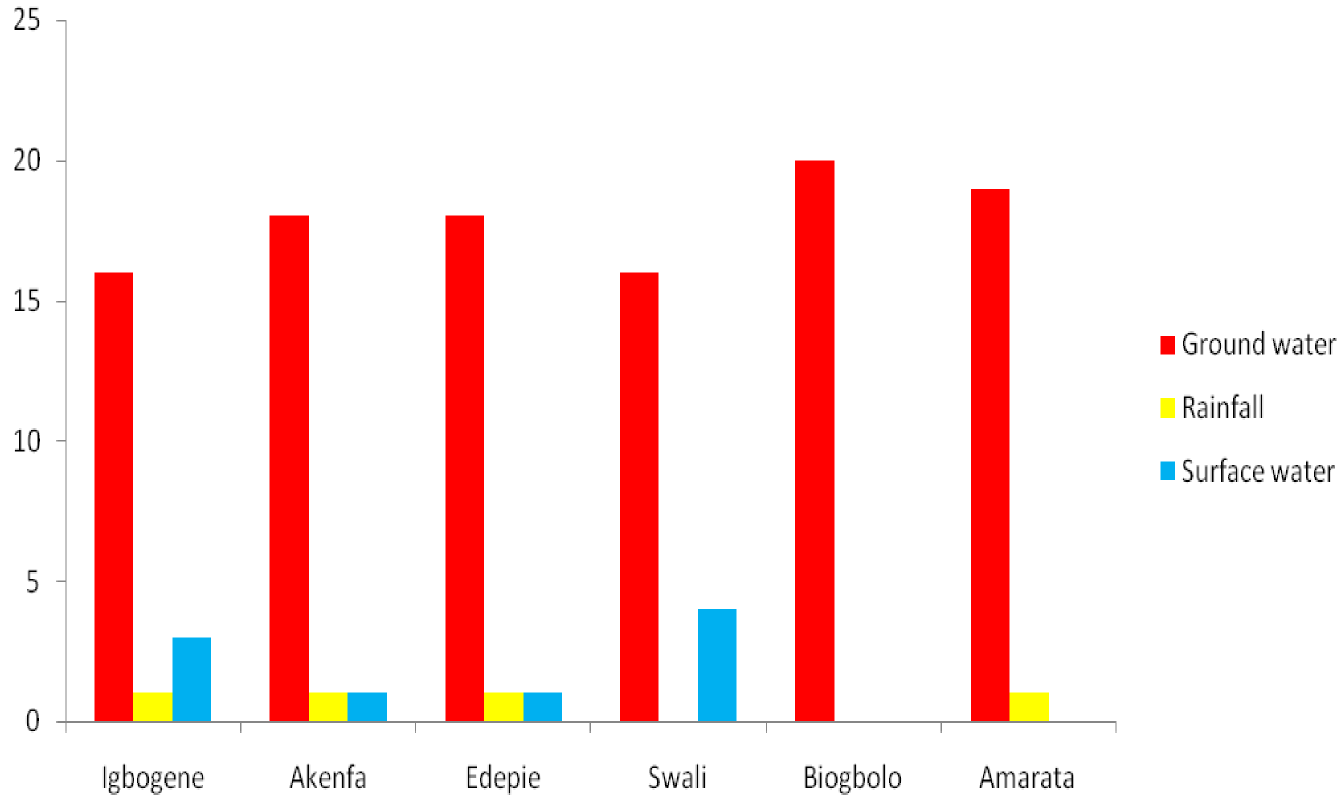

Figure 2. Sources of water in Yenagoa.

Edepie communities, 90% used borehole as the source of water while 5% each made use of rainfall and surface water. However, in Swali, 80% made use of groundwater while the remaining 20% depended on surface water. Similarly in Biogbolo and Amarata, 100 and 95% of total respondents depended on ground water. Generally, 89.2% of total respondents in the study area made use of ground water while 7.5 and 3.3% depended on surface water and rainfall. This shows that majority in the study area made use of borehole as their main source of their water.

Groundwater and surface water use in the area

Table 3, Figures 3 and 4 explains the different uses of ground and surface water in Yenagoa. In Igbogene, 65% of total respondents used water for domestic purposes while 25 and 10% used for agricultural and industrial purposes respectively. In Akenfa community, 80% used water for domestic purposes while 20% used it for agriculture. In Edepie, 70% used water for domestic purposes while 30% made use of water for agricultural purposes. In Biogbolo, 75% of total respondents used groundwater for domestic purposes while 15 and 10% used it for agricultural and industrial purposes. 85% of total respondents in Amarata community used water for domestic purpose while 15% used it for agricultural purpose. In all, 78.3% of total respondents used water for domestic purposes while 18.3 and 3.4% made use of water for agricultural and industrial purposes.

Water treatment methods

It is observed from Table 4 that people adopted three methods of treating water in the area namely boiling, filtering and addition of chemicals. In Igbogene, 10% of respondents agreed that boiling method is used to treat water while 15 and 5% believed in filtering and addition of chemicals. 70% of respondents in Igbogene do not treat water before use. In Akenfa, 5 and 5% treat water using boiling and filtering methods respectively while 90% do not treat water. In Edepie and Swali communities, 10 and 10% of respondent treat water using boiling and filtering methods respectively while 80% do not treat water before use. In Biogbolo, 15, 15 and 10% used boiling, filtering and addition of chemicals to treat water respectively while 60% do not treat water before use. In Amarata community, 20, 30 and 10% agreed to the use of boiling, filtering and chemical addition methods respectively for treating water while 40% do not treat water. In total, 11.7,

Table 3. Use of water in the study area.

Uses	Igbogene		Akenfa		Edepie		Swali		Biogbolo		Amarata		Total	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Domestic	13	65.0	16	80.0	14	70.0	19	95.0	15	75.0	17	85.0	94	78.3
Agricultural	5	25.0	4	20.0	6	30.0	1	5.0	3	15.0	3	15.0	22	18.3
Industrial	2	10.0	0	0	0	0	0	0	2	10.0	0	0	4	3.4
Total	20	100	20	100	20	100	20	100	20	100	20	100	120	100

F- Frequency; % - Percent.

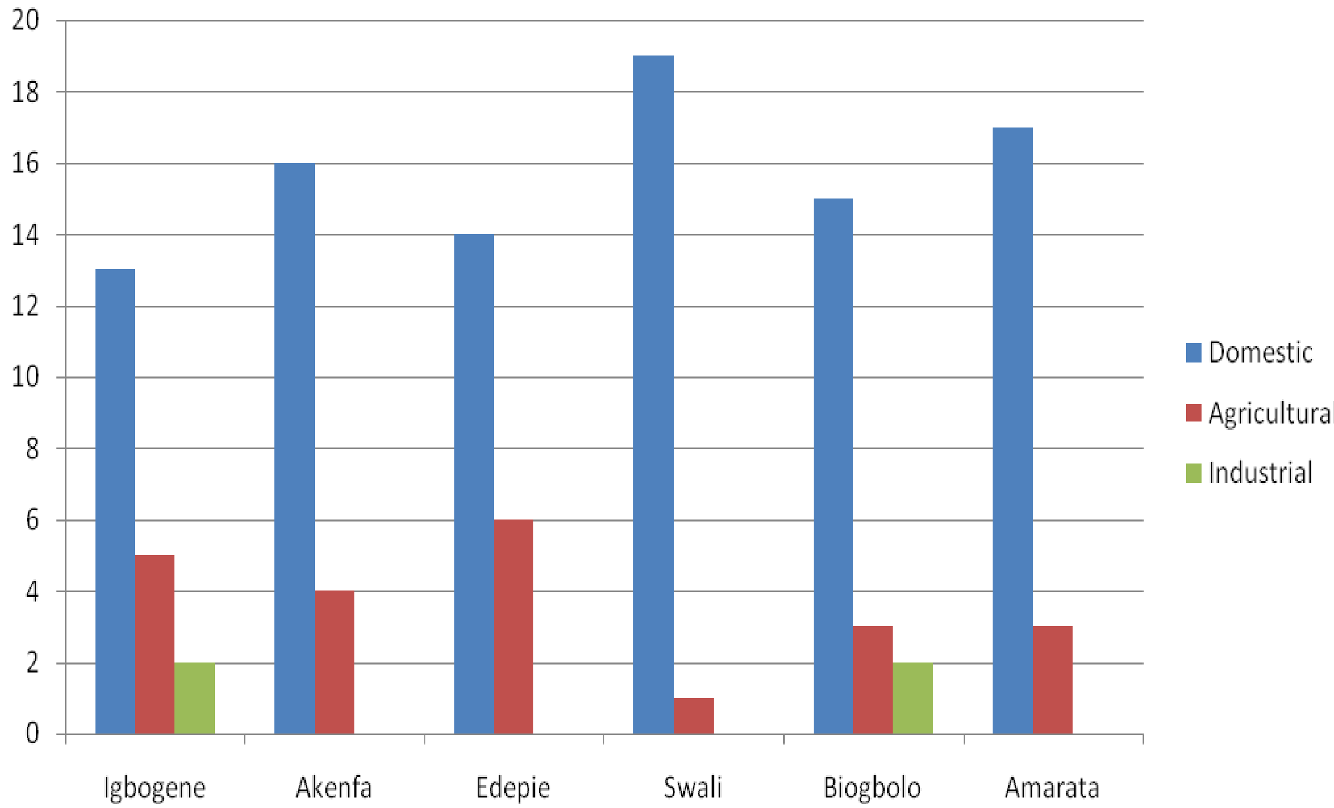

Figure 3. Water use among the selected communities.

14.2 and 4.1% believed that boiling, filtering and addition of chemicals are used to treat water respectively while 70% of total respondents do not treat water. These show that majority does not subscribe to water treatment in Yenagoa and this may pose serious impacts on their health status.

Impacts of water pollution on residents

The result of the analysis displayed in Table 5 presents the effects of water pollution on the health status of the residents in Yenagoa. In Igbogene, 35 and 20% believed that water pollution causes typhoid and diarrhea respectively while 45% believed that it causes skin irritation. However, in Akenfa, 25, 20 and 5% of total respondents perceived that pollutants in water can cause typhoid, diarrhea and cholera respectively while 50% perceived that it causes skin irritation. In Edepie, 25, 30, 15 and 30% of respondents perceived that water pollution leads to typhoid, diarrhea, cholera and skin irritation respectively. In Swali, 40% believed that water pollution results to typhoid while 25, 5 and 20% believed that water pollution cause diarrhea, cholera and skin irritation. 30% of respondents in Biogbolo believe that water pollution causes typhoid while 20% believed that it causes skin irritation.

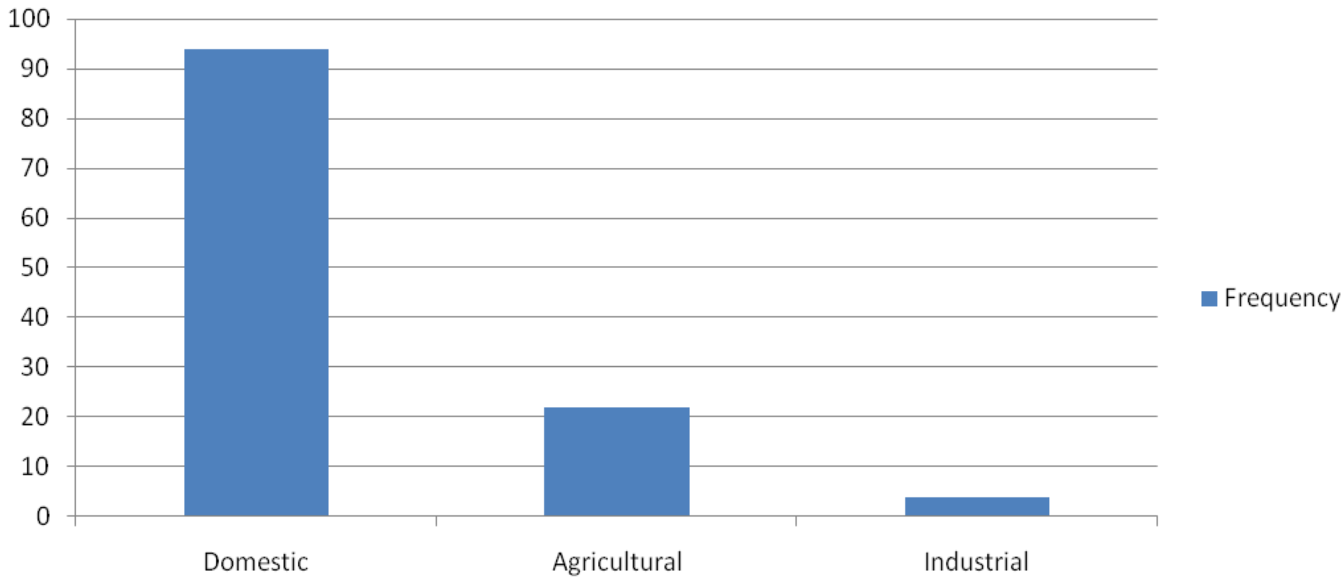

Figure 4. Water use in the entire study area.

Table 4. Water treatment methods in the study area.

Treatment	Igbogene		Akenfa		Edepie		Swali		Biogbolo		Amarata		Total	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Boiling	2	10.0	1	5.0	2	10.0	2	10.0	3	15.0	4	20.0	14	11.7
Filtering	3	15.0	1	5.0	2	10.0	2	10.0	3	15.0	6	30.0	17	14.2
Addition of Chemicals	1	5.0	0	0	0	0	0	0	2	10.0	2	10.0	5	4.1
None	14	70.0	18	90.0	16	80.0	16	80.0	12	60.0	8	40.0	84	70.0
Total	20	100	20	100	20	100	20	100	20	100	20	100	120	100

N.B.: F- Frequency; % - Percent.

Table 5. Effects of water pollution on human health.

Health effects	Igbogene		Akenfa		Edepie		Swali		Biogbolo		Amarata		Total	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Typhoid	7	35.0	5	25.0	5	25.0	8	40.0	6	30.0	2	10.0	33	27.5
Diarrhea	4	20.0	4	20.0	6	30.0	5	25.0	4	20.0	1	5.0	24	20.0
Cholera	0	0	1	5.0	3	15.0	1	5.0	2	10.0	0	0	7	5.8
Skin irritation	9	45.0	10	50.0	6	30.0	4	20.0	4	20.0	3	15.0	36	30.0
None	0	0	0	0	0	0	2	10.0	4	20.0	14	70.0	20	16.7
Total	20	100	20	100	20	100	20	100	20	100	20	100	120	100

N.B: F- Frequency; % - Percent.

In Amarata, 10% agreed that water pollution causes typhoid and 15% agreed that it causes skin irritation. As shown in Table 5 and presented in Figure 5, 27.5% of total respondents believed that water pollution causes typhoid while 20, 5.8 and 30.0% agreed that water pollution causes diarrhea, cholera and skin irritation respectively. It shows that residents in the study area are really suffering from typhoid, diarrhea and skin irritation diseases while the case of cholera is not frequent (Figure 6).

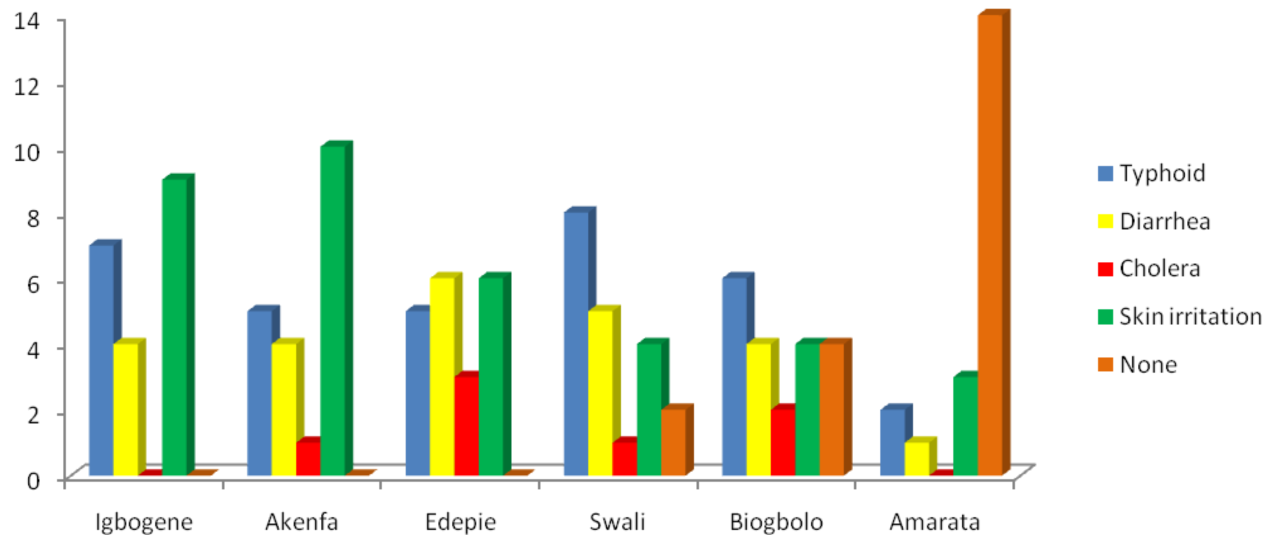

Figure 5. Levels of diseases caused by water pollution.

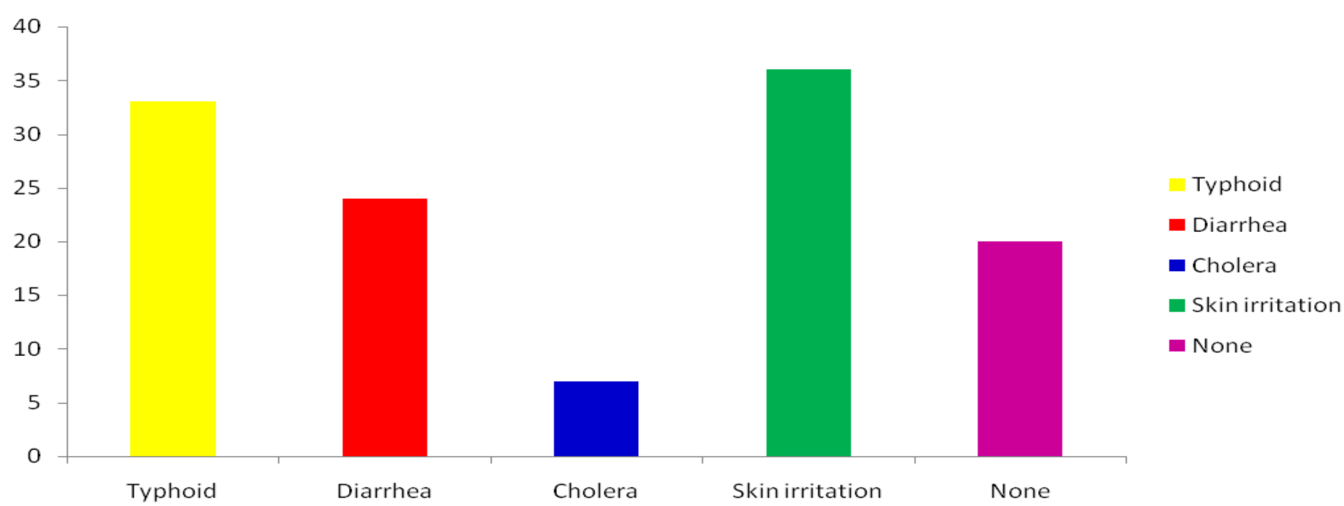

Figure 6. Total level of occurrence of diseases caused by water pollution.

Implications of results

The pH of the ground water was slightly acidic and slightly alkaline and the concentration fell within the WHO standard while the TDS in Yenagoa was low. These values are indications of the inland nature of the aquifers and their remoteness from the influence of any saline intrusion (Galley et al., 1975). The concentration of heavy metals (Lead, Iron, and Copper) in groundwater samples revealed that they were generally low. Lead ranged between 0.00 and 0.02 mg/L while Iron ranged between 0.001 and 0.073 mg/L and Copper which ranged between 0.0016 and 0.105 mg/L. The result corresponds to an Environmental Impact Assessment study by Shell Petroleum Development Company (SPDC) (2006) confirming that the concentration of these heavy metals in the ground water is still within acceptable levels.

The nitrate and sulphate concentrations were generally low in the ground and surface water but still higher in the latter. Their values were within the WHO limit for potable water. The low values may be due to the use of agricultural chemicals at a low rate in the study area. Chaturvedi (1976) confirmed that in many developing countries, agricultural chemical use has been low in comparison to levels in industrialized countries. The total coliforms, faecal coliforms and THC were high in the study area. This may be attributed to the direct discharge of untreated waste water in Yenagoa from the industries. Morris (1994) concluded that direct discharge of untreated wastewater has led to substantial increases in pollutants (NO_3^-, NH_4^+, Cl^-, faecal coliforms, and dissolved organic carbon) in the shallow aquifers. The pollution especially the faecal coliform may contribute to the occurrence of diseases like diarrhea and cholera in Yenagoa. As a result of the high presence of coliform in the ground and surface water of Yenagoa, should be subjected to adequate treatment before human consumption. A report by Shell Petroleum Development Company (SPDC) (2006) stated that the WHO requires that drinking water should be without faecal coliform bacteria.

It was discovered that majority of the people prefer ground water to surface water in the study area. This may be attributed to the colourless nature of ground water. Surface water unlike ground water supplies are affected by short term drought (although long term drought affects both). Groundwater is generally free of sediments, color, pathogenic (diseases) organisms, in severely polluted areas. In cases where ground water is polluted, such conditions are considered irreversible (Christopherson, 2002). Phiilp (1994) also confirmed that ground water is an important source of water supply for municipalities, agriculture and industry.

The perception of individuals to the cause of diseases due to polluted water in the study area confirmed that water pollution can lead to various forms of diseases like typhoid, skin irritation, cholera and diarrhea. The reason may be due to the concentrations of heavy metals like lead, copper, and iron which might have been released to the environment through industrialization and transportation. Horsfall et al. (2002) and Abia et al. (2002) corroborated that many of the industrial operations release various toxic heavy metals in their effluents. Heavy metals, arsenic and arsenical compounds, barium, chromium, lead, cadmium, manganese, zinc and other harmful materials are known to cause serious health effects. Such health problems includes but not limited to acute and chronic respiratory problems, gastro-intestinal tract infection, cardiovascular system disorder, nervous system and blood forming organisms malformation cases of skin and lung cancer. Pedley and Howard (1997) concluded that in many urban and peri-urban areas, the use of pit latrines and soak pits discharge wastes below the soil and weathered zone layers, thus polluting ground water.

Conclusions

The laboratory analyses carried out on the parameter of water samples reveals that the pH level of the water in the study area was slightly acidic and slightly alkaline. All water parameters tested in the area were lower in concentration to WHO standard except Iron (Fe) under surface water and THC, total coliform and faecal coliform in both the groundwater and surface water. Comparing the concentrations of water parameters between groundwater and surface water in Yenagoa, all the physico-chemical variables were higher significantly in the surface water than the groundwater. Yet chloride, nitrate, sulphate and calcium were very low in the study area in both the surface and groundwater. The proper analysis and efficient utilization of groundwater cannot be over emphasized and its importance cannot be overestimated. Its uses are very important in all aspects of human life. Its importance is as any other source of water, but due to its availability and proximity, it makes it seem more important as compared to other sources of water. Although the communities in Yenagoa Local Government Area are semi-urban settlements or also known as a developing urban areas which are surrounded by water channels but the use of the groundwater is still paramount compared to other sources of water available in this environment. The other sources of water (rain and the river) prior to this time were also much utilized as aforementioned due to their availability. The study gave a proper insight of the preference of groundwater (borehole) to the surface water and there was significant difference in the choice between the ground water and surface water. This may be due to the notion that groundwater is safer and cleaner than any other source of water Yenagoa.

The study also reveals that boiling, filtering and adding chemicals were the common methods of treating water in the area but by the minority. Majority still lack the knowledge about water treatment, especially for domestic use. Inadequacy of treating water was directly correlated to the issue of occurrence of diseases in the area and the relationship was found to be a positively strong correlation and water treatment could explain 81% of the occurrence of the diseases in the area. The study revealed that lack of water treatment has resulted to the occurrence of some diseases like typhoid, diarrhea, cholera and skin irritation.

Following the results of this study, groundwater is of better quality than surface water. This study therefore, recommend that more groundwater and surface water assessment studies in the study area and the entire state be carried out because the production, creation and the availability of these data through proper analysis ensures effective management and utilization of water resources in the study area. The government should employ the services of an interagency working group on groundwater management that would allow the UN agencies concerned to focus efforts on this course and develop mutually reinforcing normative and operational programs. More boreholes are needed to be sunk in the study area by the Federal, State and Local Governments.

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