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# Analysis of Ground Water Quality and Health of Residents in Eket Local Government Area of AkwaIbom State, Nigeria

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***Abstract:*** *The study examined the physio-chemical and bacteriological quality of ground water in 37 randomly sampled communities in Eket Local Government Area of AkwaIbom State, Nigeria. The water samples were collected from private boreholes at different locations in the communities andanalysed for total viable plate count, total coliform count, faecalcoliform bacteria and physio-chemical properties with a view to assessing its impact on Residents Health. The result of physio-chemical analysis showed high variability in water colour, large homogeneity in temperature and a pH tilted towards acidity. The presence of high volume of bacteria content (specifically coliform count and E.coli which are the major causes of water-borne disease) revealed the poor quality of borehole water and the attendant negative impact on Residents Health Status. It is believed that borehole water quality and population Health by extension could be improved by ensuring appropriate location of borehole (at least 25m) away from potential pollutant, regular treatment of borehole water and proper chanelling of sewage.*

***Keywords****: Water quality; ground water; borehole; health; AkwaIbom State; water borne disease.*

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## I. Introduction

The quality of ground water is of vital concern to public health managers especially in developing countries where over 60% of households depend on ground water for water supply (WHO, 2015). Water quality parameters reflect the level of contamination or otherwise in water sources and show whether or not water is suitable for human consumption. The wanton consumption of highly polluted groundwater in Nigeria has dire consequences on the health status of the people. According to UNICEF (2010), more than 319 million people in Sub-Saharan Africa do not have access to clean and safe drinking water and depend largely on ground water from private and public boreholes.

The quality of ground water is often threatened by the presence of excess quantities of heavy metals, certain radioactive isotopes, faecalcoliforms bacteria, phosphorus, pathogens and viruses as well as organic chemicals such as pesticides and herbicides (Udofia, 2009). Groundwater contamination can be caused by old, poorly maintained and improperly used septic systems, storm water runoff; the injection of waste into wells; excess fertilizers or pesticides on farm fields; leakage from landfills and ground gasoline storage tanks; improper storage and disposal of hazardous materials; oil and gas well and salt water intrusion into aquifers. Ground water contamination remains a serious and growing problem in most rural and urban communities in Nigeria.

A number of studies have attempted to outline the incidence of groundwater contamination and its causes andconsequences. For instance, Salami, Iroegbu and Egila (2001) observed that the quality of groundwater samples obtained in Bukuru, a rural community in Jos, Nigeria were affected by refuse dump sites located near the wells. The laboratory analysis of the water sample indicated high pH values of 8.5 indicating a high acidic content.

Furthermore, the investigation showed that water samples obtained from wells situated further away from dump sites had lower levels of contaminants, thereby affirming that contaminants discharged from the dump sites were likely the contributing factor to the poor quality of groundwater in the area.

Anale (2004) observed that most groundwater sources in some urban centers in Nigeria contained substantial microbial contaminant including E. coli, and S.typhii. Anale attributed the incidence to indiscriminate sinking of boreholes near toilets, soak- away, dirty gutter and poor drainage.

In the western region of KasanoharaPlateau, Japan;Jum and Toshiyuki (2005) observed that the pollution of groundwater with nitrate was caused by livestock excrement.They also observed thatnatural existence ratio of nitrogen load occurred due to leaching from the unlined storage pond used for pig waste management. Consequently, they proposed an abolition of the unlined storage pond method and recommended the composition of pig waste management Systemas nitrogen load reduction measures for the area.

Aimiuwu(2008) also observed that the groundwater chemistry in Benin City, Nigeria showed heavy growth of coliform due to the seepage of sewage into the borehole lining.

The health implications of the consumption of contaminated ground water cannot be over stressed. The UNEP (2016) report on “sick water” revealed the level of endemic causes of cholera and other infectious diseases in Africa caused by exposure to unsafe drinking water. The report also showed that half of the hospital Beds in Nigeris were filled with people suffering from water-related diseases. According to the WHO (2012) report, disease like cholera, typhoid fever, dysentery and hepatitis A were caused by ingestion of causative water inhabiting pathogens. Guinea worm, schistosomiasis and a host of other parasitic nematodes likewise find their way into the human body through drinking or bathing contaminated water. In most cases borehole water is used directly without treatment and the water may be faecally contaminated.

In Eket Local Government Area, a coastalzone in AkwaIbom State, Nigeria where this study is based, most of the communities dependon borehole depth (less than 10 meters to the aquifer). The area has unconfined shallow depth with water level values generally below 10 meters. Therefore, groundwater can easily be harvested at a depth of less than 10 meters. Generally the soil contain high fraction of sand that allow leaching of contaminants in the soil. With the unconfined nature of the soil and low water table; during the rainy season, aquifer rises to the sub-surface causing pollution loading and gradually raising the level of contamination. Moreso, borehole constructiondefects such as insufficient casing depth, improper sealing of the space between the casing and the borehole, cracked borehole casing, as well as poor well caps can allow sewage borne micro-organism to seep into and contaminate borehole groundwater in the area.

Given the enormous industrial activity and the attendant increase in population in Eket Metropolis and its adjoining coastal communities, there is need to safeguard the health of the residents through a deliberate effort to improve borehole water quality upon which their water supply depends. The control and monitoring of borehole water quality requires a first hand investigation into the physio-chemical and microbial properties of borehole water in the area. This study represents one of such attempt aimed at analysing the quality of borehole (groundwater) and the health status of residents in the coastal communities of AkwaIbom State and Nigeria, with a view to making recommendations that would help stabilize water quality and health status of residents.

## II. Materials and Method

The study was designed as an empirical research utilizing experimental approaches through laboratory analysis to examine the quality of groundwater in Eket local Government Area ofAkwaIbom State, Nigeria.Thirty seven water samples were collected from different private boreholes spread across 37 communities in the study area. These water samples were analysed for physio – chemical and microbial properties in line with WHO standards. The water samples were collected in June, 2016 and stored in clean150 ml polyethylene bottles and preserved in ice chestsfor onward delivery to the AkwaIbom State Ministry of Environment, Uyo for laboratory analyses using standard method. All samples were allowed to settle down for about 4 hours before Laboratory analysis was conducted in order to eliminate turbidity influence on the analysis.

Specifically, the water samples were tested for microbial load such as total viable plate count, total coliform and faecalcoliform bacterial. Physical properties such as electrical conductivity, Ph, total dissolved solids (TDS) and temperature were analysed using potable meters. Chemical properties such as salinity, chloride, calcium, alkalinity and total hardness were determined using titrimetric method. Sulphate, and nitrate were determined using spectrophotometer, while magnesium were determined using an atomic absorption spectrophotometer.

In addition, epidemiological records of people treated for water borne diseases (such as typhoid, dysentery, cholera, and diarrhea) for the period of study (January – September, 2016) were collected from the archives of government owned hospitals/health centres in the study area and used for the study

## III. Results and Discussion

### 3.1 Physio-chemical and Bacteriological Properties of ground water (borehole) in the study area

Table 1 shows the summary of descriptive analysis of the physio-chemical and heavy metals parameters investigated in the 37 sampled borehole water points in the study area. The mean value of physio-chemical parameters investigated and the World Health organization (2008) Standards are also presented.

**Table 1:Descriptive StatisticsComparingPhysio-chemical Parameters with WHO Standards.**

| Parameters | N | Range | Minimum | Maximum | Mean | SD | WHO Standard (2008) |
|---|---|---|---|---|---|---|---|
| Colour | 37 | 15.00 | 5.00 | 20.00 | 6.351 | 3.466 | 15.00 |
| Temperature | 37 | 1.70 | 26.10 | 27.80 | 26.797 | 0.446 | 27-28 |
| Turbidity | 37 | 0.69 | 0.24 | 0.93 | 0.476 | 9.184 | 5.00 |
| DO | 37 | 1.30 | .50 | 1.80 | 1.481 | 0.251 | 6.00 |
| pH | 37 | 2.27 | 5.38 | 7.65 | 6.709 | 0.524 | 6.5-8.5 |
| EC | 37 | 60.20 | 27.10 | 87.30 | 61.402 | 20.387 | 1000.00 |
| TDS | 37 | 35.05 | 14.15 | 49.20 | 31.681 | 10.456 | 500 |
| $Na^+$ | 37 | 2.20 | 1.20 | 3.40 | 2.489 | 0.498 | 200 |
| K | 37 | 1.00 | 0.20 | 1.20 | 0.543 | 0.297 | 150 |
| Cl | 37 | 1.53 | 7.40 | 8.93 | 8.141 | 0.426 | 250 |
| $NO_3^-$ | 37 | 0.35 | 0.01 | 0.36 | 0.081 | 0.063 | 10 |
| $SO_4^-$ | 37 | 2.00 | 0.30 | 2.30 | 1.767 | 0.418 | 1.5 |
| Alkalinity | 37 | 6.90 | 1.00 | 7.90 | 1.997 | 1.012 | 200 |
| Total Hardness | 37 | 23.92 | 15.68 | 39.60 | 25.041 | 6.213 | 100 |
| Calcium Hardness | 37 | 21.91 | 13.15 | 35.06 | 22.779 | 5.910 | 200 |
| Magnesium Hardness | 37 | 3.44 | 1.10 | 4.54 | 2.316 | 0.678 | 150 |
| Phosphate | 37 | 0.17 | 0.02 | 0.19 | 0.096 | 0.052 | 3.5 |
| Copper | 37 | 0.04 | 0.01 | 0.05 | 0.028 | 0.011 | 1.00 |
| Lead | 37 | 0.06 | 0.00 | 0.06 | 0.008 | 0.010 | 0.01 |
| Zinc | 37 | 0.17 | 0.01 | 0.18 | 0.034 | 0.030 | 0.10 |
| Nickel | 37 | 0.02 | 0.00 | 0.02 | 0.009 | 0.005 | 0.07 |
| Iron | 37 | 0.39 | 0.02 | 0.41 | 0.207 | 0.111 | 0.30 |
| Arsenic | 37 | 0.00 | 0.00 | 0.00 | 0.001 | 0.000 | 0.005 |
| Cadmium | 37 | 0.05 | 0.00 | 0.05 | 0.004 | 0.008 | 0.05 |
| Manganese | 37 | 0.09 | 0.00 | 0.09 | 0.005 | 0.015 | 0.40 |

Source: Authors Analysis, 2016.

As data in Table 1 indicates, the mean temperature of the borehole water samples was $26.797^0$C, turbidity value of 0.476 NTU were obtained while the mean value of electrical conductivity was 61.402Us/cm. The colour value for samples vary from 5.00 HU to 20.00 HU. Total dissolved solids value of 31.73mg/l was recorded. The mean of pH stood at 6.71. Hardness level was 25.09mg/l. dissolved Oxygen (DO) level recorded was 1.50mg/l.

The mean value of inorganic (sodium, potassium, chloride, nitrate, sulphate, calcium, magnesium and phosphate) were 2.90mg/1,0.58mg/1,8.12mg/1, 0.08mg/1, 1.78mg/l, 23.10mg/l, 2.23mg/l. 2.32mg/l and 0.10 mg/l respectively. Alkalinity was 1.84 mg/l. the level of heavy metals (copper, Lead, Zinc, Nickel, Arsenic, Cadmium and manganese) stood a t 0.028 mg/l, 0.067 mg/l, 0.001 mg/l, 0.010 mg/l, 0.001 mg/l, 0.003 mg/l respectively.

The sample values of some borehole water was outside acceptable limit they include WS6= 0.410, WS15= 0.386, WS16 = 0.400, WS27= 0.536 and WS33 = 0.361.

Sulphate value of WS2,WS3, $WS_4$, $WS_4$, $WS_{10}$, and $WS_{29}$were within acceptable value of WHO.

The mean of pH stood at 6.71.The results of $WS_6$, $WS_{11}$, WS28 and $WS_{29}$ shows a tilt toward acidity of the borehole water in those locations.

5.00HU colour was recorded for all the water sample except $WS_{28}$ was elevated to 20.00mg/l above WHO (2008) standards.

The outcome of microbial plates count obtained from this research showed the presence of coliform count and E.coli. The total bacteria ranged from 11.00 to 198cfu/100ml and faecalcoliform bacteria counts from 1.00 to 33.00cfu/100ml respectively. The total viable count ranged from 20.00 to 4300cfu/100ml for borehole water 30mm, whereas zero count was recorded in some water samples.

The highest total value plate count was recorded at $WS_{17}$ total coliform bacterial, were recorded highest at $WS_{23}$ and highest faecalcoliform bacteria count was recorded at $WS_{23}$ respectively.This probably may be due to proximity of the borehole water source to septic tank, direction of flow, the soil physics of the area and the velocity of flow of the underground water and settlement pattern.Table 2 displays the result of the microbial (bacteriological) analysis conducted on the water samples in the study area.

**Table 2: Bacteriological Analysis of Underground (Borehole) water in the Study Area.**

| Location | Samples Code | Coordinate Easting | Northing | Vol. of Water Sample Filtered (100ml) | Total Plate Viable Count (cfu/100ml) | Total Coliform Bacteria cfu/100ml | FaecalColifom Bacteria (E.coli) cfu/100ml | WHO Standard cfu/100ml |
|---|---|---|---|---|---|---|---|---|
| Eket Urban Ward 1 | | | | | | | | |
| 1. IkotNsidibe | $WS_1$ | 379412 | 519959 | 100 | 2700 | 131 | 18 | 0 |
| 2. IkotAtaku | $WS_2$ | 379911 | 520013 | 100 | 1800 | 122 | 9 | 0 |
| Eket Urban Ward 2 | | | | | | | | |
| 1. Uquo | $WS_3$ | 379830 | 518114 | 100 | 70 | 18 | 0 | 0 |
| 2. Atabang | $WS_4$ | 379529 | 517932 | 100 | 2200 | 127 | 12 | 0 |
| 3. Idua | $WS_5$ | 378788 | 519640 | 100 | 0 | 0 | 0 | 0 |
| Eket Urban Ward 3 | | | | | | | | |
| 1. IkotEbok | $WS_6$ | 378617 | 518550 | 100 | 1900 | 12 | 1 | 0 |
| 2. EtebiIdongAkpa | $WS_7$ | 378473 | 518604 | 100 | 2400 | 125 | 13 | 0 |
| 3. UsungInyang | $WS_8$ | 378420 | 517710 | 100 | 800 | 0 | 12 | 0 |
| 4. IkotEbiyan | $WS_9$ | 378254 | 517953 | 100 | 3100 | 129 | 14 | 0 |
| Eket Urban Ward 4 | | | | | | | | |
| 1. Idung Imo | $WS_{10}$ | 378382 | 517264 | 100 | 0 | 0 | 0 | 0 |
| 2. AfahaEket | $WS_{11}$ | 378752 | 517059 | 100 | 2100 | 126 | 1 | 0 |
| 3. OkopediIdung | $WS_{12}$ | 381243 | 514745 | 100 | 120 | 19 | 5 | 0 |
| 4. Etebi | $WS_{13}$ | 381030 | 515046 | 100 | 2000 | 110 | 8 | 0 |
| 5. AtaiNdon | $WS_{14}$ | 380138 | 513825 | 100 | 100 | 157 | 0 | 0 |
| 6. EkpeneAfaha | $WS_{15}$ | 379993 | 513747 | 100 | 1600 | 28 | 5 | 0 |
| EketCentral 1 Ward 5 | | | | | | | | |
| 1. Ebana | $WS_{16}$ | 383419 | 516967 | 100 | 500 | 12 | 0 | 0 |
| 2. Ede Urua | $WS_{17}$ | 383320 | 517102 | 100 | 4300 | 183 | 27 | 0 |
| 3. EsitUrua | $WS_{18}$ | 383274 | 516850 | 100 | 20 | 14 | 0 | 0 |
| EketCentral II Ward 6 | | | | | | | | |
| 1. Osiok | $WS_{19}$ | 383482 | 516368 | 100 | 800 | 16 | 5 | 0 |
| 2. IkotEne | $WS_{20}$ | 383273 | 516308 | 100 | 0 | 0 | 0 | 0 |
| 3. Ofiyo | $WS_{21}$ | 383277 | 516533 | 100 | 900 | 18 | 7 | 0 |
| EketCentral III Ward 7 | | | | | | | | |
| 1. AtaiIdung | $WS_{22}$ | 382971 | 515267 | 100 | 0 | 0 | 0 | 0 |
| 2. IdungOfiong | $WS_{23}$ | 383205 | 515058 | 100 | 600 | 198 | 32 | 0 |
| 3. IkotAfaha | $WS_{24}$ | 384125 | 513378 | 100 | 160 | 21 | 9 | 0 |
| 4. AsngIkot | $WS_{25}$ | 384258 | 513528 | 100 | 700 | 16 | 0 | 0 |
| EketCentral V Ward 8 | | | | | | | | |
| 1. Efoi | $WS_{26}$ | 386097 | 512584 | 100 | 2100 | 127 | 30 | 0 |
| 2. UkotOdiong | $WS_{27}$ | 386247 | 512325 | 100 | 1700 | 33 | 8 | 0 |
| EketCentral V Ward 9 | | | | | | | | |
| 1. Odor | $WS_{28}$ | 383732 | 509583 | 100 | 0 | 0 | 0 | 0 |
| 2. Ndito | $WS_{29}$ | 383656 | 503592 | 100 | 0 | 0 | 0 | 0 |
| Eket Ward 10 | | | | | | | | |
| 1. NduoEduo | $WS_{30}$ | 384175 | 509692 | 100 | 1100 | 21 | 8 | 0 |
| 2. IkotOso | $WS_{31}$ | 381216 | 509717 | 100 | 800 | 15 | 6 | 0 |
| 3. IkotObioAnana | $WS_{32}$ | 381433 | 508346 | 100 | 3500 | 170 | 2 | 0 |
| Eket Ward 11 | | | | | | | | |
| 1. IkotInyang | $WS_{33}$ | 381517 | 508630 | 100 | 0 | 0 | 0 | 0 |
| 2. Okon | $WS_{34}$ | 379776 | 508965 | 100 | 400 | 11 | 0 | 0 |
| 3. IkotUkpong | $WS_{35}$ | 380091 | 506424 | 100 | 0 | 0 | 0 | 0 |
| 4. IkotIkpe | $WS_{36}$ | 379930 | 506262 | 100 | 4000 | 0 | 22 | 0 |
| 5. IkotObio Ata | $WS_{37}$ | 393050 | 506254 | 100 | 300 | 17 | 5 | 0 |

cfu/ml = colony forming unit per milliliter

Microbial plate counts of isolate obtained from the different samples at Eket locations

Source: Authors' Analysis (2016)

The presence of coliform count shows that water is vulnerable to contamination by more harmful microorganisms. The presence of *E.coli* in water samples indicates faecal contamination such as bacteria, viruses and parasite. This is because according to WHO (2008) a coliform count in a drinking water should be zero.

A special reference is made to borehole water sample ($WS_{17}$, $WS_{23}$, $WS_{26}$, and $WS_{36}$) from Ede Urua, IdungOffiong, Efoi and IkotIkpe which were found to be highly contaminated.

Faecalcolifom may be introduced into borehole water in this manner causing high load of enteric pathogenic bacteria from septic tanks through percolation to the underground water level thus faecally contaminating the drinking water source of the study area.

The distribution of bacteriological indicator in the water sample also shows that total viable plate count was more than total coliform counts and faecal bacteria respectively. The least bacteria count was faecal coliform.

### 3.2 Residents Health Status and Incidence of Water Borne Diseases in the Study Area

Report of treated cases of water borne diseases such as cholera, typhoid, dysentery, diarrhea and other water related diseases were obtained from government health facilities in the study area.

As data in Table 3 indicates; within the time of this investigation (April 2016 to September, 2016)a total number of 100 patients were treated at various health facilities for water borne disease. Out of this number, 12 percent were treated for cholera, 36 percent were treated for typhoid fever, 23 percent were treated for dysentery, 21 percent were treated for diarrhea and 4 percent were treated for hepatitis A.The results showed that most of the reported cases of water borne diseases were attributed to consumption of highly polluted water. The implication of this is that incidence of water borne diseases in the study area can be attributed to the poor quality of borehole water.

**Table 3: Total Number of Persons treated for water Borne disease (Cholera, Typhoid fever, Dysentery, Diarrhea and Hepatitis) in the study Area**

| Location | Cholera | Typhoid fever | Dysentery | Diarrhea | Hepatitis | Total |
|---|---|---|---|---|---|---|
| Eket-Urban Ward 1 | 0 | 4 | 0 | 1 | 0 | 5 |
| Eket-Urban Ward 3 | 0 | 3 | 0 | 1 | 0 | 4 |
| Eket-Urban Ward 4 | 0 | 5 | 7 | 0 | 0 | 12 |
| Eket-central 1 Ward 5 | 1 | 6 | 0 | 2 | 0 | 9 |
| Eket-Urban Ward 6 | 1 | 1 | 0 | 1 | 0 | 3 |
| EketCentral III Ward 7 | 4 | 8 | 4 | 0 | 3 | 19 |
| Eket central v Ward 8 | 3 | 5 | 8 | 2 | 0 | 18 |
| Eket-Urban Ward 9 | 0 | 2 | 0 | 1 | 0 | 3 |
| Eket ward 10 | 2 | 4 | 2 | 5 | 0 | 13 |
| Eket-Urban Ward 11 | 0 | 1 | 0 | 0 | 0 | 1 |
| Total | 12(12%) | 36(36%) | 23(23%) | 21(23%) | 4(4%) | 100(100%) |

Source: Ministry of Health, Uyo, AkwaIbom State

Data in Table 3 also shows that the commonest water borne disease in the study area were: Typhoid fever, and then followed by dysentery. The results also reveal that the highest cases of water borne diseases were reported in Eket Central Ward III and 7 and in Eket Central V Ward 8, and in Eket Urban Ward 3 and Eket Ward 10 respectively. The incidences of these waterborne diseases probably might have been caused by proximity of borehole water source to septic tanks. Landuse, soil properties, vegetation and topography affect contamination transport, therefore septic tank sludge can release bacteria and viruses into groundwater (USGS, 2004). This means faecal contamination of water is globally recognized as one of the leading causes of water borne diseases. The potential of drinking water to transport microbial pathogens to people, causing subsequent illness, is well reported by Aimiuwu, (2008).

**Table 4: Chi-Square result summary showing relationship between water quality and health of residents in the study area**

| | Value | Df | Asymp. Significant (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 58.047 | 24 | .000 |
| Likelihood Ratio | 67.130 | 24 | .000 |
| Linear-by-Linear Association | 2.342 | 1 | .126 |
| N of Valid Cases | 100 | | |

Source: Author's Analysis (2016)

The significance of the relationship between water quality and health of residence was tested using chi-square and the result obtained as presented in Table 4. The result shows that the calculated $X^2$ (58.047) was greater than its corresponding critical $X^2$ (36.42) and the p-value was less than 0.05($p=0.000$, $p<0.05$).The null hypothesis (Ho) was rejected which means that there is significant relationship between water quality and health of residents of Eket Local Government. This result implies that the quality of water in the study area affects the health of the residents of Eket Local Government Area while the alternative hypothesis ($H_1$) was accepted.

World Health Organisation(WHO)recommends that borehole should be located at least 30m away from Pit Toilet and 18m from septic tank (Chukwurah, 2001). This, however, is not the case for all of the sampled sites in the study area and this eventually affects the whole of Eket Local Government Area posing a great danger on the health of the residents.

Water pollution has been documented as a contributor to a wide range of health problems and disorders in humans directly or indirectly. It has been shown to have drastically negativeeffects on our environment, animals, and other habitats. The risks of health being negatively impacted by polluted drinking water are high. It can range from physical to severe illness or even death.Water borne diseases in the study area were influenced by the quality of borehole water. Comparison of the microbiological parameters of the samples with WHO showed that the groundwater was contaminated and was accountable in the area.

This findings show that water borne diseases in the study area were influenced by the quality of boreholes water source. The significant variations in water parameter among borehole water sampled in the area could be attributed to distances between the boreholes and septic tank systems.

Results also showed that total coliform and faecalcoliform were significant above WHO recommended limits for total and faecalcoliform bacterial in drinking water and were therefore not suitable for human consumption (drinking) without proper and adequate treatments and as they could caused typhoid fever, diarrhea, dysentery cholera and other water borne diseases.

## IV. Conclusion and Recommendations

The study confirmed the high degree of contamination of ground water in the area. Specifically, the presence of dangerous microbial organisms such as coliform count and E.coli in water samples confirmed the unsuitability of borehole water in the study area.

The study also revealed the significance relationship between the quality of borehole water and the incidence of water-borne diseases in the area. There is sufficient empirical evidence linking the endemic incidence of cholera, diarrhea, dysentery and typhoid fever with the poor quality of underground water consumed by residents.

In view of these findings, the following recommendations were made in order to improve water quality and population health in the study area:

i. Stakeholders in the ministry of Environment, Land/Urban Planning must carry out rigorous sensitization and enlightenment campaigns on the health implications of poorly constructed, ill-maintained and in appropriate location of borehole water in the area.
ii. Regular monitoring by relevant agencies must be conducted to enforce compliance with locational standard both for sewage facilities and borehole water.
iii. The proliferation of boreholes in developing countries is largely due to failure of municipal water supply systems. Municipal Authorities can discourage private boreholes by guaranteeing regular supply of municipal water.
iv. To curb impending epidemic arising out the consumption of contaminated borehole water, disinfectant and proper treatment of private borehole water should be encouraged.

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