**Physicochemical and Microbiological Quality of Borehole Water Samples in Owerri North - West Local Government Area, Imo State, Nigeria**

**1Peter-Ikechukwu, Anne (Corresponding author)**

Department of Food Science and Technology, Federal University of Technology, P.M.B 1526, Owerri, Imo Nigeria.

**1 N. O. Kabuo; 1 E.N. Bede; 2 R. O. Enwereuzoh; 1 C. Amandikwa;1 D. C. Okafor; 1 S. O. Alagbaoso and 1IdaresitOkposen**

1Department of Food Science and Technology, Federal University of Technology, P.M.B 1526, Owerri, Imo Nigeria

2Raw Materials Research and Development Council, 17 AguiyiIronsi Street, Maitama District Abuja

**ABSTRACT:** *Assessment of the quality of borehole water samples from Federal Housing Estate and Sites and Services areas of Owerri North, Imo State, Nigeria was conducted to determine the suitability of these borehole water samples for human consumption. six samples of borehole water obtained from six different families living in these areas were analyzed for microbial, chemical and physicochemical parameters using standard analytical methods of Association of official Analytical chemists (AOAC). The result of microbial analysis revealed that all the water samples from Chuk’sresidence,Ebe’s residence, Uwuru’s residence,Okre’s residence, Agbu’s residence and Ngwe’s residence referred to as samples D, E, F, G, H, and M respectively had total coliform count of 64.0cfu/100ml, 5.0cfu/100ml, 41.0cfu/100ml, 16.0cfu/100ml, 124.0cfu/100ml and 0.0cfu/100ml respectively. This showed that sample D, F, G, and H exceeded the standard of 10 coliform counts/100ml. The entire samples resulted at 0 counts for Escherichia coli. Samples D, F, G and M tested negative for pseudomonas test, whereas samples E and H did not. The chemical analysis showed that all the samples did not meet up with the recommended standard of pH (6.5-8.5) by World Health Organization (WHO), United Nations International Children’s Emergency Fund (UNICEF) Standard Organization of Nigeria (SON) and National Agency for Drug and Administration Control (NAFDAC).However, there was significant difference (p<0.5) between samples D and E. Samples F, G, J and M were not significantly different (p>0.5)from one another. Sample M was the least significant while sample D was the most significant at pH 4.6 and 6.4 respectively meaning that it is safe for consumption. The temperatures were not significantly different and did not exceed standard limit of 370C. The total dissolved solid also did not exceed the limit of 500ppm as recommended by World Health Organization /United Nations International Children’s Emergency Fund (WHO/UNICEF) and the conductivity limit was not exceeded. All the samples did not exceed limits for zinc, copper, lead, magnesium, cadmium and iron which are 3mg/l, 1mg/l, 0.01mg/l, 0.02mg/l, 0.03mg/l and 0.3mg/l respectively except for calcium, where samples D, E, G and H were beyond standard of 0.4mg/l. All the samples were significantly different for each parameter except for lead of which the entire sample were all the same. The depth of Sample G borehole was according to the regulatory standard of 150 ft., and from the analysis the entire parameters were within standard except for pH.The study concludes that increase in population in Federal Housing Area and Sites and Services Area in Owerri coupled with the rise in human activity pose a great pressure on provision of safe drinking water.*

**INTRODUCTION**

Water is a colorless, transparent, tasteless, scentless compound of oxygen and hydrogen the formula H2O in its intermediate state between ice and vapour (Linton 2010). Water covers 70.9% of the Earth surface and is vital for all known form of life. On Earth, it is found mostly in Oceans and other large water bodies (CIA, 2008). Research claims that Ocean holds 97% of surface water such as rivers lakes, ponds (Gleick, 1996). A very small percent of Earth’s water is contained within biological bodies and manufactured products (Gleick, 1993). Water presently on earth moves through a cycle of evaporation, precipitation and runoff, usually reaching the sea (Gedney*et al.*, 2006) described as evapotranspiration. To have safe drinking water is a human right and need for every man, woman and child. Having good water also is essential in breaking the cycle of poverty since it improves people’s health, strength to work and ability to function, yet over 884 million people around the world live without safe drinking water (WHO, 2008). In urban and predominantly rural communities with over 85% of the population living below an average income, traditional drinking water sources such as open reservoirs, springs and open wells are still being used. Water from such sources seldom complies with WHO limits for drinking water. Borehole water has become the most used source of water dating back to ancient China (202BC- 220AD), the Han dynasty used deep boreholes, reaching as deep as 600m (2000ft) (Loewe, 1968). This borehole water fills the spaces between the rocks and soils making an aquifer (Driscoll, 1986). Ground water depth and quality varies from place to place and this affects the quality of water obtained. Also, the various kinds of rocks and soils which it moves through affect it too. Water moving through underground rocks and soils may pick up natural contaminants, even with no human activity or pollution in the area (Beltaos*et al.*, 2006). In addition to nature’s influence, water is also polluted by human activities, such as defecation, dumping garbage, poor agricultural practices and chemical spills at industrial sites (Coe, 2001). Even though water may be clear, it does not necessarily mean that it is safe for drinking. It is very important to judge the safety of water with respect to its physical, chemical and bacteriological property. Over time, regions of Owerri enjoyed the municipal water supply that the government provided, including World Bank, Federal Housing areas and Sites and Services. As time passed, the distribution of municipal water supply seized and some areas like Federal Housing and Sites and Services were affected. With little or no municipal water supply, no rivers or nearby streams and the urgent need for safe water, indigenes of these localities faced the only source which is underground borehole water. As much as underground borehole water seemed to be a remedy, several factors affect its usage. Distance between the site of the borehole and septic/suck away tank, distance between borehole and refuse dump unit, depth of the borehole and the distance between borehole and neighbor’s septic tank are all factors to be solely considered prior to drilling borehole due to limited plot allocation.

However, according to WHO standard and guidelines, borehole water should be sunk 150ft below the ground level. It should be situated far and opposite from refuse disposal and sewage disposal unit. But in an area like Federal Housing and Sites and Services where houses are closely situated, these standards by default are not met. Additionally, the increasing rate of sinking of borehole in these areas would likely results into environmental hazard if not checked.

Hence, the necessity to check for the quality of borehole water in these regions is paramount, considering the rise of water borne diseases which is as a result of the alteration of some physiochemical and biological quality of the water.

This work investigated the physical, chemical and microbiological composition of borehole water samples from Federal Housing areas and Sites and Services area of Owerri, on a notion to see to its compliance with WHO/UNICEF standard WHO, (1994).

**Significance of the Study**

1. The study should provide information on the status of borehole water in Federal Housing and Sites and Services area of Owerri, Imo State.
2. At the end of the study members of these communities would have full knowledge about their borehole water and measures of adequate treatment where necessary.
3. As much as the study creates awareness to the members of the community, it also gives the government an insight on the quality of borehole water in the region and ways to regulate borehole sinking

**MATERIALS AND METHODS**

**Area of Study**

Borehole water from Federal housing and Sites and Services areas of Owerri, in Owerri North-West Local Government Area of Imo state were sampled because their only source of drinking water is borehole and they are well populated to fit into the scope of this study.

**Sample Collection and Types of Samples**

Six samples of water were collected from six different houses in these areas. They were obtained by pumping water fresh from the borehole through the tap, which was collected in sterilized labeled bottles.

**Table 1: Showing the sampling point and location of borehole.**

|  |  |
| --- | --- |
| Sampling Point | Location of Borehole |
|  Sites and Services | Chuk’sresidence (Sample D)Ebe’s residence (Sample G)Uwuru’s residence (Sample H) |
| Federal Housing | Okre’s residence (Sample M)Agbu’s residence (Sample F)Ngwe’s residence (Sample E) |

**Materials Used**

Sampled bottled borehole water, autoclave, incubator, spatula, petri dish, pH meter, thermometer, conductivity meter, beaker, evaporating dish, desiccator, hot plate, measuring cylinder weighing balance, watch glass, microscope, atomic absorption spectrophotometer, culture media (Chromocult agar and Centrimide agar), masking tape, conical flask.

**Sterilization of Materials**

All the glass wares used for this experimental study which include beakers, measuring cylinders, petri-dishes, were sterilized in an autoclave at 121oc for 15 minutes to avoid cross contamination of the samples.

**Experimental Methods**

The testing of the borehole water samples consist of the following; Physicochemical, Chemical, Microbiological analysis. These analyses were carried out according to the procedures of National Agency for Food and Drug Administration Control (NAFDAC) in Isolo-Oshodi expressway, Lagos state and as described by AOAC (2005), Mustafa, (1988), (WHO,1994) Itah and Ekpombok, (2004).

**PHYSICO-CHEMICAL ANALYSIS OF THE BOREHOLE WATER SAMPLES**.

**Determination of Temperature**

The temperature was determined with a centigrade thermometer capable of reading from 0oC to 110oC. The thermometer was dipped into the borehole water samples and the reading taken after equilibrium.

**Determination of pH**

The pH was determined with a pH meter equipped with a glass electrode. The pH meter was calibrated using standard buffers, buffer 4 and 7 and de-ionized water. The electrode was cleaned, dried and dipped into the different samples and the reading was recorded when the reading became stable. After the pH of the first sample was recorded, the electrode were re-washed with distilled water before dipped into subsequent samples until all the samples was tested.

**Conductivity**

The conductivity was determined with a conductivity meter which was calibrated using conductivity solution at 25oC. 50ml of each of the borehole water samples were poured inside different beakers then the meter was switched on and inserted into the beakers containing the borehole water samples. The conductivity value was recorded when the reading was stable.

**Total Dissolved Solids**

A clean platinum evaporating dish was placed in an oven set at 100oC for one hour. Then it was placed in a desiccator to cool and it was weighed. It was then transferred into a hot plate; thoroughly mixed with 100cm3and was transferred by a means of measuring cylinder. The cylinder was rinsed several times with distilled water to make sure that all suspended matter was transferred to the dish. After the sample was evaporated the dish and the residue were dried in an oven set at 103oC for one hour, cooled in the desiccator and then reweighed.

**Chemical Analysis of the Borehole Water Samples**

These were done using NAFDAC procedure which is also described by Adeyeye (1994) and it was done in triplicate.

**DETERMINATION OF METALS**

The metals determined include**;** zinc, copper, calcium, magnesium, cadmium, iron, and lead using atomic adsorption spectroscopy. The procedure was carried out as follows:

**Pretreatment of Sample for the Determination of Zn, Cu, Ca, mg, Cd, Fe, Pb.**

One hundred (100cm3) of the thoroughly mixed sample was transferred into a beaker and 5.0cm3 of concentrated nitric acid was added to it. The beaker was placed on hot plate and evaporated to near dryness making sure that the sample did not boil. The beaker containing the residue was cooled and another 5.0cm3 concentrated HNO3 added. It was covered with a watch glass and returned to the hot plate and heated until a gentle refluxing occurred. Heating was continued with additional conc. HNO3 as necessary until digestion was completed as signaled by a light coloured residue. Two (2.0cm3) of conc.HNO3 was added and the beaker warmed slightly to dissolve the residue. The walls of the beaker and the watch glass were washed with deionized distilled water and the resultant solution filtered to remove silicate and other insoluble materials that clogged the atomizer before making up the volume to 50cm3.

**Preparation of Standard Curve and Determination of Concentration of the Different Metals:**

All the stock solution prepared were equivalent to 1g metal in 1dm3 solution giving 1000mg/dm3 concentration. From these standard solutions equivalent to 5, 10, and 15mg/dm3 of the metals under determination were prepared. Each set of the standard solution was fed into the computerized spectrophotometer which calibrates itself internally. After feeding, the sample was aspirated into the oxidizing air- acetylene flame and a direct reading of the metals’ concentration was obtained at the metal’s absorbance wavelength which is as follows: Zn - 213.9nm, Cu – 324.8nm, Ca – 423nm, Mg – 285.2nm, Fe – 508nm, Cd – 228.8nm and Pb – 217nm.

**Microbiological Analysis of the Borehole Water Samples**

NAFDAC procedure was used as described by Itah and Ekpombok, (2004)and the analysis was done in triplicate. Plate count method was used for the analysis This method relied on micro-organism growing a colony on a nutrient medium so that the colony becomes visible to the naked eyes and the number of colonies on the plate can be counted. Cultured plates with about 30 to 300 colonies were used for enumeration. Samples were cultured on a nutrient media in a petri dish that is sealed and incubated. Typical one set of plates is incubated 22oc for 24hrs and second plate at 37oc for 24hrs. The composition of the nutrient media contained reagents that resist the growth of non – target organisms and made the target organism easily identified often by a color change in the medium. At the end of the incubation period the colonies were counted by microscope for accurate counting. The nutrient agar used and the respective color change for each of the micro-organisms includes: Chromocult agar used for coliform with a color change of pink, Chromocult agar used for *E. coli* and color change blue and centrimide agar was used for *Pseudomonas auregenus* with a color change of green.

**Statistical Analysis**

Data obtained were subjected to Analysis Of Variance (ANOVA) and the least significant difference (LSD) was used to separate their means.

**RESULTS AND DISCUSSION**

**Physicochemical Parameters**

The results of the physicochemical analysis carried out on the different samples of water are shown in Table 2. From the analyses of pH, all the samples fell within pH 4.62- 6.41 with sample M and G tending towards acidity at pH 4.62 and 4.85 respectively. Sample E, F, H fell at pH 5.79, 5.37 and 5.25 respectively and sample D at 6.41 which is the closest to the pH 7.0 i.e. neutral. Even though pH has no direct effect on human health, its indirect action on physiological process cannot be over emphasized (Adenkunle*et al.,* 2004; NSDWQ, 2007).From the table, the pH of the samples shows that sample D and E weresignificantly different (p < 0.5). Sample D was the most significant and it tended towards the regulatory standard of 7.0. Sample F and H were not significantly different and sample G and M were also not significantly different. The table also revealed that sample M had the least significance to the standard and it had the highest tendency towards acidity. The temperature of all the water samples was within the range of 260c -270c. This result shows that the water is safe for drinking, with respect to the temperature, as it did not exceed WHO limit of 370C. From table 2, all the temperatures of the samples were not significantly different. They all were in line with the standard of 0-370C. According to Nigerian Standard for Drinking Water Quality, the temperature of drinking water should not exceed ambient temperature.

Table 2 shows that the total dissolved solid (TDS) was lowest at 12ppm in sample H and highest in sample M at 37ppm, not exceeding NAFDAC standard of 500ppm.

The TDS is the term used to describe the inorganic matter present in solution or water. The principal constituents are usually calcium, magnesium, sodium and potassium cation, carbonate, hydrogen carbonate, chloride and nitrate anion (WHO, 1996). The presence of TDS in water may affect the taste. It has been reported that drinking water with extremely low concentration of TDS may be unacceptable because of its flat insipid taste (WHO, 1996). The turbidity of all the water samples used in this study is in agreement with both WHO and NSDWQ standard. Water turbidity is very important because high turbidityis often associated with higher level of disease causing microorganism, such as bacteria and other parasites (Shittu*et al.,* 2008).Also from Table 2 the total dissolved solid showed a significant difference (p <0.5)among the samples. Samples E, F and G were significantly the same and sample G and H were significantly the same. Sample H had the least total dissolved solid and sample M had the highest.

From the conductivity test carried outthe table revealed that the entire samples fell within the range of 6.9- 30.9 u꜡꜡꜡S/cm. samples E F and G were significantly the same and samples D, E and M were significantly different. Sample M had the highest conductivity (30.9u꜡꜡꜡S/cm) and sample E had the least conductivity (6.9u꜡꜡꜡S/cm).

**CHEMICAL PARAMETERS**

**Heavy Metals**

Results of heavy metals analysis carried out showed that sample E had the lowest zinc content at a concentration of -0.0465mg/l and sample H had the highest at -0.0914mg/l but did not exceed WHO limit of 3mg/l. From Table 3, there was significant difference among all the samples for zinc, although they do not pose any health effect. Lead concentration did not exceed WHO limit of 0.01mg/l, with sample H at -0.4514mg/l being the lowest and sample E highest at -0.3102mg/l. From the table, it is conspicuous that all the samples were significantly the same. High level of lead in the body can cause death or permanent damage to the central nervous system, the brain and kidney (Jennings *et al.,* 1996). All samples did not exceed the standard for copper (2mg/l) but the entire samples were significantly different. Sample G had the highest significance at -0.0718mg/l, while sample M had the lowest significance at -0.1348. None of the samples exceeded limits for magnesium and calcium with a standard of 1 and 5mg/l respectively. From Table 3, sample D, E F, G, H and M were all significantly different for calcium analysis (p<0.5). Sample D was the most significant (2.6444) and sample M was the least significant (0.0983). From this result, there will be little or no hardness of the water as a result of low calcium content. All samples were significantly different for magnesium analysis (p<0.5). From table 3, sample M had the highest significance (-0.1531mg/l) whereas sample D had the least significance (-0.3868mg/l). Magnesium also contributes to water hardness but with these results, there will be no hardness. Cadmium limit of 0.03mg/l was also not exceeded with sample H and M significantly the same and highest at -0.0476mg/l and sample G lowest at 0.0219mg/l. From the table, there will be little or no hardness of the water as a result of low calcium content, results of the sample did not exceed calcium limit of 5mg/L. All samples were significantly different for magnesium analysis. They did not exceed the permissible standard of 0.2mg/l. Sample M had the highest significance whereas sample D had the least significance. All the samples were significantly different for cadmium analysis except sample H and M which were significantly the same; they all did not exceed the standard limit of 0.03mg/l. All samples for iron analysis did not exceed the permissible standard of 0.3mg/l. they were all significantly the same. Results for iron analysis showed that the entire samples were significantly different (p< 0.5). Sample G had the highest significance (-0.124mg/l) while sample M had the least significance (-0.4102mg/l). Iron is essential in the body as it helps in blood circulation, it does not pose any health effect except it is excessive in the body.

**Microbiological Examination**

The result of the microbiological quality of the borehole water samples shown in Table 4 revealed that the coliform count ranged from 0-124cfu/100ml. Samples E and M fell at 0 and 5 respectively which is not beyond the standard of 10 coliform count/100 ml of sample. Samples D, F, G and H were above NAFDAC standard hence did not conform to standard. High total coliform counts vividly indicate that the water from samples D, F, G and H boreholes are faecally contaminated.

**Table 2: Ranked means and standard deviation of the physicochemical parameters**

Samples pH Temperature Total Dissolved solid Conductivity

 (0C) (ppm) (uS/cm)

D 6.4±0.1528a 27±1.000a 30±3.000b 13±1.000b

E 5.8±0.1000b 26±1.155a 16±2.000c 9.7±0.200c

F 5.4±0.2000c 27±0.000a 15±1.000c 9.8±0.200c

G 4.9±0.2000d 27±1.000a 16±2.000cd 10.1±0.400c

H 5.3±0.2517c 26±0.000a 12±1.000d 6.9±0.200d

M 4.6±0.1000d 27±2.000a 37±2.000a 30.4±0.110a

**Table 3 Mean and standard deviation of the heavy metals analysis**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Samples** | **Zinc (mg/l)** | **Copper (mg/l)** | **Lead (mg/l)** | **Calcium (mg/l)** | **Magnesium (mg/l)** | **Cadmium (mg/l)** |  **Iron (mg/l)** |
| D | -0.0902 ± 0.0002e | -0.0912 ± 0.0002c  | -0.5302 ± 0.0002a | 2.6444 ± 0.0002a | -0.3868 ± 0.0001f | -0.041 ± 0.0001c | -0.184 ± 0.001b |
| E | -0.0465 ± 0.0001a | -0.0959 ± 0.0001d | -0.2058 ± 0.7125a | 1.01710 ± 0.0001d | -0.2815 ± 0.0001c  | -0.0391 ± 0.0001b | -0.2668 ± 0.00003e |
| F | 0.0855 ± 0.0003d  | -0.1299 ± 0.0001e | -0.4954 ± 0.0001a | 0.10950 ± 0.0002e | -0.1642 ±0.0001b | -0.0419 ± 0.0002d | -0.236 ± 0.0002d |
| G | 0.0819 ± 0.0003b | -0.0718 ± 0.0002a | -0.4825 ± 0.0003a | 1.98520 ± 0.0002c | -0.2912 ± 0.0001d | -0.0219 ± 0.0002a | -0.124 + 0.0002a |
| H | 0.0914 ± 0.0003f | -0.0865 ± 0.0001b | -0.4814 ± 0.0003a | 2.5821 ± 0.0001b  | -0.3617 ± 0.0001e | -0.0476 ± 0.0001e | -0.2149 ± 0.0001c |
| M | 0.0845 ± 0.0028c | -0.1348 ± 0.0001f | -0.5138 ± 0.5324a | 0.0983 ± 0.0001f  | -0.1531 ± 0.0001a | -0.0476 ± 0.0001e | -0.3102 ± 0.0002f |
|  |  |  |  |  |  |  |  |

**Table 4: Microbiological Quality of then Borehole Water Samples**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sample** | **Coliform (cfu/100ml)** | **EscherichiaColi(cfu/100ml)** | **Pseudomonas aerogenus(cfu/100ml)** |
| D | 64 | 0 | -ve |
| E | 5 | 0 | +ve |
| F | 41 | 0 | -ve |
| G | 16 | 0 | -ve |
| H | 124 | 0 | +ve |
| M | 0 | 0 | -ve |

This finding is not surprising considering the high population and close proximity of these boreholes to septic tanks. The sewage could seep slowly into underground water, thereby polluting it. Also, long term usage of boreholes may lead to deterioration of the water quality, because the pipeline may become corroded with random cracks and in most cases clogged with sediment (Onemano and Otun, 2008). This will allow the passage of inorganic metals and bacteria.

The implication of this finding is the possibility of the presence of pathogens that may cause acute intestinal illnesses, which are generally considered discomfort to health and could become fatal for some susceptible groups (such as infants, elderly and those who are sick) (Addo*et al.,* 2009; Olowe*et al.,* 2005; NSDWQ, 2007). In addition to human and animal waste contamination, parasitic organism such as *Giardia* and *Cryptosporidium* may be present (EPA, 2003; Shittu*et al.,* 2008). Generally, underground water is often considered as the purest form of water (Shittu*et al.,* 2008), although it’s vulnerability to contamination could be due to improper construction, animal waste, proximity to toilet facilities, sewage, refuse dump site and various human activities surrounding it (Bilton, 1994; Shittu*et al.,* 2008). However, no *E. coli* were detected in all the water samples, which indicate that all the water samples are free from recent faecal contamination. The ability to detect faecal contamination in drinking water is necessary, as pathogenic microorganisms from human and animal faeces in drinking water pose the greatest danger to public health. The E. coli test carried out revealed that all the samples had a total of 0 counts at the end of the third day. This shows that the borehole water samples do not contain any fecal contamination. Pseudomonas aerogenus analysis carried out tested positive for samples E and H. This microbial analysis revealed that sample H had the highest form of contamination, as it tested positive for pseudomonas test and had the highest count of coliform.

**THE CORRELATION OF THE DISTANCE BETWEEN THE BOREHOLE, SEPTIC TANK AND REFUSE DUMP UNIT**

 The correlation of the questions generated from the questionnaire was shown in Figure 1. From the histogram, it is clear and can be derived that sample H had the closest distance from borehole to septic tank and borehole to refuse dump unit. This was made obvious in the result as sample H had the highest coliform count of 124cfu/100ml. High total coliform counts vividly indicate that the water from the wash boreholes is faecally contaminated. Water from this environment must be treated before drinking. Also, the graph revealed sample I had the farthest distance of borehole from neighbor’s septic tank and refuse dump unit and it was proven with a total coliform count of 0cfu/100ml.

**Figure 1 showing depth and distances derived from Questionnaire**

All samples labeled are according to Table 1

This statistically proves that all these factors affect the drinking water quality so they should be adequately monitored before drilling of borehole.

**COMPARISM OF RESULTS OF PHSICOCHEMICAL PARAMETERS**

Results of the pH, temperature, total dissolved solids (TDS) and conductivity were shown in Figure 2. Sample M had the highest conductivity and TDS. Sample D had the highest pH and the temperature of the entire sample ranged from 26- 270C. The physicochemical parameters do not have any direct effect on the water samples but are very necessary to fall within standard. The depth of the borehole of water sample Dis at 130 feet (figure 1) and the same sample has the most significant pH (6.4) tending towards neutrality. Sample G is the only borehole that was sunk at the standard depth of 150 feet and from the result, the temperature was appropriate, the TDS was not beyond standard, the conductivity also fell within the range but the pH was acidic (4.9). The acidity of this pH could be due to the topographical/geological status of the region or from the depth of the borehole, indirectly opposing the standard of 150 feet.

**Figure 2 showing the pH, conductivity, TDS and temperature.**

All samples labeled are according to Table 1

**CONCLUSION AND RECOMMENDATION**

**Conclusion**

Increase in population in Federal Housing Area and Sites and Services Area of Owerri, in Owerri North - West Local Government Area, Imo State, Nigeriacoupled with the rise in human activity pose a great pressure on provision of safe drinking water. However, the aim of the study was achieved. Therefore, there is an urgent need for awareness to be created about the present situation of these boreholes, to enlighten the people on the necessity for further treatment of this water where necessary before they can be used for drinking and domestic purposes.

**Recommendation**

As much as food is ensured to be consumed wholesome, so is the need for good water consumption. Therefore to reduce contamination in drinking water, a comprehensive laboratory test should be carried out. This can be enforced and supported by the government and on the other hand indirectly reduce inordinate drilling of boreholes. Also borehole water samples that do not meet the standard should be treated before consumption. Moreover, seminars and talk forum can be held on the necessity of consumption of potable water, as held by Nestle periodically in Lagos. This would help to insight inhabitants on the importance of potable water and its adequate quality.

**REFERENCES**

Adenkunle LV, Sridhar MKC, Ajayi AA, Oluwade PA, Olawuyi JF (2004) Assessment of the health and socio-economic implication of sachet water in Ibadan, Nigeria.Afri. J. Biomed. Res. 7(1):5-8.

Adeyeye, E. I. (1994).‘Determination of heavy metals in Illisha Africana, associated water, soil sediments from some fish ponds’, International Journal Environmental study, 45 : 231 – 240.

Addo KK, Mensah GI, Bekoe M, Bonsu C, Akyen ML (2009) Bactrioelogical quality of sachet water produced and sold in Teshie-Nungua, Surburbs of Accra, Ghana. Afr. J. Food Agric. Nutr. Dev. 9(4):1019-1030.

Beltaos S, Prowse T, Bonsari R, Macky L, Romolo A, (2006). Climatic Effect of the Jam Flooding of the Peace Athabasca Delta Hydrol process 20: 4031-4050.

Bilton G (1994). Waste Water Microbiology.Gainesville, New-York.WileyIBS.pp. 118.

CIA-the world feedbook Central Intelligent Agency, Retrieved 20 December 2008. http://www.cia.gov

Coe M.T (2001) Human and Impacts on the Water Research of Chad Basin, J Geophys Res- Atmos.,vol 2 (2) 3349.

Driscoll, F.G., 1968, Groundwater and Wells, St. Paul, Minnesota, Johnson Division, Second edition, p. 1,089

Environmental Protection Agency EPA (2007).Factolds: Drinking water andwater Statistics. <http://www.epa.gov/safewater/data/getdata.html>. Accessed September I2, 2014.

.

Gedney, N., Cox P.M, Belts R.A, Boucher O.,Huntingford C., (2006): detection of a direct carbon dioxide effect in continental river runoff records*.*vol43,pp 835- 838.

Gleick P. H (1993).Water in crisis: a guide to the World’s fresh Water resources, “Water reserves on the earth “.Oxford University Press, pp 13, table 2.1.

Gleick P. (1996).‘Basic requirement for human activities: meeting basic needs’, International Water 21 (2),83 – 92.

Itah, A. Y., and Ekpombok, M. U. M. (2004).Pollution status of swimming pools in south-south zone of south-eastern Nigeria using microbiological and physicochemical indices. *Southeast Asian journal of tropical medicine and public health*, *35*, 488-493

Jennings,G.D. Sneed, R. E., Clair, M.B., 1996: Metals in drinking water. Published by: North Carolina Cooperative Extension service Publication no.:AG-473-1. Electronic version 3/1996.

Linton, J. (2010). *What is water?: The history of a modern abstraction*. UBC Press.

Loewe, M., (1968) *Everyday Life in Early Imperial China during the Han Period 202 BC-AD 220.*  London: B.T. Bats ford ltd.: New York: G.P, Putnam’s Sons, p. 194.

Mustapha, A.I.: Ibrahim, A., Hauna Y.I and Abubakar, S. (2013). Physiochemical and bacteriological analyses of drinking water from wash boreholes in Maidugiri metropolis. *African journal of Food Sci. vol.* 7(1): 9-13

NSDWQ (2007). Nigeria Standard for Drinking Water Quality, Nigeria Industrial Standard, Approve by Standard Organization of Nigeria Governing Council. ICS 13. 060. 20: 15-19.

Olowe OA, Ojurongbe O, Opaleye OO, Adedosu OT, Oluwe RA, Eniola KIT (2005) Bacteriological Quality of Water Samples in Osogbo Metropolis. Afr. J. Clin. Exper.Microbiol. 6(3): 219-222.

Onemano JI, Otun JA (2003). Problems of Water quality standard and monitoring in Nigeria. Paper presented at the 29th WEDC International Conference at Abuja Sheraton Hotel and

Shittu OB, Olaitan JO, Amusa TS (2008) Physico-Chemical and Bacteriological Analysis of Water Used for Drinking and Swimming Purpose. Afr. J. Biochem. Res. 11:285-290.

World Health Organisation (1994).Guideline value for Food and Drinking Water, Geneva Conference, Switzerland, pp 3.

World Health Organization (WHO) (1996). Total dissolve solid in drinking water. Guideline for drinking water quality. 2:0-1.

World Health Organization (WHO) (2008).Combating water borne diseases at the household level, Geneva, Switzerland.Pp 24.Tower, Nigeria on 22-26 September 2003.