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Water Drinking Quality Assessment of a Hand Dug-Well using Treatment Plant Installed in Akure, Nigeria

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Abstract: It has been established by researchers that cost of installing hand-dug well for water generation for human consumption is of low cost and affordable by many people compared to bore holes water cost. The level of water quality needs assessment before consumption. In this study, ground water quality (hand dug-well water) was assessed and its suitability for drink ability was compared with Nigeria Industrial Standard (NIS) for water drinking quality in Akure city, Nigeria. Samples as-received (initial sample) and treated sample were taken to laboratory for analysis. Certain physical, chemical (organic and inorganic) disinfectants and micro-biological constituents in the water samples were examined before and after the treatment of the water samples to determine the water quality for domestic consumption. Laboratory analysis of water parameters also disclosed the fact of significant contamination in ground water, since, the initial water sample has colour, odour and taste. The initial sample has total coliform count higher than NIS standard which is an indication of faecal contamination whereas the treated sample was found within acceptable limit. Therefore, the water needs to be treated before consumption. The pH value for the treated water sample (5.8-7.5) was slightly acidic and fairly neutral. Other chemical inorganic parameters such as aluminum, arsenic, barium, hardness and so on are found to be within the specified standard for the treated sample. Treating the water before drinking will be appropriate to the consumer to reduce any water health challenge.

Key words: Water quality assessment, ground water, chemical inorganic parameters, physical parameters, hand dug-well, micro-biological parameters

INTRODUCTION

Water is one of the most common substances and vital liquid for life on earth for man, animals and plants (Wright, 2011; Andrew, 2012; Mohsin *et al*., 2013). It is a good solvent for many substances and rarely occurs in its pure form in nature (Adewumi *et al*., 2014). Natural water can be grouped into either surface water which includes rainwater, streams, lake water, river water, sea water or ground water such springs, well-water or boreholes (Garg, 2009). Well-water is a ground water source which sometimes contains a lot of clay and other mineral salts. Although, ground waters are more reliable for domestic and agricultural irrigation purpose (Haruna *et al*., 2008; Shyamala *et al*., 2008; Okeola *et al*., 2010; Oko *et al*., 2014) to avoid underground water pollution, well or borehole as source of drinking water should be situated away from latrine and lined with bricks and be covered. In Africa, availability of good water is scarce. In Nigeria, both the rural and the urban areas lack portable water. People in rural areas depend on streams and rivers for their domestic use and other activities (Oko *et al*., 2014) while urban centres largely depend on usage of well water or borehole, since, government had failed in its responsibilities to her populace. The quality of life and its household community can significantly improve when better water supply is provided (Amirtharajah and O'melia, 1990). Insufficient or unsafe water in developing countries as well as local factors such as climate, population density and local practices have been attributed to the outbreak of some diseases in poor or developing countries (Bajwa, 2003; Sakai *et al*., 2013). Furthermore, Sakai *et al*. (2013) gave the estimate of people dieing of diarrheal diseases yearly to be about 2 million without mentioning other water borne diseases. Moreover, Daramola and Akindureni (2017) reported that

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among water borne diseases, the leading cause of death among infants and children in Nigeria is diarrhea. In order to control these diseases, a sufficient amount of safe drinking water is important. Hence, improvement of the water quality matters as any chemical composition imbalance of water beyond the permissible limits or standard imposes a harmful effect on human and environment (Syed *et al*., 2014).

In tropical countries, water consumption tends to be high because of high seasonal temperature variations (Bunke and Droge, 1984), therefore, water quality assessment is paramount. Water quality depends upon its origin and history. Climatic, geographic and geologic conditions all play important parts in determining water quality (Chatterjee, 2001). This has caused various researchers (Sakai *et al*., 2013; Asadullah *et al*., 2013; Soomro *et al*., 2011; Ahmad *et al*., 2012; Khan *et al*., 2013; Daniel *et al*., 2016) to conduct numerous studies in different areas within the same area, state and country. Akure is a growing city in Nigeria owing to rapid development in infrastructures, new industries establishment as well as expansion of older ones (Oko *et al*., 2014). These have led to population increase and invariably more demand of quality water. Various studies have been conducted to examine and evaluate the quality of water drinking in Akure. Adewumi *et al*. (2014) examined the physico-chemical properties of water as well as the concentration level of heavy metals and effluent composition in Ala River and compared with World Health Organization (WHO) standard. Results revealed that most of the water parameters determined where within the permissible limits for portable water except for Mn, Ni and Pb. The water was concluded to be safe for different uses except for consumption purpose unless it is treated. Water samples were taken from three different water corporations in Akure (Daramola and Akindureni, 2017). Standard water quality tests were conducted on each sample and compared with NAFDAC and WHO standards for drinking water. Results showed that some of the samples from the companies were fit for consumption while some were not. It was recommended that chlorination facilities be installed for quality water production. Furthermore, hydrochemical analysis was conducted on both surface and ground water samples in Akure by Ojo *et al.* (2014). Standard analytical techniques were used on the samples. Results revealed variations due to different samples used, however, it was stated that all samples used were of freshwater type. These and more studies have been conducted in different areas of Akure where the populace are exposed to unsafe portable water due to various contamination activities. Every household now provides water for usage through well digging or borehole. The quality of the water obtained should be ascertained for good quality before consumption. This study aims at assessing the drinking water quality of a well dug in Akure for occupants in a three bedroom of four flats.

MATERIALS AND METHODS

Description of the study area: The study was conducted in Akure, the capital of Ondo State, Nigeria. Oba Ile Housing Estate in Akure North Local Government area represents the main study area. These areas are surrounded by government/corporate buildings and residential homes. Figure 1 displayed the location of study.

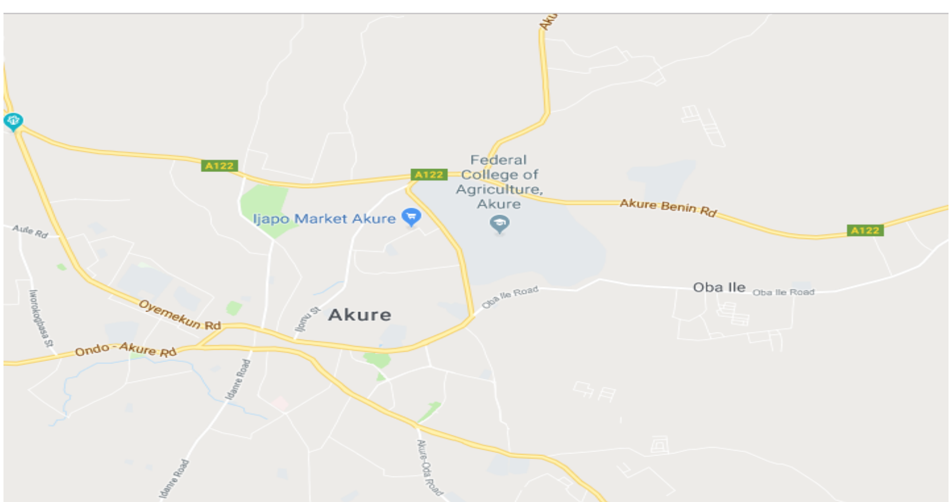

Fig. 1: Location of the study area in Akure

Collection: Water samples were obtained from hand dug well sited in the location of the study. The water samples were collected in sterilized wrapped bottles for a period of one month in a deep freezer to deter necessary chemical additions that will contaminate the samples (Ojo *et al.*, 2014). The samples were brought to the laboratory for analysis. Standard methods as stated by Nigerian standards for drinking water quality were followed in carrying out the sampling and analysis. The initial and treated samples were analysed.

Analysis: Physical/organoleptic parameters such as colour, odour, taste, temperature and turbidity were determined. Water possesses some level of colour. Thermometer calibrated in degree Celsius was dipped into the water sample to determine its temperature while a turbidity meter was used for turbidity determination. pH was obtained using pH meter.

Chemical organic and inorganic parameters such as detergents, mineral oil, pesticides, phenols, poly aromatic hydrocarbons, oxidisability, aluminum, arsenic, barium, cadmium, chloride, copper, fluoride, hardness ($CaCO_3$), hydrogen sulphide, lead and sodium were determined using titrimetry method and spectrophotometer. Micro-biological limit test/bacteriological analysis were carried out using viable counting technique (CFU).

RESULTS AND DISCUSSION

Physical parameters: The initial water sample has values higher than the acceptable required standard for colour, odour and taste which are 16, 16.3 and 16.4 TCU, respectively, in Table 1. This implied that the water sample has colour, odour and taste. Decomposition of organic matter and sewage leakage could attribute to colours in ground water. Moreover, the unacceptable taste and odour values obtained could be as a result of decayed organic matter, living organisms and iron embedded in the well (Mohsin *et al.*, 2013). Although, there is no health based effect of colour of water, however, when the colour is of higher grade, further investigation should be carried out to ascertain the presence of organic matter or industrial waste (World Health Organization, 2004). The temperature of the sample was within the acceptable range. However, after the water sample has been treated, the colour, odour and taste where observed to be below the acceptable level for consumption. The turbidity level is 4.9 and 4.6 NTU for both the initial and the treated samples, respectively (Table 1). The turbidity level is below the acceptable standard for both

Table 1: Physical/organoleptic parameter and maximum allowable limits

Parameters/Units	Standard acceptable levels	Initial samples	Treated samples
Colour (TCU)	≤15	16.0	14.5
Odour	≤15	16.3	14.7
Taste	≤15	16.4	14.6
Temperature (°C)	Ambient	-	-
Turbidity (NTU)	≤5	4.9	4.6

the NIS and WHO standards for drinking water. The clarity of water is affected by turbidity which presents undesirable look of the water (Oko *et al.*, 2014). Turbid water poses microbiological contamination potentiality which may constitute different health challenge (Sorlini *et al.*, 2013).

Chemical organic constituents: Although, the initial and the treated water samples chemical organic parameters determined met the required NIS standard as shown in Table 2 but for values higher than the required limits there would be direct health impact on the consumer. Consummation of water above these limits can possibly lead to carcinogenic occurrence for the consumer. It was observed that better outputs were obtained for every parameter when initial and treated samples were compared. The water sample was found to be less of chemical organic parameters and this made it suitable for usage.

Chemical inorganic constituent: From Table 3, the pH value obtained for the initial water sample was 7.5-9.5 which was not in line with the acceptable standard. The treated sample (5.8-7.5) showed acceptability, since, it fell within the NIS standard for water drinking quality. This implied the water sample was slightly acidic and fairly neutral. The acidic tendency could enhance corrosion of household plumbing system (Daramola and Akindureni, 2017). The values obtained for the treated sample vary slightly with the work by Adewumi *et al.* (2014) where the value obtained was between 7.00 and 8.40. This was fairly basic (alkaline) in nature. The pH value does not have any health implication on the consumer.

The mean values for aluminum, arsenic, cadmium, chlorine, copper, fluoride, hardness, hydrogen sulphide, lead and sodium for both the initial and treated samples were found to be with the acceptable limits, respectively. However, the value obtained for barium in the initial sample (0.9 mg/L) was higher than the required standard. The treated sample with 0.68 mg/L was observed to be in the standard acceptable level. Since, the treated sample values for all the chemical inorganic parameters were below the maximum permitted level, the water was said to have no health impact such as cancer, hypertension, gastrointestinal disorder and so on.

Table 2: Parameterfor chemical organic constituents

Parameters/Units	Standard acceptable levels	Initial samples	Treated samples
Detergents (mg/L)	≤0.010	0.0060	0.0050
Mineral oil (mg/L)	≤0.003	0.0028	0.0026
Pesticides (mg/L)	≤0.010	0.0070	0.0050
Phenols (mg/L)	≤0.001	0.0008	0.0005
Poly aromatic hydrocarbons (mg/L)	≤0.007	0.0069	0.0068
Total organic carbon or oxidisability (mg/L)	≤5.000	4.9000	4.6000

Table 3: Parameter for chemical inorganic constituents

Parameters/Units	Standard acceptable levels	Initial samples	Treated samples
Aluminum (Al) (mg/L)	≤0.2	0.18	0.16
Arsenic (As) (mg/L)	≤0.01	0.006	0.005
Barium (mg/L)	≤0.7	0.9	0.68
Cadmium (Cd) (mg/L)	≤0.003	0.0026	0.0025
Chloride (Cl) (mg/L)	≤250	249.8	249.6
Copper (Cu) (mg/L)	≤1	0.9	0.8
Fluoride (F) (mg/L)	≤1.5	1.49	1.46
Hardness (as $CaCO_3$) (mg/L)	≤150	149.7	149.5
Hydrogen Sulphide (H_2S) (mg/L)	≤0.05	0.046	0.045
Lead (Pb) (mg/L)	≤0.01	0.006	0.005
pH	≤6.5-8.5	7.5-9.5	5.8-7.5
Sodium (Na) (mg/L)	≤200	199	198

Table 4: Parameter for dis-infectants and their by-products

Parameters/Units	Standard acceptable levels	Initial samples	Treated samples
Free residual chloride (mg/L)	≤0.2-0.25	0.3-0.28	0.2-0.249
Trihalomethanes total (mg/L)	≤0.001	0.0006	0.0005
2, 4, 6-trichlorophenol (mg/L)	≤0.02	0.018	0.016

Table 5: Parameter for micro-biological limits test

Parameters/units	Standard acceptable levels	Initial samples	Treated samples
Total coliform count (Cfu/mL)	≤10	12	9.8
Thermo tolerant or *E. coli* (Cfu/100 mL)	0	0	0
Faecal Streptococcus (Cfu/100 mL)	0	0	0
Clostridumperfringens spore (Cfu/100 mL)	0	0	0

Dis-infectants investigation: The standard acceptable levels, initial sample and treated sample results for dis-infectant parameters and their by-products were presented in Table 4. According to Nigerian standard for drinking water quality obtained from Nigerian industrial standard (SON., 2015), the health impact of water with high disinfectants level is carcinogenic. It was observed from Table 4 that the initial sample has a value of free residual chlorine above the recommended standard. However, when it was treated, the value obtained fell in the range approved. For both the initial and treated values of trihalomethanes and 2, 4, 6-trichlorophenol, the values were within the permissible limit. This implied that the water were it for drinking based on the requirements met.

Micro-biological investigation: The total *E. coli* form in the initial water sample has a value higher than the prescribed standard. This implied that there were an indication of faecal pollution of the water or the water line has been mixed with sewerage line (Daramola and Akindureni, 2017; SON., 2015). The result of the treated sample showed that the total *E. coli* form in the water is lesser in comparison with the initial sample. In Table 5, *E. coli*, faecal streptococous and clostridium perfringens spore for both the initial and treated samples are found to be appropriate with the standard. This implied that there are no urinary tract infections or diarrhea, nor recent or intermittent faecal contamination in the water sample (SON., 2015).

CONCLUSION

Assessment of the quality of hand dug-well water by way of the parameters obtained after analyses for both the initial and treated samples has been investigated. The physico-chemical and micro-biological parameters for the treated water sample were found to be suitable for consumption and for domestic purposes. In the micro-biological analysis done, the initial sample exhibit total coliform count higher than the NIS standardand pose a threat to human's health. The total *E. coli* form seen in the initial sample shows the indication that the well water may have been contaminated. Hence, the well water dug was said to be suitable when treated.

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