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Safety assessment of drinking water in Anyigba town, Kogi State, Nigeria.

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Abstract

Physicochemical and bacteriological analyses were carried out on water samples obtained from Kogi State University borehole, Anyigba township borehole, River oganeaji, River okura and vended sachet water used for drinking and food preparation in Anyigba, Kogi state, Nigeria following the standard methods of analyses. The results obtained were compared with World Health Organization (WHO) standards for drinking water. With the exception of water samples obtained from River Okura and River Oganeaji that did not comply with turbidity (8.0 and 7,0 NUT) and taste standards respectively, samples obtained from the University and township boreholes as well as vended sachet water were within the standards set for, pH, odour, total dissolved solids, total hardness, calcium and magnesium. Microbial analysis showed that none of the samples complied with the bacteriological standards as total viable counts exceeded 1.0 × 102 and coliform bacteria were present in vended sachet water and samples from Rivers. Escherichia coli, Salmonella spp, Staphylococcus aureus, Shigella spp and Bacillus spp were isolated from samples of water from Rivers Oganeaji and Okura respectively; hence these were the most polluted water sources. Borehole water was found to be the safest in terms of bacteriological quality. The study demonstrated that most water sources used for drinking and food preparation in Anyigba do not meet the potable

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water standards according to WHO, hence they can be potential sources of water borne diseases.
Key words: Physicochemical, bacteria; drinking water; water analysis; Anyigba.

Introduction

Water is one of the most important and abundant resources on earth (Frank *et al.,* 2019). It is however estimated that about 1.8 billion people (28 % of the world's population) globally had no access to safe drinking water in 2010 and that additional 1.2 billion (18% of the world's population) use water from sources with significant sanitary risks (Friedland *et al.,* 2015). It has been projected that by 2030 more than half of the world population may be facing water based vulnerability as water demand in some developing Nations will exceed supply by 50 % (Onyango *et al*., 2016). Increase in human population, growing economies, changing lifestyles and evolving consumption patterns exert enormous pressure on the provision of safe drinking water especially in developing countries (Frank *et al.,* 2015). Studies have shown that more than 80 % of diseases such as diarhoea, cholera, dysentery etc in the Tropics are traceable to unsafe drinking water leading to more than 30 % of associated preventable deaths (Mberekpe and Eze, 2014; Oladairo and Aiyedun, 2016; Baghat *et al.,* 2018). Water is vital to our existence in life and its importance in our daily life makes it imperative that thorough microbiological and physicochemical examination be conducted on water used for drinking and food preparation. Natural water sources are at risk of contamination from numerous sources of contaminants e.g., extensive agricultural and industrial activities coupled with urbanization resulting into the contamination of aquifer (Reuben *et al.,* 2018). There are many pollutants in groundwater due to seepage of organic substances and inorganic chemicals, heavy metals and pathogenic microbes from human and animals (Edokpai *et al.*, 2018). In Nigeria, majority of rural populace do not have access to potable water and therefore, depend on stream, river, well and borehole water for drinking and domestic use (Shittu, *et al.,* 2008).

Water intended for human consumption, preparation of food and drinks or for personal hygiene should not contain agents pathogenic for humans. However, varieties of pathogenic organisms that continue to live in water include bacteria, fungi, protozoa, algae and viruses where they form a complex ecosystem whose dynamics are usually difficult to understand (Onesimus, 2019).These varieties of microorganisms play an essential role for contamination of water and results in a variety of outbreaks of diseases and death.

Potable or drinking water refers to water that has acceptable quality (as ascertained by WHO guidelines or National standard for drinking water quality) in terms of physical, chemical and microbiological characteristics so that it can be safely used for drinking and cooking (Onesimus, 2019). Potable water therefore, must meet strict criteria and standards to ensure that water supplied to the public is safe and free from pathogenic organisms as well as toxic compounds. Pathogen free water is attainable by selection of quality uncontaminated sources of water or by efficient treatment and disinfection of water known to be with human or animal faeces. Microbial faecal contamination is the most common reason for water to be considered unsafe for drinking and food preparation because of the high probability of the presence of pathogenic organisms (Mbekpere and Eze, 2014; Lukabye and Andama, 2017). Some of these indicator organisms include *Escherichia coli,* Clostridium pafringens, Klebsiella species and E. feacalis which serve as indicator for the presence of pathogenic bacteria such as *Salmonella typhi, Vibrio cholerae* and *Pseudomonas aeruginosa*. These pathogens cause diarrhoea, salmonellosis, dysentery and gastroenteritis which are common among rural dwellers of developing countries (Onyango *et al.,* 2016). WHO (2004) reported that millions of people die yearly from diarrhoea disease and a larger proportion are children aged below five years. It was estimated that safe water could prevent 1.4 million deaths from diarrhoea each year (Friedland *et al.*, 2015).

Anyigba is a town in the Eastern part of Kogi State of Nigeria. It is a fast growing town because of the presence of a State-owned University. The population of Anyigba as at 2010 was estimated to be Eighty thousand (Tokula *et al.,* 2012). There are no tap water running in Anyigba presently, despite the installation of taps at designated points owing to vandalization, poor maintenance culture and total negligence on the part of Government. The inhabitants of Anyigba therefore, depend on River (Oganeaji), River (Okura), bore holes and vended sachet / bottled water for drinking and domestic requirements. Continuous consumption of water from these sources is of public health concern. An understanding of the physicochemical and microbial properties of water consumed in Anyigba is therefore pertinent. Therefore, the focus of this paper was to assess the quality of water used for drinking and food preparation in Anyigba, Kogi state in Nigeria based on the key physicochemical and bacteriological properties in relation to WHO standards on water used for drinking. This is supported by the fact that several water-borne diseases have been reported in Anyigba Government Hospital. Also information on the quality of drinking water in Anyigba is scanty.

Materials and Methods

Sample collection.

Samples of water were obtained from river Oganeaji, river Okura, Anyigba township borehole, Kogi state University, township borehole and popular sachet water vended in Anyigba. The samples were collected in sterile glass bottle with screw closure maintaining aseptic condition. They were transferred in cool boxes to the Food Science Laboratory, Faculty of Agriculture, Kogi state University, Anyigba for subsequent analysis.

Determination of Physicochemical Properties

The pH and total dissolved solids (TDS) of the collected samples (50 mL of water each) were determined at the point of sampling using portable hand pH meter (Hanna instrument, Beiging, China) and digital TDS- meter as described by WHO (2011). Turbidity of 50 mL of water sample was determined using a turbidimeter as described by APHA (2005). Titration method involving 0.1 M disoldium salt of ethylenediamine Tetraacetic acid (EDTA) with 25 mL of water sample and eriochrome black T indicator (Sigma-Aldrich, Steinheim, Germany) was used to determine the total hardness of the water samples (APHA, 2005). Tests for odour and taste were carried out according to the method described by Sule *et al.* (2011). For each water sample, 20 mL volume was poured into a clean beaker. The beaker was then shaken vigorously to check for any frothing and allowed to settle. The beaker was then observed under bright light for presence of any particulate matter and then brought close to the nose to observe for any odour present. About 20mL of each sample was tasted with the tongue and immediately rinsed with taste free distilled water after each sample, the result was recorded accordingly.

Bacteriological Analyses.

Bacteriological analysis was carried out following the method described by APHA (2005). The viable bacterial count was determined in duplicate using pour plate method with nutrient agar as the medium of choice. The plates were inoculated aerobically at 37 oC for 24h. The total coliform count per 100mL of the water sample was determined using multiple tube fermentation technique with reference to the Most Probable Number (MPN). A 100mL of each water sample was inoculated into bottles of sterile double strength MacConkey broth each bottle containing an inverted Durham tube for gas collection and detection. This was inoculated aerobically at 37 ^{o}C for 24h and positive tubes were noted. A loopful of broth from the positive tubes in the presumptive test was transferred into EC (Elevated coliform) broth and incubated at 44 ^{o}C. Developed colonies were purified using the streaking method. The pure culture was then characterized on the basis of colony morphology, cellular morphology staining and biochemical reactions and subsequently identified as described by Frank et al. (2019).

Results

Table 1: Physicochemical properties of water used for drinking in Anyigba

Parameter	A	B	C	D	E	WHO Standard
pH	6.7 ± 0.03	6.3 ± 0.07	8.3 ± 0.07	8.0 ± 0.02	7.5 ± 0.03	6.5-8.5
Odour	U	U	U	U	U	U
Taste	-	-	+	+	+	-
Turbidity (NTU)	2.0 ± 0.00	3.0 ± 0.01	7.0 ± 0.04	8.0 ± 0.03	2.5 ± 0.02	6.0
Total dissolved solids (mg/l)	26.7 ± 0.09	50.7 ± 0.14	340 ± 0.26	400 ± 0. 17	80 ± 0.21	500
Total Hardness (mg/l)	20.5 ± 0.11	36.8 ± 0.27	70.6 ± 0.14	65.0 ± 0.17	40.5 ± 0.14	500
Ca (mg/l)	40.7 ± 0.13	49.0 ± 0.16	35.0 ± 0.11	30.0 ± 0.09	35.0 ± 0.12	65.0
Mg (mg/l)	30.3 ± 0.11	36.5 ± 0.15	25.0 ± 0. 08	28.0 ± 0.12	34.0 ± 0.16	50.0

Values are means ± standard deviation of triplicate determinations.

Keys:
A = Kogi state University Borehole, B = Anyigba Township Borehole, C = River Oganeaji, D = River Okura, E = Sachet water popularly vended in Anyigba, WHO = World health organization, U = Unobjectionable, - = No taste, + = has taste.

Table 2: Bacteriological analysis of water used for drinking in Anyigba

Sample	Total viable count (cfu/ml)	Total coliform count (cfu/ml)	Faecal coliform count (cfu/ml)
A	1.0×10^3	*	*
B	2.1×10^3	*	*
C	3.6×10^4	2.0×10^2	1.8×10^2
D	4.6×10^5	2.6×10^3	2.3×10^2
E	2.2×10^2	1.6×10^2	*
WHO Standard	1.0×10^2	*	*

Keys:
A = Kogi state University Borehole, B = Anyigba Township Borehole, C = River Oganeaji, D = River Okura, E = Sachet water popularly vended in Anyigba, WHO = World health organization, * = absent

Table 3: Distribution of bacterial species in water used for drinking in Anyigba.

Isolate	A	B	C	D	E
Escherichia coli	Absent	Absent	Present	Present	Absent
Salmonella spp	Absent	Absent	Present	Present	Absent
*Staphylococcus aureu*s	Absent	Present	Present	Present	Present
Vibrio cholera	Absent	Absent	Absent	Absent	Absent
Shigella spp	Absent	Absent	Absent	Present	Absent
Bacillus spp	Absent	Absent	Present	Absent	Absent

A = Kogi state University Borehole, B = Anyigba Township Borehole, C = River Oganeaji, D = River Okura, E = Sachet water popularly vended in Anyigba, WHO = World health organization.

Discussion

Physicochemical properties

Physicochemical composition of water used for drinking and domestic purposes in Anyigba is presented in Table 1. The pH of water samples ranged between 6.7 and 8.3 which are within the limit considered suitable for human consumption (WHO, 2011). The pH of water plays an important role in the survival rate of microorganisms and neutral pH will support a large number of bacteria. Turbidity of water measures the degree to which water loses its clarity due to the presence of suspended particles. These suspended particles could serve as reservoirs for disease causing organisms such as viruses, bacteria and other particles, which can pose a health hazard (Frank et al., 2019). From the present study, water from Okura River (sample D) and river Oganeaji (sample C) had turbidity values greater than 5 nephelometric turbidity units (NTU) which is the limit recommended By WHO (2011). This implies that water from these sources act as potential habitat for pathogenic organisms due to high levels of suspended particles. Suspended particles act as substrate for microorganisms in water, thus promoting growth of microbial population. The high value of turbidity can be attributed to sediments of soil and plants as well as the shallow nature of water bodies, which could lead to acquisition of suspended particles (Palamulem and Akorth, 2015).

Total dissolved solids in water measures the combined content of inorganic and organic substances confined in molecular, ionic and micro granular suspended forms. All water samples analyzed have total dissolved solids within the acceptable limits recommended by World Health Organization. High total solids in water may interfere with the clarity, colour and taste of water thereby, indicating the presence of toxic minerals and microorganisms of health importance in water (Onyango et al., 2018). Total dissolved solids are primarily affected by depth, turbulence, runoff and sediment load generated by the flow dynamics of aquatic system. Total hardness of water samples ranged between 20.5 and 70.6 mg/L. These values were within WHO acceptable limits of 500mg/L for drinking water and water for domestic use (WHO, 2011). The values obtained in this study were in consonance with the values previously reported by Reuben et al. (2018) who studied the physicochemical parameters of drinking water in Keffi, Nigeria. Hard water does not only affect laundry at home, it also causes discoloration of cooking utensils at home. Water hardness is occasioned by carbonate and bicarbonate of calcium and magnesium. Their relative low concentration as recorded was indications of low contents of carbonate and bicarbonate.

Bacteriological analyses

Results of the bacteriological analysis of the water samples are presented in Table 2. The total viable count measures a range of viable bacteria that are naturally present in the environment (Shitu et al., 2008). The total bacterial counts for all the water samples examined exceeded the limit of 1.0 × 102 cfu/mL which is the standard limit of total viable count for drinking water (WHO, 2011). The total viable count is indicative of the presence of high organic and dissolved salts in the water. The sources of bacterial contamination include surface runoff, pasture and other land areas where animal waste are deposited. Other sources include seepage or discharge from septic tanks, sewage treatments facilities and natural soil / plant bacteria (Onesimus, 2019). These contaminants are reflected in the higher loads obtained in Oganeaji (3.6 × 103 cfu/mL) and Okura Riverrs respectively.

The WHO recommends that there should be no coliform in drinking water per 100ml of water (WHO, 2011). Samples of water from boreholes (samples A and B) were not contaminated with coliforms. Water samples from Oganeaji, Okura Rivers and vended sachet water (samples C, D and E respectively) were contaminated with coliform bacteria (Table 2).The presence of coliforms in water points out the possibility of contamination by other pathogenic microorganisms that further renders such water unsafe for drinking and food processing (Onyango et al., 2018) Sachet water analyzed contained total coliform but was devoid of faecal coliform. Therefore, it may be misleading to conclude that sachet waters vended in Anyigba town are microbiologically unsafe for human consumption. Because total coliforms are found ubiquitously in the environment, their presence may not always mean evidence of contamination by human faeces. The presence of coliform bacteria however implied inadequate treatment (Bahgat et al., 2018) or may relate to poor sanitary conditions of operatives. This presents a risk factor and portends serious health hazards as operatives may be a carrier of enteric pathogen and a likely source of contamination.

Bacterial isolates

Further selective plating and biochemical tests conducted for some selected colonies (Table 3) revealed the presence of E. coli, Salmonella typhi, Staphylococcus aureus, shigella spp and Bacillus spp in samples obtained from River sources. Previous researchers (Reuben et al., 2018) reported similar results in water obtained from Rivers in Keffi, Nigeria. The high occurrence of members of Enterobacteriacea family in water samples obtained from Rivers Okura and Oganeaji further confirmed the high coliforms count observed. The isolation of these potential pathogenic organisms poses health risks to the users of this water. The presence of E. coli and opportunistic pathogens in samples C and D indicated resent faecal contamination and is of major health importance. Similar studies were carried out by Basic-Johnson et al. (2017) who analyzed quality of drinking water in some selected communities in southwest Nigeria, the results showed that some water sources were contaminated due to faecal organisms such as E. coli and Salmonella species. The presence of Staphylococcus aureus suggests human contamination as the organism is commensal on the skin and nostril of humans (Olowe et al., 2006). The organism may be associated with food poisoning which involves the elaboration of heat labile toxins. Hence, the concentration of these microbial indicators and pathogens in the water samples analyzed are indications of serious bacterial contamination. Thus, water from these sources should be treated before use for drinking and for food preparation.

Conclusion

The study examined the physicochemical and microbiological parameters of water used for drinking and food preparation purposes in Anyigba, Kogi state Nigeria. Although some of the physicochemical parameters fall within the WHO acceptable limits, some were however observed to be above the requirements. Water samples obtained from River sources were found to be the most contaminated in terms of bacteriological quality. With the exception of boreholes, the bacteriological quality of sachet water vended in Anyigba was not within the outlined quality standards according to WHO. The condition under which sachet water `are produced and packaged will need to be improved. The National Agency for Food and Drug Administration and Control (NAFDAC) will need to properly monitor the production and certification of sachet water packaged for drinking and domestic use in Anyigba. We may therefore conclude that there is a potential risk of contracting waterborne diseases by those using the untreated water in Anyigba.

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