Determination of Physicochemical parameters of Tap water and Sachet Water in University of Uyo, Akwa Ibom State, Nigeria.

ABSTRACT

The usage of contaminated drinking water, human population suffers from varied of water borne diseases. Therefore, it is necessary that the quality of drinking water be checked at regular time interval. This study is aimed at investigating the physicochemical parameters of tap water and sachet water sold in University of Uyo, Uyo, Akwa Ibom State, Nigeria. Two sites were considered for this study; Faculty of Biological Science and Male hoste for tap and sachet water respectively. The results revealed that temperature, dissolved oxygen, pH, turbidity, total dissolved solid, electrical conductivity and total hardness recorded 27.624±1.51^{o}C and 26.46±0.46^{o}C, 13.97±2.34mg/L and 2.87±1.21mg/L, 6.29±1.10 and 7.54±2.87, 8.34±4.5NTU and 1.14±0.5NTU, 118.23±29.5mg/L and 17.65±5.05mg/L, 331.57±50.43µS/cm and 71.12±23.33µS/cm and 95.58±44.70mg/L and 10.07±3.91mg/L for Tap water (TW) and Sachet water (SW) respectively. It was concluded that the values for TW were not considerably within the allowable limit by WHO, unlike SW. Therefore, SW was considered safe for human consumption. However, regular maintenance and management of the TW is recommended to enable it fit for human consumption.

Keywords: Comparative study, Water parameters. Tap water. Sachet Water, Drinking water

1. Introduction

All living organisms on earth directly or indirectly depend on water which is one major and most important element to survive. It is made up of over 70% of the body mass in human (Eldon and Bradley, 2004). It has been regarded as a universal solvent that can dissolve many chemicals which may be beneficial to man and its environment.In many developing countries, many infectious diseases are associated to water as it is one most important route for it spread and transmission (Tar *et al.*, 2009). It has been stated than groundwater has greater importance to civilization than surface water, because groundwater is the largest reserve of drinkable water in regions where humans can live (Udoessien, 2003).Ground water is found beneath the ground surface and fills the voids in the rocks and soil; it is a source of water for wells, boreholes and springs (Devic *et al.*, 2014). Groundwater quality in a region is largely determined by both natural processes (dissolution and precipitation of minerals, groundwater velocity, quality of recharge waters and interaction with other types of water aquifers) and anthropogenic activities (Devic *et al.*, 2014).Thus good drinking water is a luxury but one of the most essential requirements of life (Ajewole, 2005). Due to the inability of government to meet the ever increasing water demand, people resort to ground water sources such as shallow wells and boreholes as alternative water resources (LAWMA, 2015). Natural groundwater is a supposed good and quality water source but this can deteriorate as a result of inadequate source of protection and poor management. The two major sources of water are the ground and surface water. Boreholes and hand dug wells constitute ground water sources while streams, rivers, and lakes are surface water sources (Edori and Kpee, 2016;Ebong *et al.,* 2018). It is estimated that a population in the sub-Saharan Africa of over 1.5 billion depends on groundwater as source of drinking water. Over the years, groundwater has been extensively exploited. In Nigeria, over 120 million persons use boreholes as main source of drinking water (Obioma *et al.,* 2020;Solana *et al.,* 2020). Millions of persons living in semi-urban areas depend on dug wells for water supply (Zige*et al.,* 2018).

Pollution of ground water arises from different sources which include, splashing of runoff into wells, if left uncovered, insanitary condition during borehole construction, leachate from old burned waste pit, flooding at borehole site or latrine into the hole through cracks in aquifer and annular of the hole (Essien and Bassey, 2012). They also added that, other sources of contamination includecloseness of borehole to septic tanks especially in cases of space as a constraint and boreholes are drilled around the area (Essien and Bassey, 2012). These ground water sources can easily be contaminated by faecal matter and thus increases the incidence and outbreaks ofpreventable water-borne diseases (Alonge *et al.,* 2018). Packaged water is any potable water that is manufactured or processed for sale which is sealed into food-grade bottles, sachet or other containers and intended for human consumption (Warburton, 2000).Against all odds by government and private stakeholders in most developing African countries, thesupply of quality drinking water remains both an urban and most especially rural public health problem, including Mali, where diarrheal diseases continue to cause particularly high mortality (AFD Territorial Diagnosis of the Segou Region in Mali, 2016). However, World Health Organization (WHO) (2018) reported that about 1.1 billion people lack good quality of water and 2.4 billion do not have access to adequate sanitation. More than 2 million people especially children below five years in developing countries with insufficient hygiene and sanitation. In many developing countries including Nigeria, clean pipe borne water availability is limited and inadequate for the teeming population. Thus, an increasing number of people in semi-urban areas in the country depend on dug wells and water vendors for water supply (Idowu *et al.,* 2011). However, these water sources are unsafe without treatment, because of high level of perturbations by anthropogenic activities, including road construction (Akpabio *et al.,* 2024).Human activities are a major source of water pollution making it unfit for food processing, plant, animal and man consumption, industrial uses, agricultural activities, fishing (Ademorati, 2006) and to mention but a few. However, before the advent of industrialization, the degree of contamination of water by pollutant was low. New age activities like manufacturing process led to pollution of service water source. Typical example is the location of chemical industries or road construction (Akpabio *et al.,* 2024) that released its effluent into the river. In addition, agricultural processes involving the use of fertilizers, herbicides and pesticides produce toxic substances that are as well released as effluents into water bodies (through water cycle as run off) (Obi *et al,* 2007). It is pertinent to understand that for water to be classified "clean and safe" for human consumption, it must be free from any form of organisms and chemical substances in concentrations sufficiently high to affect health. (Nsi*et al.,* 2020). Accurate and timely information on the water quality is necessary to arrest the problem through public policies and improvement on the implementation on water quality programmes. One of the most effective ways to communicate information on water quality trends is with indices. The water quality index (WQI) is commonly used for the detection and evaluation of water pollution and may be defined as ‘a rating reflecting the composite influence of different quality parameters on the overall quality of water’ (Etim *et al.*, 2013). The indices are broadly characterized into two parts: the physicochemical and biological (bacteriological) indices. Physicochemical indices are based on the values of various physicochemical qualities in a water sample. These are vital for water quality monitoring. A number ofscientific procedures and tools have been developed to assess the water contaminants (Dissmeyer, 2000). These procedures include the analyses of different parameters such aspH, turbidity, temperature, dissolved oxygen, alkalinity amongst others. These parameters can affect the drinking water quality if their values are considerably high in concentrations than the safelimits set by the WHO and other regulatory bodies (WHO, 2011).Several studies have been conducted to ascertain these parameters in varyingdrinking water sources, well water (Ezeribe*et al.*, 2012; Mile *et al.*, 2012; Aboh *et al.*, 2015), borehole water (Ibe and Okplenye, 2005;Onwughara*et al.,* 2013and Isa *et al.*, 2013), lake (Okorondu and Anyadoh-Nwadike, 2015), packaged water (Ugochukwu *et al.*, 2015; Halage *et al.*, 2015) and stream/river water (Joshi*et al.*, 2009; Lawal and Lohdip, 2011). Thus, this study was aimed atinvestigating the physicochemical parameters of tap water and sachet water in University of Uyo, Uyo, Akwa Ibom State

2.0 Methodology

2.1 Study Area

This study was conducted in Uyowhich is the capital city of Akwa Ibom State, Nigeria. It lies in the coastal zone of the tropical rainforest of Nigeria, within latitude 4°32' N and 5°33' N and longitude 7°25' E and 8°25' E. Uyo is located in the rain forest belt with an elevation of 1000mm above sea level. The climatic condition is warm humid, high temperature and heavy rain distribution almost all year round. The rainy season progresses from May and reaches its peak in August and diminishes by October, while the dry season begins in November and ends in April. Based on reports of the last population census, Uyo has an estimated population of 222,841 (Atser and Udoh, 2015). The specific locations were Faculty of Biological Science and Male hostel, University of Uyo, Permanent Site with coordinates 37^{0} 30^{1} 25^{11}E, 55^{0} $28^{1}15^{11}$N.

2.2 Sample Collection

This study was carried out in the month of May, 2024. Samples for Tap water (TW) collected from Faculty of Biological Science and Male hostel, University of Uyo. They were collected into a sterile container and stored in the refrigerator at 40°C until analysis was completed and 1:1 nitric acid was added to the sample for preservation.While plastic sealed water were purchased fromshops that sell Sachet Water (SW) and were all taken to Animal and Environmental Biology Laboratory for further analysis.

2.3 Determination of Physicochemical parameters

All physicochemical parameters were analysed within 24 hours of sample collection.The parameters analyzed were eight which includes: Temperature, Dissolved Oxygen (DO), pH, Turbidity, Total dissolved solids (TDS), Electrical conductivity (EC)and Total hardness (TH).

The instruments were a thermometer calibrated in degree Celsius for temperature, a pH meter (model HI 98130 Hanna) for pH, a digital turbidity meter (2100AN HARCH Model) for turbidity, a digital conductivity meter model NATOP PB5 (London, UK) for EC.DO, TDSand TH were done according toAPHA (1998) and Ademorati (1996) respectively.

3.0. Results

The physicochemical parameters determined for TW and SW in this study were temperature, DO, pH, turbidity, TDS, EC and TH as presented in Table 1. The temperature, DO and pH values of the samples ranged between 26.46-27.62°C, 2.87-13.97 mg/L and 6.29-7.54 respectively. DO levels amongst both samples were significantly different($p>0.05$). Turbidity values for TW and SW were 8.34±4.5NTUand 1.14±0.5NTU respectively. There was a significant difference ($p>0.05$) in the values for turbidity and pH obtained amongst both samples. TDS, EC and TH recorded 118.23±29.5mg/L and 17.65±5.05mg/L, 331.57±50.43µS/cm and 71.12±23.33µS/cm and 95.58±44.70mg/L and 10.07±3.91mg/L for TW and SW respectively. They were statistically significantly different ($p>0.05$) amongst themselves.

Table 1: Mean Standard Error of the physicochemical parameters of borehole and bottle water in urban area in Uyo, Akwa Ibom State, Nigeria

Physicochemical parameters	Units	TW	SW	WHO Limit (2018)	Remarks
Temperature	^{o}C	27.624±1.51	26.46±0.46	25-30	WL
Dissolved Oxygen	mg/L	13.97±2.34	2.87±1.21	5.0-10	AL/BL
pH	-	6.29±1.10	7.54±2. 87	6.5-8.5	BL/WL
Turbidity	NTU	8.34±4.5	1.14±0.5	0-5	AL/WL
Total Dissolved Solid	mg/L	118.23±29.5	17.65±5.05	250-500	WL
Electrical conductivity	µS/cm	331.57±50.43	71.12±23.33	>500	WL
Total Hardness	mg/L	95.58±44.70	10.07±3.91	>500	WL

Keys: *TW – Tap Water; SW – Sachet Water; BL - Below limits; WL - Within limits; AL - Above limit; WHO -World Health Organization*

4. Discussion

Water is essential for life and it activities. However, chemical and biological processes of life are only successful when it is within the accepted quality standards. There are alterations in the physiochemical parameters, it is imperative that it goes through processes to improve it quality prior to such usage, especially for drinking, else, the pollution which is responsible for many adverse health conditions.

Based on our result, it is clear evidence to show that the reservoir (the tank), is slightly polluted. Thesample parameters studied showed that the temperature values were within the allowable limit according to WHO (2018). Onwughara*et al.* (2013) and Atiku *et al.*,(2018) reported similar results for borehole (tap water) samples. However, cool (low temperature) is more suitable for drinking, as higher water with temperature encourages the growth of microorganism. Thus, a contributing factor to the cause of odour, taste and colour (Okoye and Okoye, 2008), which is very unsafe for consumption. For TW, the result could be associated to the cold weather as of the time of collection of the samples. The month of May (period of collection) is a raining season in the temperate region like Akwa Ibom State. The suitable values for SW could be associated with the cold storage of the SW; as customers prefers cold water for consumption.This study conforms with Afangideh*et al.,* (2021), that reported allowable temperature range (26-29.5^{o}C) compared to low temperature range (22-23.8^{o}C) reported by Akpen*et al.,* (2018). This is clearly assumed to be as a result of refrigerating these products as there were purchased from retailers.Danso-Boateng and Frimpong (2013) reported 28.94ºC and 28.81ºC respectively for average temperatures of plastic sachet and bottled water brands produced and/or sold in Kumasi, Ghana. However, temperatures within this range are favourable for maximum growth of mesophyll bacteria including human diseases causing agents (Onweluzo and Akuagbazie; 2012). Water is conventionally acceptable when consumed cold (>20^{o}C)(WHO, 2011; USGS, 2018).

DO levels in surface and underground water depend on the physical, chemical, and biological activities of water body (Mulla *et al*., 2012). The DO value obtained for TW was above allowable limit indicating aerobic and healthy state for algae growth. High DO combines with high water temperature and nutrient can create a conducive environment for algae growth and blooms; which poseit unfit for human consumption. The significantly low level of DO recorded for SW is likely attributed to the methods of processing, treatment and storage. According to Karimzadeh *et al.,* (2015), oxygen can be depleted during production and storage processes; this is to prevent oxidation reaction that can give rise to taste. The high level of DO in the TW is likely attributed to the process of pumping the water which cause aeration to take place. This agrees with Atiku *et al.,* (2018) that recorded above limit for DO for samples from river.

pH is a significant factor that impacts many biological and chemical processes. It is a water quality assessment parameter which is very important in evaluating water supply and treatment (Odu*et al.,* 2020). The suitability of drinking water within pH range of 6.5 to 8.5 is considered acceptable (WHO, 2011). Acid water tends to be corrosive to plumbing and faucets, particularly, if the pH is below 6. The TW was acidic which are suitable for plant, but poses threats to direct consumption by humans and animal; Okon *et al.*, (2020) reported that suitable pH level of fish is considerably within 7.0-8.0. However, BW samples showed allowable limits set by WHO (2018). Malini *et al.,* (2017), reported that packaged water (SW) with pH below 4 is usually marketed as "ultra-purified' or "ionized" water. This is because some water brands uses a process called electrolysis or reverse osmosis to produce "ionized" water. This process has the ability to removes many natural minerals and salt from the water; thereby resulting to low pH level.

Turbidity is the degree of cloudiness of water and the measure to which water loses its transparency. Low insignificant levels of turbidity in drinking water may not pose significant effect in humans (WHO, 2006), but will affect the aesthetics of the water and could discourage consumption. In this result, the values were above the WHO (2017) limit setfor TW (borehole). The turbidity levels of the TW suggest high level of suspended materials,bacteria, planktons and dissolved organic and inorganicmaterials (Reza *et al.,* 2009). The allowable level recorded for SW was indicative of proper treatment (filtration) during processes of the product. This could account for the reason why total dissolved solids (TSS) were not insignificantly observed detectable in SW, which renders it good for consumption.

Higher TDS are reported to reduce water clarity, which could contribute to reduced photosynthetic activities and possibly lead to an increase in water temperature (Harrison, 2007). Beyond certain limit, TDS impacts a peculiar taste to water and reduces its portability, and may cause gastrointestinal irritation (Singh *et. al*., 2009). Both water samples indicated the availability of total dissolved solids (TDS). Although, TW recorded higher value which was recorded to be significant, both were within the permissible limits (>500 mg/l) ofWHO (2018). However, low TDS (low minerals, cation and anions) water consumption in humans could lead to some health challenges such as goiter, hypertension, ischemic, heart disease, etc., especially, in the presence of poor dietary habits (Akpoborie and Ehwarimo, 2012). Low TDS in SW is likely attributed to the intensive processes involved in the production.

The ability of a solutionto conduct an electrical current that is governed by themigration of the solutions which is dependent on the natureand numbers of the ionic species in that solution is known as Electrical conductivity (EC) is (Sa'eedand Mahmoud, 2014). This ability is directly related to the concentration of ions in the water (Wetzel, 2001) which comes from dissolved salt and inorganic materials (Department of Wildlife and Fisheries Sciences, 2014). The level at which water can conduct electricity is directly proportional to the level of ions present, likewise the reverse is the case. Distilled or deionized water can act as an insulator due to its very low (if not negligible) conductivity value (NOAA, 2014).EC is an important tool in determining the purity of water. This study recorded both samples to be within the permissible limit (>500µScm^{-1}) (WHO, 2018). This result conforms to Airaodion*et al.,* (2019) report that sachet water sold in Oyo state ranged between 28.30-136.40µScm^{-1}; which was although higher than our result, however within allowable limit for drinking water. The high level of EC in TW is likely attributed to lack of tank (reservoir) treatment.

The hardness of water is a property that decreases the ability to form soap lather and also increases scale formation in hot-water heaters and low-pressure boiler at high levels. For surface water the total hardness (TH) of water is mainly due to calcium and magnesium salts (Gopalkrushna, 2011;Kumar and Pal, 2012)and is derived from dissolved limestone or anthropogenic effluents. According to Durfor and Becker (1964) hardness is classified into four, which includes; 0-60mg/l (soft), 61 -120mg/l (moderate), 121-180mg/l (hard) and >181mg/l (very hard). WHO (2011) International standards for drinking water also classified total hardness of water <50mg/l as “soft water”, 50-150mg/l as “moderately hard water” and

>150mg/l as hard water. Based on these ranges of classification, the TW and SW could begrouped as “soft” and “moderate”. This investigation proved that both samples were within recommended limit (>300 and >500mg/L) (WHO, 2011, 2018). However, SW is safer for human consumption.

5. Conclusion

This study investigated the physicochemical parameters of tap water (TW) and sachet water (SW) sold in University of Uyo, Uyo, Nigeria. The results reveal that DO, pH and Turbidity did not meet recommended limits by World Health Organization (WHO) for TW. There is need for adequate sensitization and proper periodic monitoring and management of the water in the study areas to safeguard well-being of the exposed populace. For SW, all parameters, exceptDO were within the recommended limits by WHO, which renders the SW sold in the vicinity satisfactorily fit for human consumption and could be consumed for as long as 15 weeks if stored at room temperature.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (Chat GPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author (EEA) uponrequest.

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