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Comparative Determination of Physicochemical and Microbial Quality of Sachet Drinking Water Sold in Okada, Edo State Nigeria

I. C. Onuguh[1], I. Y. Aaron[2], R.I. Nnadozie[3], V. J. Oke[1] and O.S. Imade[4]

[1]Department of Chemistry, Igbinedion University Okada, Edo State Nigeria
[2] Nigerian Stored Products Research Institute, Ilorin, Nigeria.
[3]Department of Biology, Federal University of Technology Owerri, Nigeria
[4]Department of Biological Sciences, Igbinedion University Okada, Edo State Nigeria
Correspondence: acoibenzinno@gmial.com

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Abstract— *Sachet drinking water produced and marketed by three different companies in Okada Community, Edo State Nigeria were examined and compared with the WHO drinking water quality standards. This was done to ascertain if they met the minimum required standard for human consumption. They were purchased and labeled E, F and I and were subjected to physicochemical and microbial tests. The parameters evaluated were TDS (Total dissolved solids), pH, Chloride, DO (Dissolved oxygen), Turbidity, Electrical conductivity (EC), Potassium, Calcium, Magnesium, Iron, Lead, Cadmium and Zinc. Their TDS ranged from 0.154 to 0.693 mg/L; pH ranged from 6.8 to 8.0;* Cl^- *concentrations ranged from 5 to 10 mg/L; DO ranged from 5.4 to 6.5 mg/L; Turbidity ranged from 0.0 to 0.2 NTU and EC ranged from 0.330 to 0.451μS/cm. They were all within the limits stipulated by the considered standards. Their essential nutrient (K, Ca, Mg and Fe) contents were significantly less than the limits stipulated by the standards. Toxic heavy metals of Pb and Cd were below detectable limits. Total coliform count and* SO_4^{2-} *concentrations were also zero. They had poor values of EC and very poor concentrations of essential nutrients. It was therefore recommended that there should be an improvement on the ratio of all the essential nutrients in the studied sachet water products to positively enhance the health of their users.*

Keywords— ***Sachet drinking water, essential nutrients, electrical conductivity, physicochemical, total coliform***

I. INTRODUCTION

Sachet water is ready-to-drink water packed in a plastic bag. It is referred to as “pure water” in Nigeria and other neighboring African countries. The sachet water produced by machines in the industries is referred to as “machine-sealed” sachet water, whereas the one produced by manually filling a plastic bag with water and knotting it is referred to as “hand-tied” sachet water (Okioga, 2007). Because it is affordable, ready to drink, and always available, sachet water has grown in popularity and been accepted by the general public. Borehole is the main source of sachet water produced by small scale industries. These industries treat water by aeration, double or single filtration and in rare cases, disinfection is applied. In most cases, the water source determines the level of treatment to be undergone (Asthana, *et al*., 2017).

Ideally, drinking water should be colourless, odourless, tasteless and free of disease causing microorganisms. It should also not contain or might have negligible concentrations of substances considered to be toxic to the body. The quality of drinking water globally is of great interest because of its attendant public health impacts. Sachet drinking water is very common in our nation as it is a major source of water for restaurants and food vendors in the country. Its popularity has tremendously grown because it is cheap and available. In order to protect the health of consumers, it is necessary to ascertain the qualities of sachet drinking water sold to people in different regions (Olaoye and Onilude, 2009). International and national guidelines for quality drinking water are to be used as basis in checkmating the safety of drinking water.

Drinking water must adhere to specified national and international standards. It must be devoid of any pathogenic bacteria and contain minimal concentrations of substances that are acutely hazardous or seriously detrimental to health over the long term. Drinking water should ideally be crystal clear and devoid of any odors or anything that might impart flavor or color. In some parts of Africa, dangerous physical, biological, and chemical elements (such as fluoride, fine suspended debris, and fecal coliform) enter the water as it percolates through the soil, rendering it unfit for human consumption.

In the developing countries, many people lack access to a reliable source of safe drinking water. It has been reported that many vendors do not treat their sachet water before selling it to the public, and many people involved in the production do not strictly adhere to the standards set by the Federal Environmental Protection Agency and the World Health Organization (Okpako *et al.*, 2009; Oladipo *et al.*, 2009). As a result, the integrity of sachet water is reportedly in question. Nigerians are consuming sachet water at an alarming pace, and they are generally unaware of the source, quality, and potential consequences of this practice. Sachet water can occasionally become contaminated during manufacture, transit, and inappropriate handling by vendors, as well as from the water production source (Adegoke *et al*., 2012). Drinking water contamination has major socioeconomic and political repercussions in addition to its effects on health (Mukhtar and Oyeyi, 2005). Since the majority of people consume it, it is necessary to evaluate its quality in order to protect the health of its users.

The aim of this study is to determine the physicochemical and microbial quality of sachet drinking water sold in Okada Community, Edo State, Nigeria and compared their outcomes with the World Health Organization's (WHO) drinking water quality regulatory standards. This will help to evaluate the safety of sachet drinking water manufactured and offered for sale in this community. The research results will (i) identify any contaminants, (ii) identify the presence and quantity of essential nutrients present, and (iii) help in proffering recommendable solutions that will guide the producers in checkmating identified deficiencies.

II. MATERIALS AND METHODS

APPARATUS:

The apparatus used included: beakers, conical flasks, measuring cylinders, burette, pipette, pH meter, conductivity meter, oven, incubator, petri dish, hand lens, colony counter, membrane filter, atomic absorption spectrophotometer, dissolve oxygen meter, and turbidity meter.

CHEMICALS:

The chemicals used included: Conc. HCl, sulphuric acid, nitric acid, potassium chloride, sodium sulphate, potassium chromate, silver nitrate, barium chloride, sodium chloride, distilled water, isopropanol, glycerol, EDTA, and murexide indicator.

STUDY AREA:

Okada Community is the capital of Ovia North East Local Government Area which occupies the South Western part of Edo State, Nigeria. This area is located between latitudes 4.5°N and 5°N; longitudes 5.5°E and 6°E. The community houses Igbinedion University Okada and its teaching hospital (Okafor-Elenwo & Avemaria, 2021). It is also known for its agricultural and commercial activities and has a prospect of becoming a big town in the future.

SAMPLE COLLECTION

The pure water samples were purchased from Okada market located at Ovia North-East Local Government Area of Edo State, Nigeria. They included (i) Edo Poly Table Water, (ii) Fifinal Table Water and (iii) IUO Table Water which were labeled E, F and I respectively.

III. METHODS

Physical Analysis:

Determination Electrical Conductivity

The electrical conductivity (EC) was determined using digital Hanna Conductivity Meter. The meter was first calibrated with standard potassium chloride solution of 0.01N. The sample readings were taken by immersion of the sensor into the water samples (APHA, 1998).

Determination of pH value

Procedure: The glass electrode was first rinsed with distilled water. The pH meter (Hanna digital pH meter) was standardized by inserting the glass electrode into the buffer solutions of pH 4.0 and 9.0 respectively. The glass electrode was now inserted into the water samples and the readings were recorded (Ademoroti, 1996).

Turbidity Determination

Nephelometric method was used for turbidity determination. The principle of this method is based on a comparison of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. Turbidity meter type; Jenway-6035 meter was standard to zero NTU (Nephelometric Unite) using distilled water before standardizing using 100 NTU and 40 NTU standards. The sample was shaken thoroughly and 10ml of the sample was transferred into a cuvette and readings were recorded (APHA, 2002).

Determination of Dissolved Oxygen

The value of dissolved oxygen was read with digital dissolved oxygen meter AR8406 SMART SENSOR. This was immersed into the water sample and readings were taken directly (APHA, 1998).

Chemical Analysis:

Determination of Sulphate by Turbidimetric Method

Sulphate was determined by measuring 20ml of the sample into a 100ml standard flask. 1ml of conditioning reagent was added with 1ml of HCl (1ml Conc. HCl + 9 ml distilled water). Then, 0.3g of sieved $BaCl_2$ was added and stirred at a constant speed. Absorbance of the sulphate was measured at 420nm with a spectrophotometer. The estimation of SO_4^{2-} concentration in the sample was done from standard curve prepared with SO_4^{2-} of different concentrations (Yogita Sharma et.al. 2016)

Preparation of Conditioning Reagent for Sulphate Determination

30ml of conc. HCl was slowly added to 300ml of distilled water. To this, 100ml of 95% isopropanol and 75g NaCl, and 50ml of glycerol was all added and mixed thoroughly.

Determination of Chloride in Water

Procedure: 50 ml of the water sample (V) was taken and 3ml of aluminium hydroxide was added and mixed. The solution was brought was brought to pH 8. 1ml of indicator (potassium chromate) was added and titrated against standard silver nitrate ($AgNO_3$) solution until reddish brown precipitate was obtained and the titre volume was noted (V1). The same procedure was repeated for blank (distilled water) and the titre volume (V2) noted (Ademoroti, 1996).

Chloride in mg/l = $\frac{V1-V2\ x\ N\ x\ 35.46\ x\ 1000}{V}$

Where N = normality of $AgNO_3$ = 0.98

Determination of Calcium

Concentration of calcium in water was determined by titration with EDTA (ethylenediaminetetraacetic acid) using murexide indicator. 50ml of sample as measured into a 250ml beaker, 1 ml of 8% NaOH solution was added with a pinch of murexide indicator and titrated with EDTA from pink to purple end point (Ademoroti, 1996).

$$\text{Calcium mg/l} = \frac{titre\ value\ x\ 400.5\ x\ 1.05}{volume\ of\ sample}$$

Determination of Heavy Metals using AAS (Atomic Absorption Spectrophotometer)

The water sample of about 100ml was digested in a 250ml conical flask by adding 5ml of the prepared aqua regia (prepared by mixing hydrochloric acid and nitric acid in the ratio of 1:3), boiled with boiling chips to almost dryness and topped up to 100ml with distilled water. This was then filtered and the filtrate was analyzed for heavy metals using Atomic Absorption Spectrophotometer (APHA, 2002).

Microbial Analysis:

Analysis of Total Coliform/ Bacterial Count

Procedure: 50ml of water sample was filtered through a membrane filter and placed on a pad with lauryl tryptose broth for 2 hours. This was later transferred to dish containing M – Endo agar and incubated for 24 hours. Colony counter under magnification was used for counting and observation (Anaja, 2008).

IV. RESULTS AND DISCUSSION

The three available sachet water brands in Okada Community were tested to ascertain and compare their physicochemical and microbial qualities with the WHO (2011) regulatory standard for drinking water. The results were summarized in Table 1.

Total Dissolved Solids (TDS)

The total dissolved solid is characterized by inorganic salts (potassium, sodium, calcium, magnesium, chlorides and sulphates) and organic matter that are dissolved in sample water (Grayson *et al.*, 2012). Sachet water taste can be affected by the presence of total dissolved solids which makes it less palatable (WHO 2003). The TDS of the tested sachet water samples in Table 1 ranged from 0.154 to 0.693 mg/L which were within the limit stipulated by the WHO standard.

Hydrogen Ion Concentration (pH)

The measurement of pH is necessary to determine the corrosiveness of the water. The pH of the tested water samples in Table 1 ranged from 6.8 to 8.0 which were within the limit stipulated by the WHO standard.

Chloride Ion (Cl^-) Concentration

High chloride ion concentration can adversely affect water taste. However, water with a chloride residual concentration of a few milligrams per litre can act as a preservative. The chloride ion concentration of the tested water samples in Table 1 ranged from 5 to 10 mg/L which were within the limit stipulated by the WHO standard.

Dissolved Oxygen (DO)

The threshold for DO is 5.0 mg/L for drinking water and more than 5.0 mg/L for agricultural purposes. Low DO may result in anaerobic conditions that cause bad odors (Adekunle et al., 2007). The DO of the tested water samples in Table 1 ranged from 5.4 to 6.5 mg/L which were within the WHO stipulated limit.

Turbidity

Turbidity relates to how cloudy a water sample is and its visibility over a glass containing it. It mainly depends on the amount of particulate matter in water (Abubakar *et al.*, 2016). Turbidity of tested water samples in Table 1 ranged from 0.0 to 0.2 NTU which were within the limit stipulated by the WHO standard.

Table 1: Physicochemical and Microbial Qualities of Water Samples in Okada Town with the WHO Standard.

PARAMETERS	UNITS	E	F	I	WHO LIMITS
TDS	mg/l	0.225	0.154	0.693	600
pH		7.6	6.8	8.0	6.5 – 8.5
Chloride	mg/l	10.0	5.0	5.0	250
DO	mg/l	6.5	5.7	5.4	2.0 (min)
Turbidity	NTU	0.1	0.0	0.2	5
Electrical conductivity	µS/cm	0.451	0.330	1.429	1500
Potassium	mg/l	0.094	0.824	3.730	30
Calcium	mg/l	3.0	2.0	5.0	200
Magnesium	mg/l	7.0	5.0	2.0	150
Iron	mg/l	0.015	0.025	0.038	$\leq$ 0.3
Lead	mg/l	ND	ND	ND	$\leq$ 0.01
Cadmium	mg/l	ND	ND	ND	$\leq$ 0.003
Zinc	mg/l	ND	0.031	0.053	5
Sulphate	mg/l	ND	ND	ND	250
Total Coliform	NM	NIL	NIL	NIL	NIL

ND = Not detected, WHO = World Health Organisation, NTU = Nephelomeric Turbidity Unit, mg/l = Milligram per litre, µS/cm = Micro Siemens per Centimetre, TDS = Total Dissolved Solids, EC = Electrical Conductivity, DO = Dissolved oxygen, AB = Absent

Electrical Conductivity (EC)

Electrical conductivity of a water sample is a measure of its ionic concentration and its ability to conduct electricity. Conductive ions come from the dissolved salts present in the water. The electrical conductivity of the tested sachet water samples in Table 1 ranged from 0.330 to 0.451µS/cm. They were significantly less than limit stipulated by the WHO standard. Very low electrical conductivity value indicates the presence of minute amount of mineral elements like magnesium and calcium in water (Ndinwa *et al.*, 2012). The long term drinking of sachet water with electrical conductivity value less than 40 will culminate into health challenges like fracture in children, pregnancy disorder, premature or low baby weight at birth and increased tooth decay (Guler and Alpalsan, 2009).

Potassium, Calcium and Magnesium Contents

Potassium (K), Calcium (Ca) and Magnesium (Mg) are essential nutrients that are important to humans though are hardly found at high concentrations that are harmful in drinking water. K helps in the nerve transmission of electric signals in body cells, Ca is essential for blood clotting and for strong bones and teeth while Magnesium for muscle contraction (Jomova et al., 2022). The K, Ca and Mg contents of the tested water samples in Table 1 were significantly less than limits stipulated by the considered standards.

Iron (Fe), Lead (Pb), Cadmium (Cd) and Zinc (Zn) Contents

Toxic heavy metals of Pb and Cd were below detectable limits in all tested water samples. Iron is also an essential nutrient needed in human nutrition. It is a major component of haemoglobin which carries oxygen from the lungs to all parts of the body (Dasa & Abera, 2018). Its daily requirement depends on the age, sex and physiological status. Iron contents of the tested water samples in Table 1 ranged from 0.015 to 0.038 mg/L which were less than limits stipulated by the considered standards. Zinc is a trace element. It was not detected in sample E but was detected in samples F and I. The Zinc contents in samples F and I in Table 1 were 0.031mg/L and 0.053mg/L respectively. They were less than the limits stipulated by the considered standards.

Sulphate (SO_4^{2-}) Concentration

Sulphate concentrations of all the tested water samples where below detectable limits. High sulphate levels in drinking water can lead to diarrhea and dehydration (Backer *et al.*, 2001).

Total Coliforms

The presence of total coliforms in sachet water is a measure of its sanitary quality and contamination. Coliform bacteria can come from fecal matter or from different other sources. Its presence can pose risk of contracting a water-borne disease. The total coliform counts of the three tested sachet water samples were zero which indicated that they were of good sanitary quality.

V. CONCLUSION AND RECOMMENDATION

The quality of the three sachet drinking water manufactured and sold in Okada Community, Edo State Nigeria was investigated in this study. Their physicochemical and microbial qualities where examined and compared with the WHO (World Health Organization) regulatory standards for drinking water. The parameters evaluated were TDS (Total dissolved solids), pH, Chloride, DO (Dissolved oxygen), Turbidity, Electrical conductivity, Potassium, Calcium, Magnesium, Iron, Lead, Cadmium and Zinc. This evaluation revealed that all the three tested samples met the WHO regulatory standard and were of good quality. However, they all had very poor concentrations of essential nutrients like Potassium, Calcium, Magnesium and Iron. Poor values of their electrical conductivity (EC) also confirmed this. The long term drinking of sachet water with electrical conductivity value less than 40 (µS/cm) will culminate into health challenges like fracture in children, pregnancy disorder, premature or low baby weight at birth and increased tooth decay (Guler and Alpalsan, 2009). It is therefore recommended that there should be an improvement on the ratio of all the essential nutrients in these studied sachet water products to enhance the health of their users.

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