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ANALYSES OF THE PHYSICOCHEMICAL AND MICROBIOLOGICAL QUALITIES OF SELECTED SACHET WATER BRANDS IN NNEWI, ANAMBRA STATE, NIGERIA

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Abstract
This study analyzed the physicochemical and microbiological qualities of five sachet water brands mostly consumed in Nnewi. The researchers used respective meters for the physical parameters, an atomic absorption spectrophotometer machine for the heavy metal determinations and streak-plate method for the determination of microbiological parameters. The five sachet water brands that were used for this study were elicited from respondents in Nnewi using a well-structured questionnaire. The study estimated the pH, electrical conductivity, total solids, heavy metal contents, total count bacteria and microbial isolates of the microbiological parameters of selected sachet water brands. Averaged results of the physicochemical parameters showed that pH estimated at 5.928, electrical conductivity-0.2636μS/m, turbidity-0.0092NTU, total dissolved solids-44.64mg/L, and total suspended solids-30.54mg/L. In addition, averaged results of the heavy metal parameters showed that lead was estimated at 0.012mg/L, cadmium-0.0576mg/L, copper-0.0252mg/L, iron-2.496mg/L, zinc-0.85mg/L, chromium-0.051mg/L and cobolt-0.8602mg/L. Results of the microbiological parameters showed that for total count, Christo was estimated at 24 x 10^4MPN/100ml, Carter- 22 x 10^3MPN/100ml, Uru- 22 x 10^4MPN/100ml, Aqua-Rapha- 21 x 10^3MPN/100ml and Chem-Paully- 78 x 10^3MPN/100ml. The study recommends that sachet water regulatory agency should ensure that sachet water brands are produced under hygienic environment in order to safeguard the public health of residents.

Keywords: Analyses, microbiological, physicochemical, quality, and sachet water

Introduction
The sale of sachet water has been on the increase in most urban cities in Nigeria. In order to safeguard public health, it is essential that available sachet water is of the highest quality (Anunobi *et al.*, 2006). In Nigeria particularly, the increased demand for sachet water products is largely attributed to factors such as inadequate public water supplies in urban areas; impression that high quality drinking water offer refreshing taste; and convenience which has made the products meet the requirements of any lifestyle when needed (Oyedeji *et. al.*, 2010). The proliferation of sachet water to the populace was to curb the magnitude of water-related diseases mostly from public water supplies. Contaminants of sachet water span the physical, chemical and microbiological impurities and the magnitude of each depends on the level of controls of all factors influencing their production (Danso-Boateng and Frimpong, 2013). The physical and chemical contaminants can easily be prevented at the pre-production stages, but the microbial contaminants need a high-level of hygiene and sanitation (Megersa, 2018). Most impurities in sachet water originate from the raw water, but may persist in the purified water due to inadequate purification techniques (Jeje and Oladepo, 2012). Product contamination may arise directly from the process or indirectly from the operatives, cleaning operations, packaging materials or cross contamination from the wet areas of floors, sinks and drains to the processing equipment (Jeje and Oladepo, *ibid*).

In safeguarding drinking water supplies, public health authorities and engineers rely on information obtained from results of regular physicochemical and microbiological analyses. The recognition that microbial contamination can be water induced has led to routine examination to ensure that drinking water is free from contamination. Water for human consumption is considered to be of greater social and economic importance, since health of the population influences all other activities (Ukpong and Okon, 2013).

In Nigeria, the failure of public water supply especially in Nnewi has compelled the inhabitants to depend on private water supply sources such as water tankers, boreholes, rain-water harvesters, packaged water, amongst others. The most widely used of these private water options is packaged water, which include sachet water. Consumption of sachet water in Nnewi could be linked to water-related diseases such as diarrhea, typhoid and dysentery. Principal microbial water-related diseases such as diarrhea and typhoid have been reported to be on the increase in human populations in Nnewi metropolis between the years 2009 to 2014 (Anambra State Ministry of Health, 2014). The consequences of these diseases are reduced quality of life and livelihoods for affected human populace. Therefore, this study aims to analyse the physicochemical and microbiological parameters of the five sachet water brands that are mostly consumed in Nnewi North Local Government Area (LGA) of Anambra State, Nigeria.

Materials and Methods

Study Area

Nnewi is located between longitudes 6°52′E to 6°57′E and latitudes 5°06′N and 6°05′N in the Anambra South Senatorial Zone of Anambra State. Nnewi covers an area of 72 square kilometres, a third of which is occupied by buildings. According to the 2006 Population Census, Nnewi North LGA has a human population of 233,658 people.

Sample Collection

The study was conducted between July 2016 and December 2016 in Nnewi North LGA. A total of five (5) sachet water brands were analyzed for physicochemical and microbiological parameters. One sample from each of the tested sachet water brands were selected for analyses. The selected five sachet water brands were elicited from respondents using a questionnaire. Responses were elicited from residents in Nnewi by adopting a purposive sampling method for the questionnaire distribution.

Physicochemical Analyses

The researchers used Model PHS-25 pH meter to determine pH, Model DDS-307 Conductivity Meter to measure the conductivity, Hanna H1 99300 TDS Meter to measure the dissolved ions content of the five sachet water samples. A Buck Model 210 VGP atomic absorption spectrophotometer (AAS) was used to determine the concentrations of lead, cadmium, copper, iron, zinc, chromium and cobolt for the five sachet water brands (HACH, 2013).

Microbiological Analysis

The researchers used streak-plate method with Mac Conkey Broth agar for the determination of microbiological parameters. An Electron Microscope and JOUAN XMTD Incubator were also used in the microbiological analyses (HACH, 2013).

Results and Discussion

Table I shows the pH, conductivity, turbidity and total solids contents for the five sachet water brands that are mostly consumed in Nnewi. Aqua-Rapha with the highest pH value is slightly acidic (pH═6.20), while Uru had the least pH value (pH═5.60). The highest conductivity was recorded with Christo (0.440μS/m), while the lowest was recorded with Chem-Paully (0.170μS/m). Turbidity was highest in Chem-Paully sachet water (0.017NTU), and lowest in Uru sachet water (0.001NTU). Total Dissolved Solids was highest in Carter sachet water (69.50mg/L), and lowest in Chem-Paully sachet water (38.20mg/L). Total Suspended Solids was highest in Carter sachet water (48.20mg/L), and lowest in Uru sachet water (12.40mg/L).

This study found out that 5.928units of pH was present in tested sachet water brands. This finding is similar to the study of Cheabu and Ephraim (2014), who assessed the quality of sachet water in Obuasi, Ghana and found out that pH yield ranged from 5.4 to 7.6. The reason for this finding is that water contains two molecules of hydrogen ion which accounted for the slightly acidic nature of tested sachet water. Thus, the hydrogen ions were responsible for the slightly acidic nature of tested sachet water brands. The study found out that 0.2636μS/m of electrical conductivity (EC) was present in tested sachet water brands. This finding is also similar to the study of Cheabu and Ephraim (2014), who found out that EC yield ranged from 0.19μS/m to 0.81μS/m. EC is a measure of free ions present in water and sachet water which contains only hydrogen and hydroxide ions is relatively low as indicated by the low EC value. Thus, the few hydrogen and hydroxide ions present in sachet water accounted for the low conductivity.

The study found out that 44.64mg/L of total dissolved solids (TDS) was present in tested sachet water brands. This finding is similar to the study of Nkansah *et al.* (2010) who assessed the quality of groundwater in Kwahu West district of Ghana and found out that TDS yielded 42.5mg/L. The low TDS value was accounted for by human activities associated with sachet water production process. Thus, dissolved solids from associated human activities are responsible for the relatively low TDS value.

Table 1: Physicochemical Parameters of Selected Sachet Water Brands in Nnewi

S/No	Brands	pH	EC (µS/m)	Turbidity (NTU)	TDS (mg/L)	TSS (mg/L)
1	Christo	6.00	0.440	0.015	48.60	35.60
2	Carter	6.04	0.240	0.003	69.50	48.20
3	Uru	5.60	0.270	0.001	20.60	12.40
4	Aqua-Rapha	6.20	0.198	0.010	46.30	29.60
5	Chem-Paully	5.80	0.170	0.017	38.20	26.90

Key: EC= electrical conductivity; TDS= total dissolved solids; TSS= total suspended solids; NTU= nephelometric turbidity units; µS/m= microsiemens per meter; mg/L=milligram per liter

The heavy metal parameters of the five sachet water brands that are mostly consumed in Nnewi are also shown in Table 2. The range in value for lead heavy metal is between Christo (0.021mg/L) and Aqua-Rapha (0.002mg/L). Cadmium heavy metal peaked at Uru (0.106mg/L), and least in Christo (0.006mg/L). The range in value for copper heavy metal is between Christo (0.063mg/L) and Carter (0.010mg/L). Iron heavy metal had its peak value in Christo sachet water (3.00mg/L), and lowest in Carter (0.96mg/L). The range in value for zinc is between Carter (1.23mg/L) and Christo (0.55mg/L). Chromium heavy metal had its peak value in Uru sachet water (0.090mg/L), and least value in Aqua-Rapha sachet water (0.021mg/L). The range in value for cobolt heavy metal is between Christo (1.110mg/L) and Carter (0.50mg/L).

In the heavy metal analyses, the study found out that 0.0252mg/L of copper was present in tested sachet water brands. This finding is similar to the study of Irenosen *et al.* (2014), who investigated some quality parameters in groundwater in Afuze, Nigeria, and found out that copper yielded 0.0102mg/L. The study found out that 2.496mg/L of iron was present in tested sachet water brands. This finding is similar to the study of Adefemi and Awokunmi (2010), who studied the physicochemical parameters and heavy metals in water samples from Itaogbolu, Ondo, Nigeria, and found out that iron content of the water ranged from 0.1mg/L to 5.3mg/L. The study found out that 0.85mg/L of zinc was present in tested sachet water brands. This finding is similar to the study of Achadu *et al.* (2013), who studied the quality assessment of stored harvested rainwater in Wukari, Nigeria, and found out that 0.99mg/L of zinc was present in the water. The study etimated 0.0576mg/L of cadmium in tested sachet water brands. This finding is similar to the study of Kerketta *et al.* (2013), who analyzed the physicochemical properties and heavy metals in drinking water in Jharkhand, India, and found out that cadmium content ranged from 0.04mg/L to 0.11mg/L. The study etimated 0.012mg/L of lead in tested sachet water brands. This finding is similar to the work of Kaki *et al* (2011), who evaluated the heavy metals pollution of Nokoue Lake in Benin and found out that 0.01mg/L of lead was present in the water. Presence of heavy metals in tested sachet water might be accounted for by contents which entrained from sachet water purification process. Thus heavy metal contents entering into sachet water purification processes were responsible for the presence of heavy metals in tested sachet water brands.

Table 2: Heavy Metals Parameters for Selected Sachet Water Brands in Nnewi

	Brands	Lead (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Iron (mg/L	Zinc (mg/L)	Chromium (mg/L)	Cobolt (mg/L)
1	Christo	0.021	0.006	0.063	3.00	0.55	0.043	1.110
2	Carter	0.005	0.030	0.010	0.96	1.23	0.048	0.50
3	Uru	0.017	0.106	0.013	4.50	0.62	0.090	1.021
4	Aqua-Rapha	0.002	0.095	0.010	1.83	1.04	0.021	1.030
5	Chem.-Paully	0.015	0.051	0.030	2.19	0.81	0.053	0.64

The microbiological parameters of the five sachet water brands that are mostly consumed in Nnewi are given in Table 3. Total count/coliform (TC) bacteria were highest in Christo sachet water (24 x 10^4MPN/100ml), and least in Aqua-Rapha sachet water (21 x 10^3MPN/100ml). Christo, Uru and Chem-Paully had three microbial isolates, while Carter and Aqua-Rapha had only two microbial isolates.

In the microbiological analyses, the study found out that 22 x 10^4MPN/100ml of total coliform (TC) bacteria was present in Uru sachet water. This finding is similar to the work of Anyamene and Ojiagu (2014), who studied the bacteriological analyses of sachet water sold in Awka metropolis, Nigeria and found out that 20.1 x 10^4MPN/100ml of TC bacteria was present. The study found out that 24 x 10^4MPN/100ml of TC bacteria was present in Christo sachet water, and 21 x 10^3MPN/100ml in Aqua-Rapha sachet water. This finding is similar to the work of Akpomie *et al.* (2015), who assessed the effect of brewery effluent on the microbiological quality Ikpoba River and found out that 25 x 10^3MPN/100ml of TC bacteria was present. The study found out that 22 x 10^3MPN/100ml of TC bacteria was present in Carter sachet water, and 78 x 10^3MPN/100ml in Chem-Paully sachet water. This finding is similar to the work of Mustafa *et al*.(2013) on the physicochemical and bacteriological analyses of drinking in Maiduguri Metropolis, Borno State, Nigeria and found out that TC bacteria yielded 57.4 x 10^3MPN/100ml.

Table 3: Microbiological Parameters of Selected Sachet Water Brands in Nnewi

S/No	Brands	Dilution Factor	Total Count (MPN/100ml)	Microbial Isolates
1	Christo	10^{-6}	24 x 10^4	*Klebsiella spp, Enterococci spp, Escherichia coli*
2	Carter	10^{-7}	22 x 10^3	*Salmonella spp, Escherichia coli*
3	Uru	10^{-6}	22 x 10^4	*Klebsiella spp, Streptococcus faecalis, Escherichia coli*
4	Aqua-Rapha	10^{-5}	21 x 10^3	*Streptococcus spp, Escherichia coli*
5	Chem.-Paully	10^{-5}	78 x 10^3	*Salmonella spp, Pseudomonas aerugonosa*

There is presence of indicator organisms such as *Klebsiella spp* and *Pseudomonas aeruginosa* in the tested sachet water brands. Unsanitary conditions in sachet water production process are responsible for the presence of indicator organisms in sachet water. Thus, disease-causing microorganisms are responsible for the presence of indicator organisms in tested sachet water brands. *Pseudomonas aeruginosa* can cause infections in the blood, lungs while *Klebsiella spp* can cause pneumonia, sepsis, wound infections and urinary tract infections. Even more health-threatening is the presence of fecal indicators such as *Streptococcus faecalis* and *Escherichia coli,* which are major causes of diseases harmful to the human body. Fecal indicators are introduced into the environment (of which water is a part) through fecal matter as they are responsible for diseases such as diarrhea, fever and pains. *Salmonella spp* which causes typhoid is present in the tested sachet water brands. This study postulated that sachet water ingested by Nnewi inhabitants may be responsible for water-related diseases such as typhoid and the presence of *Salmonella spp* (which causes typhoid) in the selected sachet water brands confirmed that.

Conclusion

In line with the objectives of this study, there is presence of pH, conductivity, turbidity and total solids content which were not significant relative to their standard regulatory values in tested sachet water brands in Nnewi. Also, there is presence of heavy metals in tested sachet water whose bio-accumulation by people of Nnewi is unhealthy. From the study carried out, there is presence of indicator organisms in sachet water in Nnewi which is responsible for morbidity of diseases such as typhoid and diarrhea in susceptible human populations in Nnewi. The study therefore call for the following recommendations,

physicochemical and microbiological qualities of sachet water brands should be in line with National Standard for Drinking Water Quality (NSDWQ) standard; total coliform microbes and indicator organisms should be hygienically removed from sachet water production process; sachet water vending machines should be properly disinfected to guard against indicator organisms entraining into them, which can serve as a source of sachet water contamination, and need for sachet water regulatory agency (National Agency for Food Drug Administration and Control) toensure that sachet water brands are produced under a hygienic environment.

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