 

# Quality Evaluation of Sachet and Bottled Water in Isuochi Town of Abia State - South East Nigeria

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**Abstract**
Bottled and sachet water were purchased from nine (9) different communities in Isuochi town of Abia state. Physicochemical and microbiological analyses were carried out to ascertain their wholesomeness using standard analytical methods. Appearance, odour, taste, Total Dissolved Solids (TDS), pH, conductivity, Total Hardness (TH), alkalinity, chloride, cadmium of all the sachet and bottled water were within the WHO, NAFDAC/SON guideline whereas chemical constituents namely zinc (2.25-41.97 mg/l), copper (1.14-5.03mg/l), calcium (2.02 – 677.4 mg/l), magnesium (0.33 – 131.32 mg/l) and iron (7.99 – 19.35 mg/l) in few samples were above the SON/NAFDAC and WHO recommended limits of 3 – 5 mg/, 1.0 mg/l, 75 mg/l, 0.2 – 0.025 mg/l and 0.3 mg/l respectively. Four out of the whole brands examined had lead levels ranging from 0.19 – 1.67 mg/l. These values were above the SON/NAFDAC and WHO recommended limits of 0.002 – 0.01 mg/l and 0.001 mg/l respectively. Also, eight out of the twenty-five satchet and bottled water were contaminated by coliform bacteria ranging from 1 – 26 cfu/ml. *Escherichia coli* ranging from 1 – 28 cfu/100ml were detected in more than 40% of the water samples. This is contrary to the recommendation by SON/NAFDAC that *E. coli* must not be detected in a 100 ml sof drinking water. However, on the average, both the bottled and sachet water were of good quality.
**Keywords**: Quality, evaluation, sachet, bottled, water, physicochemical.

## 1.1 INTRODUCTION

Accessibility and availability of fresh clean water is a key to sustainable development and an essential element in health, food production and poverty reduction (Adekunle *et al*., 2004). However, an estimated 1.2 billion people around the world lack access to safe water and close to 2.5 billion persons are not provided with adequate sanitation (Third World Forum on water, 2003). Recently, a number of small scale industries are packaging and marketing factory-filled sachet drinking water, popularly called *pure water*, that may also be considered a safe source of potable water (Dodoo *et al.*, 2006). Those who cannot afford the bottled water go for the cheaper sachet water. Rutal (1996) reported that sachet water vending machines may not be free of microorganisms, because bacteria like *Streptococcus faecalis* have been isolated from sachet water producing machines. Ground water is preferred to surface water because its purification is easier and borehole water is of better quality (Abulade *et al.*, 2007). Recently, records showed that physical and chemical contaminants in water have their own toxic effect, leading to inhibition of various biological and metabolic processes (WHO, 1997; 2001). The abundance of toxic chemicals in drinking water may cause adverse effect on human health such as cancer and other chronic diseases (Ikem *et al.*, 2002). Epidemiological studies have indicated a strong association between the occurrences of several diseases in humans particularly cardiovascular diseases, kidney related disorder, neurocognitive effect, and various forms of cancer and the presence of many metals such as cadmium, mercury, and lead (Al Saleh and Al-Doush, 1998). International standards have been set by WHO and USEPA for maximum allowable levels of these elements in drinking and packaged water (WHO, 2003; EPA, 2003). Generally, water is accepted to be of potable quality when it is clean, clear, odourless and free from microbial contaminants and harmful chemicals.

## 1.2 MATERIALS AND METHODS

### 1.2.1 Sample collection

Sachet and bottled water were purchased at nine different communities in Isouchi town of Abia State, South East Nigeria. The samples numbered 25 each representing a brand of sachet (coded S) or bottled water (coded B).

### 1.2.2 Chemical analysis

The pH of the water samples was determined using the Hanna digital pH meter (AOAC, 1990). The conductivity and the total dissolved solids were also determined using the Hanna instrument. Meanwhile, the EDTA titration method was used for total hardness (AOAC, 1990). Chloride was determined by titrating 100ml of the samples with $AgNO_3$ solution using $K_2CrO_4$ as an indicator. Calcium, potassium, zinc, iron, magnesium, lead and copper of the water samples were determined using flame method for atomic absorption spectrophotometer (AAS model-6800 perkin Elmer) (AOAC, 2006). *E. coli* count, fungi, total coliforms, total heterotrophic count, salmonella and *shigella* organisms were all determined using standard microbiological procedures (Azu, 2004).

### 1.2.3 Statistical analysis

The standard deviation and mean values were statistically obtained using the SPSS programme for personal computers to determine the accuracy of the data.

### 1.3 RESULTS AND DISCUSSION

The results of the physical and chemical analyses are presented in Tables 1 and 2. The sachet and bottled water were odourless, unobjectionable and tasteless. This is in accordance with the results of Nwosu and Ogueke (2004), and Daniel *et al*. (2007); they observed that poor odour and taste may result from contamination with dusty particles and dissolved solids implying that the waters were free from these elements. Total dissolved solid values ranged between 4.10 and 82.15 mg/l. This is lower than the maximum value allowed by SON, NAFDAC and WHO (500mg/l). Presence of solid particles in water indicates contamination (Goel, 2006) which according to Nwosu and Ogueke (2004) may be as a result of poor filtration method.

The pH values obtained ranged from 6.15 to 8.49. Sachet and bottled water S2, S3, S4, S5, S8, S9, S13, S14, B19, B23, and B24 were more acidic with pH ranging from 6.15 to 6.90. The pH result showed that the ground water of the area was acidic. Jones (1998) reported that acidic water results in corrosion of iron and steel materials (pipe and plumbing fixture), clogging of distribution pipes which could cause objectionable taste of drinks and foods, and may stain clothes and rust cooking utensils; thus the corrosion level of pipes and water storage materials could be high. Saleh *et al*. (2008) reported that at a pH less than 6.5, water is corrosive and dissolves plumbing components. High pH (8.5 or more) can promote hardness scale precipitation and make chlorine disinfectants more effective. The mean pH of the sachet and bottled water (6.15 to 8.49) fell within the permissible limit of 250 to 1000 µs/cm set by SON/NAFDAC (2007) and WHO (2003).

Conductivity is an indicator of water quality and soil salinity. The World Health Organization (WHO) international standard for drinking water (1998) classified water with a total hardness (TH) <150 mg/l as moderately hard water and water hardness above 150 mg/l as hard $CaCO_3$. The total hardness (TH) of the water ranging from 2.00 to 26.05 mg/l were far below the permissible limit (150 – 200 mg/l) set by SON/NAFDAC (2007) and WHO (2003), so could be classified as soft water. Soft water has corrosive effect on water pipes (El-Harouny *et al.*, 2010). The most suitable water for domestic use and for drinking purposes in terms of water hardness are moderately hard water and is associated with low death rate from heart diseases (ISO, 1990). The alkalinity values of all the water were outside the stipulated range of 30 – 50 mg/l by WHO (2003) and maximum limit of 100 mg/l by NAFDAC/SON (2007). High alkalinity in water gives unpalatable taste (Goel, 2006).

Chlorides ($Cl^-$) are binary compounds of chlorine. A chloride is made of chlorine chemically combined with a metal. The presence of chlorine, where it does not occur naturally indicates possible water pollution; chloride contaminates rivers and ground water giving it a salty taste and can make water unsuitable for humans to drink. High levels of chloride kill plants and
wildlife (Saleh *et al.*, 2008). Chlorine is one of the major anions in water, it is known in maintenance of acid-base balance, and hence excess of it may give rise to detectable taste in water and can cause Oedema (Ekpete, 2002). The values obtained for chloride ranged from 0.00 to 29.22 mg/l. These values obtained were well below the recommended standard values of 250 mg/l by WHO (2003) and 200 mg/l by SON/NAFDAC (2007). The average mean values of chlorides (0.00 to 29.22 mg/l) in all the analyzed water brands indicated the absence of pollutants in the different brands of sachet and bottled water in Isouchi town.

Zinc is an essential metal and plays an important role in enzyme activity (Fleck, 1976). Drinking water contains zinc on very small quantities which may reduce the possibility of its deficiency in the diet. However, its accumulation in the human body causes harmful effect such as acceleration of anaemic conditions (Tayyerb *et al.*, 2004). The values obtained ranged from 2.28 – 41.97 mg/l. The zinc value of sachet and bottled water S2, S3, S4, S6, S8, S14, S15, B16, B17, B18, B19, B20 and B24 were within the stipulated permissible limit of 3.0 – 5.0 mg/l by SON/NAFDAC (2007) while the remaining water analyzed were far above the detectable limit and was in excess in which its accumulation accelerates anaemic conditions. Copper on the other hand was above the maximum limit (1.0 mg/l) stipulated by SON/NAFDAC (2007) in all the brands of sachet and bottled water evaluated while the brands coded B16, B17, B18, B19, B20, B23, B25 were slightly below the maximum limit (2.0 mg/l) stipulated by WHO (2003) which was an indication that the water was unwholesome to consume as it could cause gastrointestinal disorder (SON/NAFDAC, 2007).

Lead analyzed in some of the water brands was below detection limit of 0.002mg/l for SON/NAFDAC (2007) and 0.00 mg/l for WHO (2003). However brands S4, S9, S10 and S12 exceeded the maximum limit of lead which is an indication of unwholesomeness for drinking and other domestic uses. Lead is a cumulative general poison and the most susceptible to its adverse effects, are the foetus and pregnant women, infants and children up to six years of age. It affects the central and peripheral nervous system and mental development in infants; it is also carcinogenic and interferes with vitamin D metabolism (WHO, 2003; SON/NAFDAC, 2007). The contamination of drinking water by lead can be through the use of lead in plumbing fitting, pipes and as soldier in water distribution systems (Quinn and Sherlock, 1990).

Cadmium was below detection limit in all the brands of sachet and bottled water. Its absence is an indication of the good quality of the water. Contamination of drinking water by cadmium may occur as a result of its presence as impurity of galvanized pipes or cadmium containing solders in fittings, water heaters and taps (El-Harouny *et al.*, 2010). Cadmium is toxic to the kidney and causes disturbance in renal handling of phosphorus and calcium; may cause desorption of minerals from bone, which may lead to development of kidney stones and osteomalaria (NAFDAC/SON, 2007). Cadmium is also associated with hypertension and cause mutations (Saleh *et al.*, 2001).

Calcium salt ($Ca^{2+}$) on the other hand exceeded the maximum limit (75 mg/l) by SON/NAFDAC (2007) for some of the water namely S1, S2, S7, S10, S11, B16, B19, B21, B22 and B24 while the rest of the brands evaluated were below the maximum limit. No evidence of adverse health effects specifically attributable to calcium and magnesium in drinking water has been established. However, excess calcium and magnesium ions make hard water (Tay, 2007). Calcium plays an important role in blood clotting in muscles contraction and in certain enzymes in metabolic processes. People who drink water that is deficient in magnesium and calcium generally are more susceptible to cardiovascular disease.

The magnesium values obtained ranged from 0.33 – 131.32 mg/l except bottled water B25 that was below detectable limit. The magnesium value of all the water brands except B25 were above the SON/NAFDAC (2007) maximum limit of 0.20 to 0.25 mg/l. Hardness in water is caused by dissolved calcium, and to a lesser extent magnesium (WHO, 2003). Water containing less than 60 mg/l of magnesium is considered as soft water (Saleh *et al.*, 2001). Therefore, in this study, two sachet water brands, S4 and S7, were the hardest water. A number of ecological and analytical epidemiological studies have shown a statistically significant inverse relationship between hardness of drinking water and cardiovascular disease (WHO, 2003). On the other hand, water hardness may protect against diseases (Derry *et al.*, 1990). Magnesium functions as an essential constituent for bone structure, for reproduction, normal functioning of the nervous system and also a part of the enzyme system (Shills *et al.*, 1988). The US National Academy of sciences estimated that a nation-wide initiative to add calcium and magnesium to soft water might reduce the annual cardiovascular death rate by 150,000 in the United States (Foster, 1994).

Iron (Fe) values ranged from 7.99 – 19.35 mg/l. This showed that iron concentration in all the 25 sachet and bottled water brands were far above the SON/NAFDAC (2007) and WHO (2003) limit of 0.3 mg/l and 0.03 mg/l respectively. This is an indication of unwholesomeness and is unacceptable to the consumers as it can give rise to iron dependent bacteria which in turn can cause further deterioration in the quality of water by the production of slimes or objectionable colour and turbidity. The results obtained might be due to runoffs and geological formations of the locations of the water sources. Iron is one of the essential components of haemoglobin which is responsible for the transport of oxygen in the body. It also occurs in the prosthetic group of the cytochromes which functions in electron transport and in some enzymes like some dehydrogenases (Wheby, 1974). Iron also facilitates the oxidation of carbohydrates, proteins and fats, therefore contributes significantly to the prevention of anaemia which is widespread in developing countries like Nigeria (Bender, 1992). Some methods of aeration can remove or reduce iron level through simple chemical reaction (Wheby, 1974).

The results of the microbiological analysis are presented in Table 5. Sachet and bottled water S5, S6, S3, B17, B19 and B24 had too numerous growth of mould and yeast, while other 19 brands were free from such fungi growth. This implies that there could be a risk of contamination that can be seen as turbidity if the brands with the fungal growth were to be stored for many days. This means that they may cause water born diseases. The result of the coliform examination on the other hand, shows that seventeen out of the twenty five water brands were free from coliforms while S10 and S4 failed the analysis. This is because coliforms isolated from both water are above the stipulated limit (≤10 cfu/ml) by SON/NAFDAC (2007). Improper handling might be a reason why coliform bacteria were detected in some of the sachet and bottled water and it is an indication of faecal contamination which causes diseases such as diarrhea, typhoid fever, bacillary dysentery (Mead *et al*., 1999). Sachet water S3, S6, and S13 and bottled water B17, B19, and B24 had insignificant growth of coliforms as the isolates from them fell within the stipulated limit (≤10cfu/ml) by SON/NAFDAC (2007).

All the water brands analyzed were free from *salmonella* and *shigella* organisms which are the major causes of typhoid fever and shigellosis respectively. Water brands S1, S3, S4, B16, B17, B19 and B24 were positive for *E. coli* organisms which were above the stipulated limit (o cfu/100ml) by SON/NAFDAC (2007). *E. coli* organism causes bacillary dysentery and may pose some potential health hazards if the organism's infective dose were achieved through intake of these substandard water brands. Water brands S6, B17, B19 and B24 were found to contain some confluent growth of heterotrophic bacteria that is more than the stipulated limit (104 cfu/ml) by SON/NAFDAC (2007). Total heterotrophic counts are used as good indicators of the overall quality of production (Ferreira *et al*., 1994; Obiri-Danso *et al*., 2003). The remaining fourteen water brands were free from microorganisms implying that they were fit for consumption even though some of them namely S15, S13, S5, S4, S3, S12, S8, S10 and B16 had bacteria isolates that were within safe limits (104 cfu/ml) by SON/NAFDAC (2007).

## 1.4 CONCLUSION

This study revealed the physicochemical and microbiological characteristics of some brands of sachet and bottled water sold in Isuochi town of Abia state, South East Nigeria.

The result has obviously shown that some of the water brands did not comply with the permissible levels of the physicochemical and microbiological elements for packaged drinking water prescribed by WHO (2003) and NAFDAC/SON (2007). Hence to minimize this problem of poor quality of packaged drinking water, it is necessary for the water companies to adopt water treatment standards recommended by the regulatory agencies (Standard Organization of Nigeria, SON, and National Agency for Food and Drug Administration and Control, NAFDAC); also the regulatory agencies should ensure that packaged water manufacturers comply with good manufacturing practices (GMP) and also ensure that substandard products do not get to the consumers.

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Table 1: Physical parameters of the sachet and bottled water

| Sachet & bottled water | Appearance | Odour | Taste | Total Dissolved Solids (mg/l) |
|---|---|---|---|---|
| S1 | C | U | U | 82.15±0.07 |
| S2 | C | U | U | 82.15±0.07 |
| S3 | C | U | U | 6.15±0.07 |
| S4 | C | U | U | 14.15±0.07 |
| S5 | C | U | U | 7.15±0.07 |
| S6 | C | U | U | 19.15±0.07 |
| S7 | C | U | U | 6.15±0.07 |
| S8 | C | U | U | 21.15±0.07 |
| S9 | C | U | U | 59.15±0.07 |
| S10 | C | U | U | 24.15±0.07 |
| S11 | C | U | U | 7.15±0.07 |
| S12 | C | U | U | 48.15±0.07 |
| S13 | C | U | U | 59.15±0.07 |
| S14 | C | U | U | 58.15±0.07 |
| S15 | C | U | U | 4.10±0.14 |
| B16 | C | U | U | 7.05±0.07 |
| B17 | C | U | U | 62.05±0.07 |
| B18 | C | U | U | 70.05±0.07 |
| B19 | C | U | U | 16.05±0.07 |
| B20 | C | U | U | 6.55±0.64 |
| B21 | C | U | U | 40.05±0.07 |
| B22 | C | U | U | 11.05±0.07 |
| B23 | C | U | U | 6.05±0.07 |
| B24 | C | U | U | 5.05±0.07 |
| B25 | C | U | U | 14.05±0.07 |
| SON/NAFDAC | C | U | U | 500mg/l |

C – clear, U – Unobjectionable, S – Sachet water, B – Bottled water, Values are means±standard deviation of duplicate determinations

Table 2: Chemical parameters of the sachet and bottled water I

| Sachet & bottled water | pH | Conductivity (µs/cm) | Total Hardness (mg/l) | Alkalinity (mg/l) |
|---|---|---|---|---|
| S1 | 7.90±0.007 | 41.15±0.07 | 6±0.07 | 8.05±0.07 |
| S2 | 6.90±0.007 | 41.15±0.07 | 14±0.007 | 8.05±0.07 |
| S3 | 6.70±0.007 | 48.05±0.07 | 2±0.007 | 8.08±0.07 |
| S4 | 6.15±0.07 | 40.05±0.07 | 2±0.007 | 6.05±0.07 |
| S5 | 6.15±0.007 | 38.05±0.07 | 2±0.007 | 8.08±0.07 |
| S6 | 7.80±0.007 | 41.00±0.007 | 2±0.007 | 6.05±0.07 |
| S7 | 7.80±0.007 | 39.05±0.07 | 4±0.007 | 2.05±0.07 |
| S8 | 6.15±0.007 | 40.00±0.007 | 4±0.007 | 6.05±0.07 |
| S9 | 6.75±0.007 | 39.00±0.007 | 4±0.007 | 2.05±0.07 |
| S10 | 7.65±0.07 | 41.00±0.007 | 6±0.007 | 6.05±0.07 |
| S11 | 7.15±0.07 | 43.05±0.07 | 8±0.007 | 4.00±0.07 |
| S12 | 8.15±0.07 | 44.00±0.007 | 4±0.007 | 6.00±0.007 |
| S13 | 6.75±0.07 | 40.00±0.007 | 22±0.014 | 2.00±0.007 |
| S14 | 6.35±0.07 | 40.00±0.007 | 6±0.007 | 4.00±0.007 |
| S15 | 7.05±0.07 | 41.00±0.007 | 18±0.014 | 4.00±0.007 |
| B16 | 7.65±0.07 | 39.00±0.007 | 8.01±0.021 | 4.00±0.007 |
| B17 | 8.25±0.07 | 38.00±0.007 | 6.01±0.014 | 4.00±0.007 |
| B18 | 8.25±0.07 | 43.01±0.014 | 6.01±0.014 | 14.00±0.007 |
| B19 | 6.65±0.07 | 42.10±0.14 | 6.01±0.014 | 4.00±0.007 |
| B20 | 7.75±0.07 | 39.01±0.014 | 4.01±0.014 | 2.00±0.007 |
| B21 | 7.85±0.07 | 39.01±0.014 | 6.01±0.014 | 10.10±0.14 |
| B22 | 8.49±0.007 | 39.01±0.014 | 6.01±0.014 | 8.00±0.007 |
| B23 | 6.80±0.007 | 40.05±0.07 | 6.01±0.014 | 4.00±0.007 |
| B24 | 6.90±0.007 | 38.00±0.007 | 26.05±0.07 | 2.00±0.007 |
| B25 | 8.10±0.007 | 38.00±0.007 | 4.10±0.14 | 2.00±0.007 |
| SON/ NAFDAC | 6.5 | 1000 | 100 | 100 |
| WHO | 8.5 | 250 | 200 | 30-50 |

S – Sachet water, B – Bottled water, ND – Not detected. Values are means±standard deviation of duplicate determinations

Table 3: Chemical parameters of the sachet and bottled water II

| Sachet & bottled water | Chloride (mg/l) | Zinc (mg/l) | Copper (mg/l) | Lead (mg/l) |
|---|---|---|---|---|
| S1 | 11.71±0.014 | 14.05±0.003 | 4.11±0.002 | ND |
| S2 | 23.45±0.07 | 2.28±0.0002 | 2.28±0.001 | ND |
| S3 | 11.71±0.02 | 4.01±0.004 | 2.06±0.003 | ND |
| S4 | 0.00±0.007 | 3.38±0.007 | 3.35±0.0007 | 1.67±0.003 |
| S5 | 5.81±0.014 | 6.94±0.002 | 2.36±0.002 | ND |
| S6 | 5.81±0.014 | 4.36±0.002 | 3.88±0.001 | ND |
| S7 | 11.72±0.03 | 7.22±0.003 | 4.11±0.003 | ND |
| S8 | 29.23±0.02 | 3.51±0.001 | 3.12±0.001 | ND |
| S9 | 5.81±0.014 | 10.54±0.003 | 4.11±0.001 | 1.48±0.001 |
| S10 | 11.72±0.03 | 5.11±0.001 | 3.58±0.001 | 0.19±0.002 |
| S11 | 5.81±0.014 | 41.97±0.001 | 3.27±0.0007 | ND |
| S12 | 5.81±0.014 | 8.73±0.002 | 5.03±0.002 | 0.93±0.002 |
| S13 | 17.51±0.014 | 11.31±0.001 | 4.11±0.001 | ND |
| S14 | 23.43±0.04 | 4.75±0.002 | 2.59±0.0007 | ND |
| S15 | 11.71±0.021 | 4.58±0.003 | 2.59±0.003 | ND |
| B16 | 5.77±0.04 | 3.27±0.001 | 1.75±0.002 | ND |
| B17 | 11.71±0.03 | 3.73±0.0007 | 1.14±0.002 | ND |
| B18 | 23.42±0.03 | 3.27±0.003 | 1.29±0.0007 | ND |
| B19 | 5.80±0.007 | 3.71±0.007 | 1.45±0.001 | ND |
| B20 | 0.00±0.007 | 2.25±0.007 | 1.68±0.0007 | ND |
| B21 | 11.7±0.007 | 24.35±0.003 | 3.81±0.0007 | ND |
| B22 | 5.81±0.014 | 5.22±0.001 | 2.82±0.0014 | ND |
| B23 | 11.71±0.02 | 5.93±0.003 | 1.45±0.002 | ND |
| B24 | 0.00±0.007 | 3.24±0.0007 | 2.67±0.003 | ND |
| B25 | 11.7±0.007 | 5.38±0.003 | 1.60±0.007 | ND |
| SON/ NAFDAC | 200 | 3.5 | 1.0 | 0.002-0.021 |
| WHO | 250 | 1.0 | 2.0 | 0.001 |

S – Sachet water, B – Bottled water, ND – Not detected. Values are means±standard deviation of duplicate determinations

Table 4: Chemical parameters of the sachet and bottled water III

| Sachet & bottled water | Cadmium (mg/l) | Calcium (mg/l) | Magnesium (mg/l) | Iron (mg/l) |
|---|---|---|---|---|
| S1 | ND | 135.21±0.0007 | 8.58±0.007 | 17.48±0.003 |
| S2 | 0.002±0.003 | 2.02± 0.0014 | 2.77±0.0014 | 7.99±0.0021 |
| S3 | ND | 2.02±0.0021 | 5.58±0.0021 | 11.11±0.0014 |
| S4 | ND | 107.63±0.003 | 80.76±0.003 | 13.11±0.0007 |
| S5 | ND | 3.36±0.0007 | 2.62±0.0007 | 10.49±0.003 |
| S6 | ND | 73.3±0.0007 | 3.28±0.0014 | 14.61±0.0021 |
| S7 | ND | 534.8±0.0014 | 131.32±0.0021 | 17.48±0.0017 |
| S8 | ND | 3.36±0.0021 | 0.33±0.003 | 9.24±0.0007 |
| S9 | ND | 14.13±0.002 | 3.02±0.0007 | 18.10±0.0014 |
| S10 | ND | 677.4±0.0007 | 59.28±0.0014 | 16.60±0.0021 |
| S11 | 0.001±0.001 | 222.67±0.0007 | 7.44±0.0021 | 13.61±0.003 |
| S12 | ND | 11.44±0.001 | 0.39±0.003 | 10.99±0.0007 |
| S13 | ND | 52.47±0.003 | 3.79±0.0007 | 14.61±0.0014 |
| S14 | ND | 20.18±0.0007 | 2.57±0.0014 | 15.86±0.0021 |
| S15 | ND | 26.91±0.003 | 2.81±0.0021 | 19.35±0.003 |
| B16 | ND | 83.42±0.0007 | 38.62±0.003 | 14.36±0.0007 |
| B17 | ND | 28.93±0.0007 | 5.72±0.007 | 12.48±0.0014 |
| B18 | ND | 30.27±0.0021 | 1.11±0.0014 | 17.60±0.0021 |
| B19 | ND | 187.01±0.0021 | 20.58±0.002 | 18.73±0.003 |
| B20 | ND | 16.14±0.0021 | 2.93±0.003 | 11.99±0.003 |
| B21 | ND | 88.12±0.0014 | 30.25±0.0007 | 13.73±0.0021 |
| B22 | ND | 76.69±0.0007 | 30.15±0.001 | 15.23±0.0014 |
| B23 | ND | 86.78±0.021 | 34.73±0.003 | 15.98±0.0007 |
| B24 | ND | 112.34±0.003 | 32.22±0.003 | 17.60±0.0014 |
| B25 | ND | 24.89±0.003 | ND | 14.36±0.0014 |
| SON/ NAFDAC | 0.03 | 75 | 0.2-0.25 | 0.3 |
| WHO | 0.05 | - | - | 0.03 |

S – Sachet water, B – Bottled water, ND – Not detected. Values are means±standard deviation of duplicate determinations

Table 5: Microbiological profile of the sachet and bottled water

| Sachet & bottled water | Fungi | Total Coliforms (CFU/ml) | Salmonella and Shigella (cfu/ml) | E-coli (cfu/ml) | THC (cfu/ml) |
|---|---|---|---|---|---|
| S1 | Nil | Nil | Nil | 3 | Nil |
| S2 | Nil | Nil | Nil | 1 | Nil |
| S3 | 9 | 8 | Nil | 10 | 6 |
| S4 | Nil | 26 | Nil | 28 | 50 |
| S5 | 15 | Nil | Nil | Nil | 23 |
| S6 | 9 | 6 | Nil | Nil | Confluent growth |
| S7 | Nil | Nil | Nil | Nil | Nil |
| S8 | Nil | Nil | Nil | 1 | 5 |
| S9 | Nil | Nil | Nil | Nil | Nil |
| S10 | Nil | 13 | Nil | 7 | 9 |
| S11 | Nil | Nil | Nil | Nil | Nil |
| S12 | Nil | Nil | Nil | 2 | 1 |
| S13 | Nil | 1 | Nil | Nil | 7 |
| S14 | Nil | Nil | Nil | Nil | Nil |
| S15 | Nil | Nil | Nil | Nil | 2 |
| B16 | Nil | Nil | Nil | 2 | 9 |
| B17 | 4 | 3 | Nil | 1 | Confluent growth |
| B18 | Nil | Nil | Nil | Nil | Nil |
| B19 | 9 | 8 | Nil | 18 | Confluent growth |
| B20 | Nil | Nil | Nil | Nil | Nil |
| B21 | Nil | Nil | Nil | Nil | Nil |
| B22 | Nil | Nil | Nil | Nil | Nil |
| B23 | Nil | Nil | Nil | Nil | Nil |
| B24 | 6 | 6 | Nil | 5 | Confluent growth |
| B25 | Nil | Nil | Nil | Nil | Nil |
| SON/ NAFDAC | - | <10 cfu/ml | - | 0 cfu/100ml | 104 cfu/ml |
| WHO | - | - | - | - | - |

S – Sachet water, B – Bottled water, ND – Not detected. Values are means±standard deviation of duplicate determinations