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ORIGINAL RESEARCH ARTICLE

ASSESSMENT OF REGULATION COMPLIANCE AND QUALITY OF SACHET WATER FACTORIES IN IBADAN NORTH LOCAL GOVERNMENT, OYO STATE, NIGERIA

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ABSTRACT

Provision of clean drinking water is one of the basic human necessities for healthy livelihood. In Nigeria, many people relied on sachet waters as an alternative source of clean drinking water. However, complaints abound regarding lack of proper water quality standard being used which is a major health concern. This study assessed the regulatory compliance of some sachet water production companies and water quality standard in Ibadan North Local Government Area, Oyo State, Nigeria. Questionnaires were administered on factory's organisational structure and staffing; facilities and equipment; water treatment processes and sanitation practices, Also, Sachet water samples were analysed for the contaminants of Turbidity, Colour, Odour, pH, Nitrate, Chloride, Iron, Electrical conductivity and E-coli count. From the questionnaire analysis, the adherence level with the regulations was poor as majority (60%) of the sachet water factories have poor organisational structure and only 33% have adequate facilities and equipment. However, water quality analysis showed that most of the sachet water parameters tested were within the standard range except for pH values and E Coli count which majority (70%) falls below standard for both. The study concludes that most sachet water brands produced are unsafe for human consumption. There is need for proper monitoring by relevant agencies towards ensuring sachet water factories continuously complied with standard operations for better public health in the study area.

1.0 Introduction

Access to safe drinking water is critical to survival, healthy livelihood and sustainable development (Edema et *al*., 2001; Adekunle *et al*., 2004). However, nearly one billion people across the globe lack access to portable drinking water (CDC, 2021). In Nigeria only around 30% of the population have access to potable drinking water (Oko, 2021). Whilst in the rural areas, drinking water sources are often limited to polluted waters from ponds, rivers or unprotected wells (Orimoloye *et al*., 2015; Okullo et *al*., 2017), which were primarily utilised with little or no treatment practices (Sridhar *et al*. 2020). In the urban areas, clean water accessibility issues are virtually the same with the rural areas, owing to the inadequate investment in public water supply infrastructure that renders pipe-borne water consumption unreliable (Emma *et al*. 2014). The non-availability of good quality drinking water has resulted in a number of public health issues such as diarrhoea, sleeping sickness, guinea worm infestation (Onweluzo and Akuagbazie, 2010; Freeman *et al*., 2017). which could have been averted simply through clean water provision.

However, the years of inadequate funding of the Nigerian public water sector has left the society with the issue of adapting different alternative measures to meet their drinking water needs (Akunyili, 2003). Generally, the high income group go for bottled water whose manufacturing practices and hygiene standards were high but expensive (Obinna, 2014; Ibrahim *et al*., 2015;

Chukwuma *et al*., 2018), while the low income group, resorted to dependence on drinking packaged waters generally referred to as '*pure water*', it is usually distributed for sale in sealed polythene containers financially affordable to the common populace (Daramola *et al*. 2019), In Nigeria, people have relied heavily on it as an alternative to clean drinking water. And in addition, this category of package water has some positive socio-economic impact; reducing societal crimes and improving standard of living through youth employment (Bello *et al*. 2017). However, complaints abound on its quality and public health issues, many sachet water samples examined by various researchers across the country were not health risk free, and has constituents above the standard permissible limit for drinking, thus leading to waterborne disease outbreaks. (Edema *et al*., 2011; Adesiji, 2012; Isikwue and Chikezie, 2014; Odeyemi *et al*., 2015; Ibrahim *et al*., 2015; Ugochukwu *et al*. 2015; Yusuf *et al*., 2015; Epundu et *al*., 2017; Omolade and Zanaib, 2017; Akpen *et al*., 2018; Umoessien *et al*., 2019; Opafola *et al*., 2020), this menace was undoubtedly a result of poor water treatment and operation conditions (Daramola *et al*. 2019; Dajal, 2019). Hence, there is need for strict attention and routine monitoring by regulatory agencies with the view of raising standards of quality of sachet water produced and sold in the country.

The National Agency for Food and Drugs Administration and Control (NAFDAC) is the sole regulatory body established and empowered to enforce compliance with the drinking water factories in Nigeria, that packaged water companies are required to undergo examination by NAFDAC which ultimately results to issuing operation license. However, today many water factories were operating illegally without license for operation, hence consumers were not appropriately guided to prevent communicable diseases through drinking certified sachet waters. Nevertheless, a careful understanding on the previous related studies on assessing the integrity of sachet water manufacturing companies basically rely on the physiochemical and bacteriological quality of the finished product and not the regulatory compliance attitude and production processes, furthermore, studies have shown that packaged water can be contaminated at various stages of the production, packaging and distribution (Addo *et al*., 2020, Osikanmi *et al*., 2020).

The aim of this research work therefore, is to assess the regulatory compliance level and the quality of sachet water factories in Ibadan North Local Government Area of Oyo State, Nigeria. So as to ensure proper and hygienic manufacturing conditions to protect the public health.

2. Methodology

2.1. Study Area

The study area was Ibadan North Local Government Area, Oyo State. The choice of the local government is based on its cosmopolitan nature and the location of many companies that deals with the production of sachet water. The city of Ibadan is located on longitude 3°54′21.28″ and latitude 7°23′39″. The LGA covers a land mass area of 145.58km^2 and a population of 432,900 people (NPC, 2016). It is bounded in the West by Ido and Ibadan North West Local Government, in the East by Lagelu, Egbeda and Ibadan South East Local Government respectively, and in the North by Akinyele Local Government. The Economic activities undertaken by the people in the study area include trading, public service and agricultural activities.

2.2. Study design

The scope of this study entailed questionnaire administration and oral interviews to fifteen (15) sachet water manufacturers in the Local Government Area over their compliance with manufacturing regulation standards. The study also covered water quality assessment of water samples obtained from ten (10) randomly selected sachet water produced in the local

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government by the factories. Fifteen (15) sachet water factories were visited and their geographical coordinate presented in Figure 1.

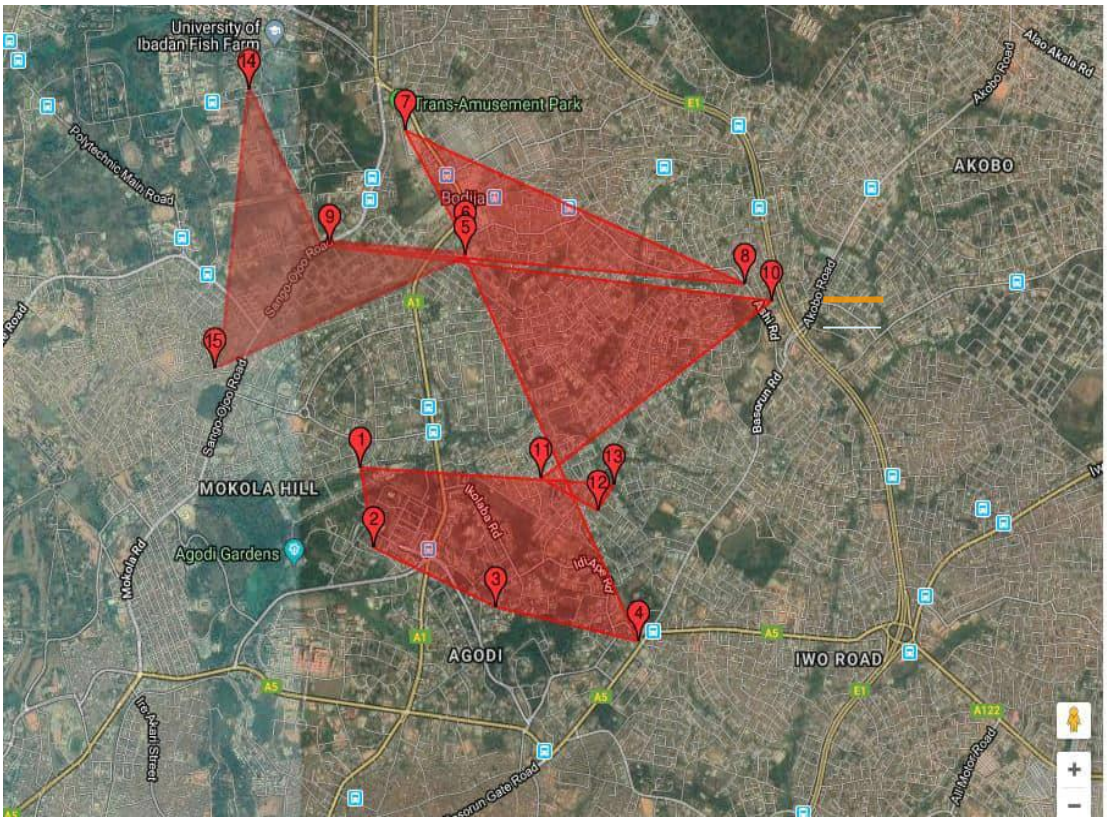

Figure 1: Map of the study area showing locations of the sachet water factories

2.4. Method of Data Sampling

The study was divided into the following phases:

Phase 1: Field survey with the aid of a questionnaire and an observational checklist to extract information from sachet water factories personnel. The questionnaire includes assessment of organizational structure and personnel, buildings, facilities and equipment (water treatment processes, production line and sanitation). The facilities and equipment auditing of the visited factories were assessed according to regulations by NAFDAC. Each of the factories' facilities and equipment auditing were carried out to assess the source of their raw water, depth of water source (if borehole), the distance of the source to nearest septic tank and the materials been used for their water reservoirs. Hence, the results were compared against Nigerian Standard of Drinking Water Quality (NSDWQ) standard (2007). Also, included as part of the facilities and equipment auditing, are types of materials used for each factory's pipes and taps, the mode of their form filling and sealing machines, the types of their UV sterilizer micro filters and each factories production line and sanitations.

Phase 2: Field water sampling and Laboratory analysis of the sachet waters being sold in Ibadan North Local Government area were carried out and a systematic random selection of ten (10) sachet waters were collected for further laboratory water quality analysis. The samples were labelled as SWF1 – SWF10. The samples were subjected to physical, chemical and bacteriological analysis, the results were compared against national and international standard of NSDWQ and

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WHO (World Health Organisation) respectively. The water quality parameters analysed were chosen in cognizance of the minimum routine check parameters for sachet water as approved by the NSDWQ (2007).

2.5. Parameters analysed

Standard for quality drinking water.

i) Physical parameters: Turbidity, Colour, Odour.
ii) Chemical: pH, Nitrate, Chloride, Iron, Electrical conductivity
iii) Bacteriological: E-coli count.

2.5.1. Procedures of laboratory analysis of water samples

- *Turbidity*: The turbidity of the water samples was measured directly with spectrophotometer at a wavelength of 580mm using the calibration curve.
- *pH value*: The pH value was determined with the use of a pH meter. The reading will be displayed on the meter.
- *Electrical conductivity*: An electrical conductivity meter was used to determine the electrical conductivity of the water sample. The reading will be displayed on the meter.
- *Chloride:* was determined using Mohr's method whew is titrated with silver nitrate solution, chlorides then precipitated as white silver chloride. Potassium chromate is used as indicator.
- *Iron:* The phenanthroline method was used for the measurement of iron.
- *Odour:* The water sample was measured by a term called odour intensity, which is related with the threshold odour. The threshold odour number represents the dilution ratio at which odour is hardly detectable
- *Colour:* The standard unit of colour is the colour produced by dissolving 1mg of platinum cobalt in 1 litre distilled water. Different standard colour intensities of solutions are prepared by dissolving known amounts of platinum cobalt with distilled water and the colour of sample is compared with the standard colour solutions.
- *E-coli count*: The *E. coli* test was done using multiple tube fermentation technique consisting of 3 phases – presumptive, confirmed and completed.

3. Results and Discussion

3.1.1. Sachet Water Organizational Structure and Buildings

The personnel and organizational structures and location of the fifteen factories visited were assessed in accordance with regulations of NAFDAC as shown in Table 1. The organizational structures as approved by NAFDAC are the structure which clearly shows each personnel's responsibility and qualification. The organizational chart will help define each personnel's duty, in the various units of such as administrative, stores, quality control, laboratory units, logistics and operations. further, a production manager must possess a minimum of Ordinary National Diploma (OND) in a related science-based course obtained from recognized tertiary institutions. However, from the assessment, it was found that the sachet water factories majorly (60%) do not fully comply with the approved regulations on the organizational structure and personnel. Hence factory's workers were irregularly engaged in the activities of the sachet water production which is against the regulating body, this may ultimately pose a great danger to the quality of sachet water. However, most (93.3%) factories have Production Manager that oversees the activities of the sachet water production and possess the minimum academic requirement of Ordinary National Diploma (6.7%) and Bachelor's Degree (86.7%) in a science related course as approved by NAFDAC, similar to Daramola et al. (2019) assessment. Regarding building location, some 33.3% do not comply with the regulations of locating the factory in a well demarcated

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places of other buildings, such as residential and commercials as indicated in Table 2, this affects free flow of personnel and materials to prevent cross contaminations.

Table 1: Organizational structure and Personnel

Variables	Valid frequencies	Percent (%)	Invalid frequencies
Do you have an adequate organizational structure showing your workers responsibilities?			
a) YES	6	40.00	0
b) NO	9	60.00	
Do you have a production manager?			
a) YES	14	93.3	0
b) NO	1	6.7	
What is the Managers level of education?			
a) BSc/HND	5	86.7	
b) OND	8	6.7	0
c) SSCE	1	6.67	
d) Others			

Table 2: Buildings

Variables	Valid frequencies	Percent (%)	Invalid frequencies
Is the entire Factory well demarcated from other buildings?			
Yes	10	66.7	0
No	5	33.3	
Is the factory sited near any of these activities or places? (Septic tank, Sewage treatment plant, etc.)			
Yes	9	60.00	0
No	6	40.00	
Does the factory have at least five rooms designated as the cloak room, packaging material store, production room and finished product store & office?	7	46.7	1
Yes	4	26.7	
No			

3.1.2. Facilities and Equipment Auditing- Phase two

Table 3 shows the results facilities and equipment of the fifteen sachet water factories visited, of which only (33%) fully complied with the regulations on the provisions of facilities and equipment, overall, the factories were rated moderately good in terms of compliance with the regulations of the facilities and equipment as regulated by NAFDAC. However major source of raw water were boreholes (100%), and were mostly (100%) at minimum depths of 100feets as required by NAFDAC to prevent infiltration from the earth surface (Akunyili, 2003). some 26.7% were located at distance less than 30meters. while 73.3% of the boreholes sunk has a more than the minimum distance of 30meters to the nearest septic tank location. Materials used for tanks, reservoir and taps are PVCs (93.3%) and Stainless steel (6.7%) as approved by the regulatory body. The mode of the factory's form filling and sealing machine is an automated mode (100%) which was designed to minimize man-material contact, safe to use, easy to clean and environmentally friendly, this is contrary to similar studies by Daramola *et al.* 2019, where quite

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a large portion of the manufacturing water brands surveyed packaged their water manually. However, quiet a number (46.7%) of the factories do not have water quality laboratory which is essential to water quality monitoring and determining the quality of their finished product before consumption, and some 26.7% lack dosing scale to quantify the amount of chemical dosage as approved by regulatory body, this may lead to desired quality being affected from inappropriate dosages. Regarding production line and sanitation, many (80%) have good production line and sanitation (Table 4) as regulated by NAFDAC and also equipped their toilets with washing facilities, and are located far from the production rooms except few (20%) as observed during inspection, which can eventually lead to contamination of the sachet water (Mosi *et al*. 2019). Nevertheless, there was some constraints in getting some information as some of the sachet water factories restrict access to their production rooms due to fear of exposing their non-compliance attitudes to standard regulations and practices, similar to experience by Daramola *et al*. (2019) study.

Table 3: Facilities and Equipment

Variables	Frequency (n)	Percentage (%)
What is the source of your raw water?		
Borehole	15	100.00
Rain water harvesting	0	0.00
Rivers,	0	0.00
Others (specify)	0	0.00
If borehole, what is the likely estimated depth?		
a) 50ft – 80ft	15	100.00
b) 80ft – 110ft	0	100.00
c) 110ft – 140ft	15	100.00
d) 140ft – 170ft	0	0.00
What is the distance of the source of water from the septic tank?		
a) 0m – 20m 0	0	0.00
b) 20m – 30m	4	26.67
c) >30m	11	73.33
What are the materials used for your tanks and reservoir?		
a) PVC	14	93.30
b) Stainless steel	1	6.67
c) Concrete	0	0.00
d) Others (Specify)	0	0.00
What are the materials used for your pipes and taps?		
a) PVC	14	93.30
b) Stainless steel	1	6.67
c) Galvanized iron	0	0.00
d) Others (Specify)	0	0.00
What is the mode of operation of your form filling and sealing machines?		
a) Manual	0	0.00
b) Semi-automated device	0	0.00
c) Automated machine	15	100.00

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Table 4: Production line and sanitation

Variables	Frequency (n)	Percentage (%)
Are toilets located far from the production rooms?		
a) YES	15	100.00
b) NO	0	0.00
Are the toilets well equipped with washing facilities such as soap or detergent.		
a) YES	11	73.30
b) NO	4	26.67

3.2. Results of the Physical, chemical and bacteriological quality of sachet water.

3.2.1. Physical assessment

The result of the physical water quality assessment (Turbidity, Colour, Odour) were all found to be in compliance with the NSDQW and WHO standard as shown in Figures 2 and 3, However, the tested samples were odourless, colourless and non-turbid, the colour values ranges from 0.01-0.04 TCU and turbidity from 0.0-0.04NTU, these findings corresponds to some similar studies across Nigeria (Ibrahim *et al*. 2015; Daramola *et al.* 2019; Opafola *et al*. 2020). Although turbidity, colour and odour were not necessarily a threat to health, nonetheless, it is an important indicator of the possible presence of contaminants (WHO, 2011), and can have a negative impact on the consumers' acceptability of waters as a result of visible cloudiness or unpleasant odour

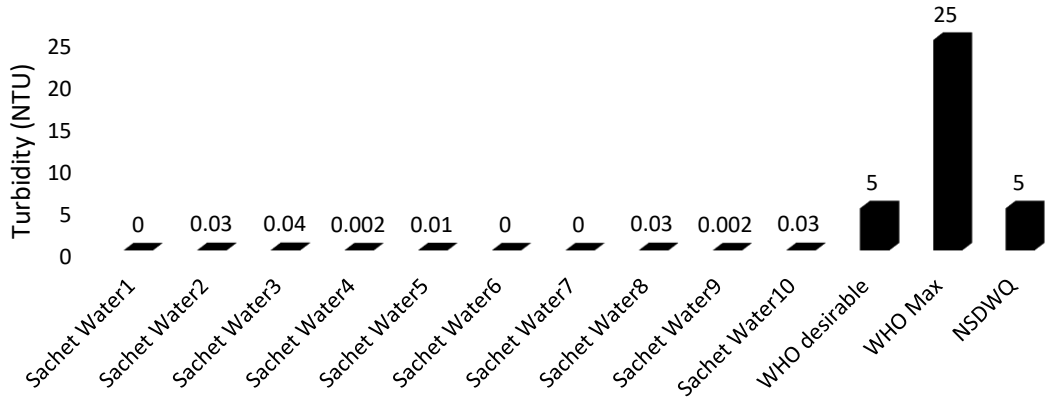

Figure 2: Turbidity Readings of the water samples.

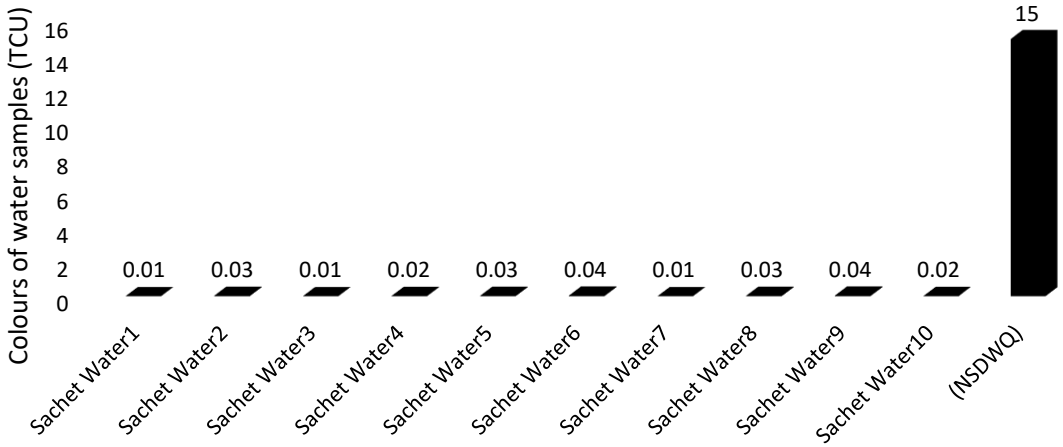

Figure 3: Colour Readings of the Samples

3.2.2. Chemical Assessment

Results of chemical water quality assessment were presented in Figures 4 to 8. The assessment includes the analysis of pH, Chloride, Nitrate, Iron and Electrical conductivity. However, except for pH, all sachet water samples fall within the allowable range of the NSDWQ and the WHO standards. high Iron level in water makes water unacceptable and results in clogging of plumbing utilities. The concentration of ions present in the water determines the degree of its electrical conductivity. Chloride in drinking water originates from sources such as urine, sewage and industrial effluents and natural sources. High concentration of chloride gives a salty taste to water and beverages, and increase rate of corrosion of metals in the piping system at lower pH. Nitrate react with haemoglobin in the blood and reduces the ability to transport oxygen in Infants (babies), which may eventually result in a serious medical condition known as blue baby syndrome or methemoglobinemia. There is also a suspected link between exposure to high nitrate and cancer in human (WHO, 2011). On the other hand, the pH value of some water samples collected (SWS1, 2, 3, 45, 9 and 10) does not meet the required standard (Figure 4). It was observed that the sachet water samples collected were slightly acidic; with values majorly less than the NSDWQ recommended lower limit of 6.5. This corresponds to studies by Daramola *et al.* (2019), where most tested sachet water samples showed mean pH of 5 which is acidic. Even though the shortfall to the minimum range limit of the pH standard is not harmful to health, however, this can cause damage to factory piping system and equipment due to the water corrosive nature.

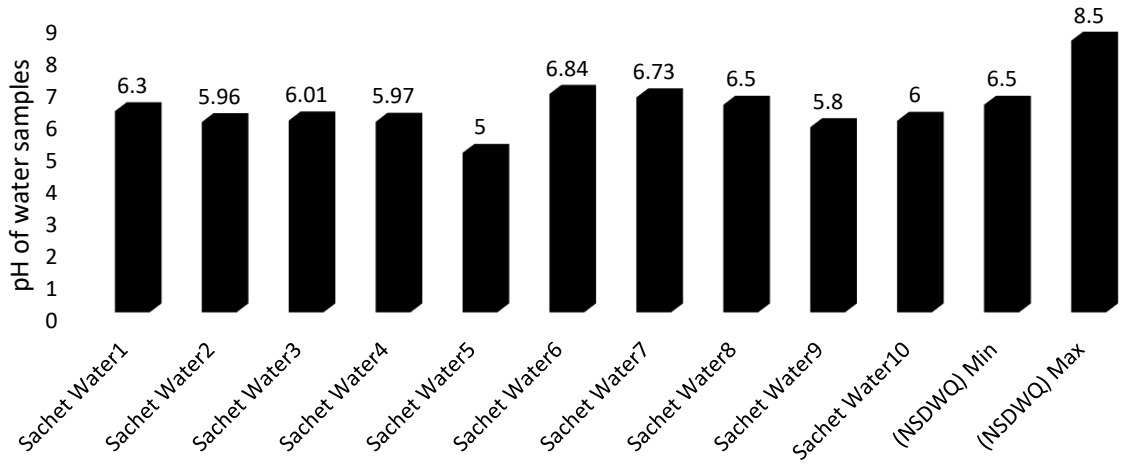

Figure 4: pH reading of the water samples

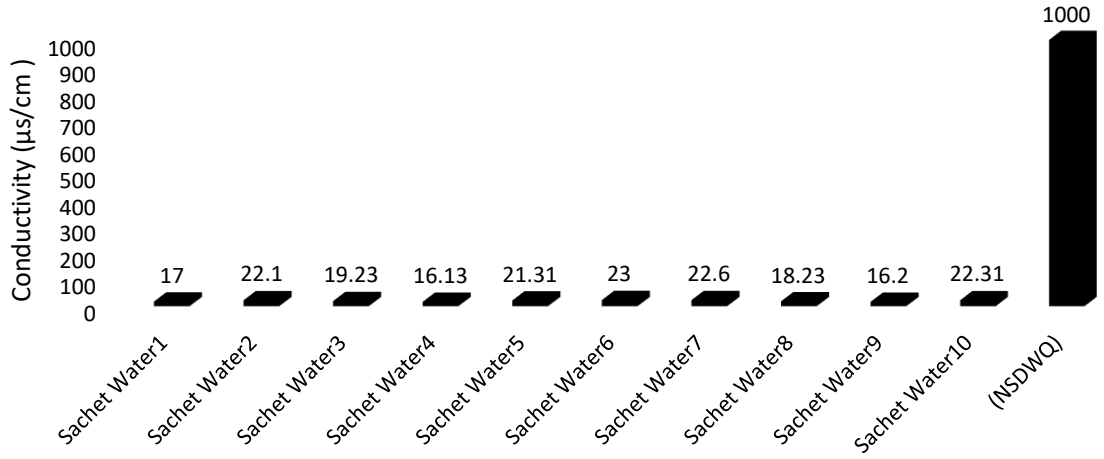

Figure 5: Conductivity Readings of the water samples

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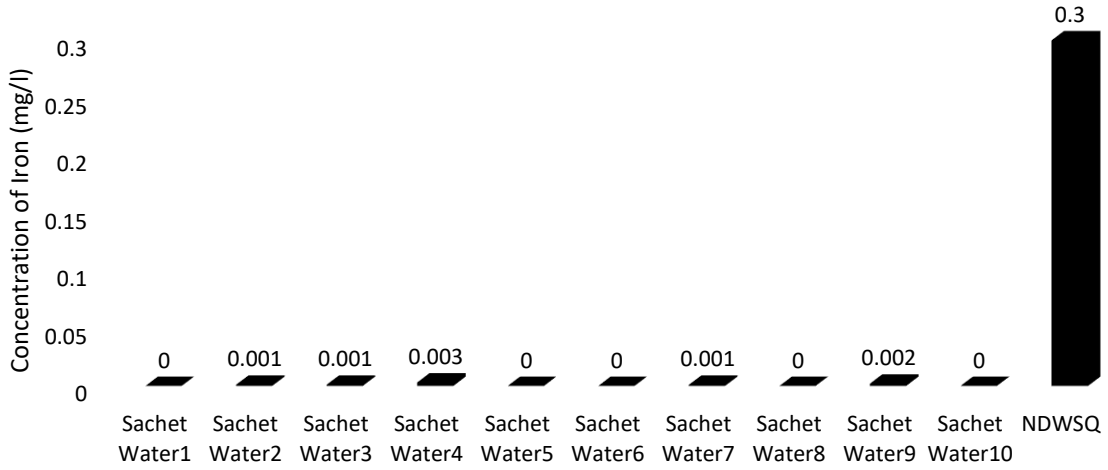

Figure 6: Concentration of iron reading of the water samples.

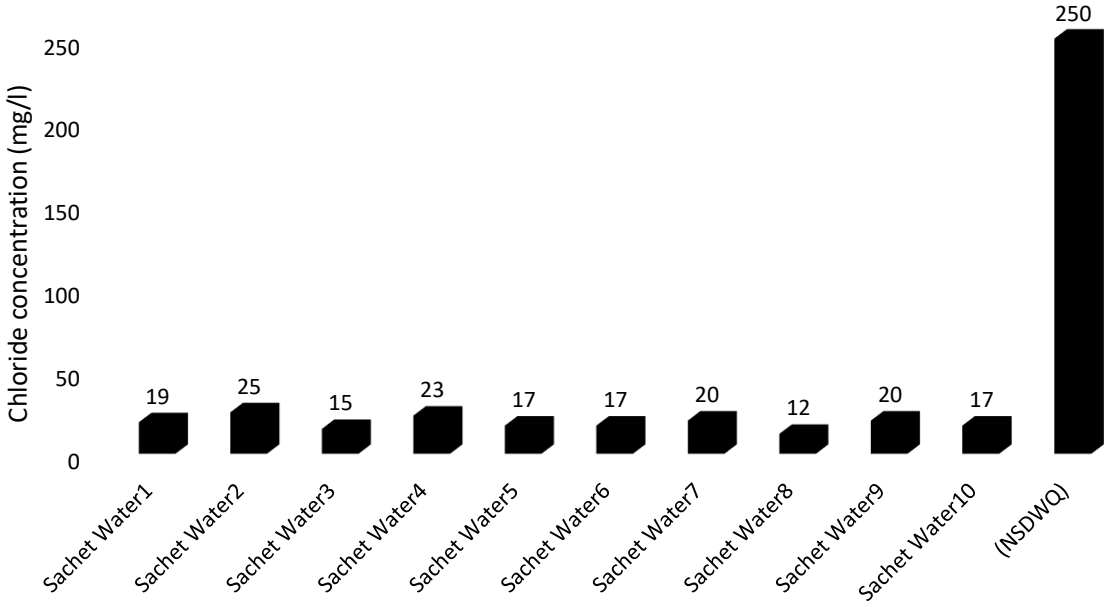

Figure 7: Chloride concentration reading of water samples

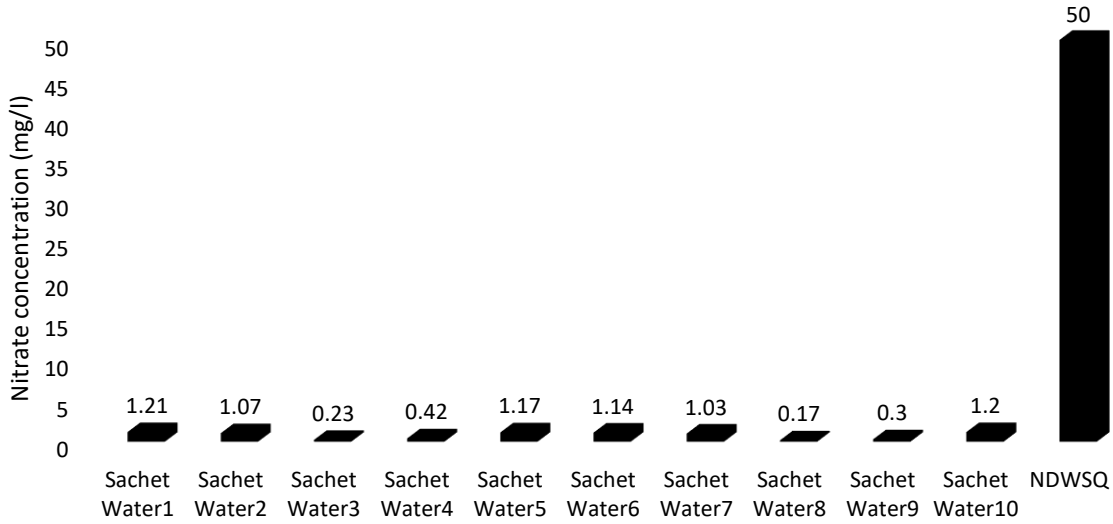

Figure 8: Nitrate Concentrations reading of the water sample.

3.2.3. Bacteriological assessment

Bacteriologically, the ten water samples were tested for *E-coli* count and the results presented in Figure 9. It showed that seven of the ten sachet water samples collected falls below the minimum allowable range with count values ranging from (1-9), as against the zero count standard for drinking water. This result is in agreement with many studies across the country (Isikwue and Chikezie, 2014; Ibrahim *et al.,* 2015; Yusuf *et al.,* 2015; Bukar *et al.,* 2015; Omolade and Zanaib, 2017; Umoessien *et al.,* 2019; Opafola *et al.,* 2020), in which sachet water tested contains pathogenic bacterias and parasites. Thus, posing a high risk to the public health. On the other hand, some few studies depicted otherwise, where the tested brands of water samples were healthy for consumption (Chukwuma *et al.,* 2018, Airaodion *et al.,* 2019) especially bottled waters (Obinna, 2014; Ibrahim *et al*., 2015; Chukwuma *et al*., 2018). This disparity could undoubtedly be related to environmental pollution of the areas, hygienic practices and regulatory compliances. However, the presence of *E-coli* (*Escherichia Coli)* in the samples is an indication of water bacterial contamination of human faeces, indicating non-compliance attitudes by the factories to standard hygiene and good manufacturing practices. Such as sighting their source of raw water (boreholes) away from septic tank and sewage effluents, which is a hazardous event (Osikanmi *et al.,* 2020). The presence of E *coli* in the sachet water is harmful to human health as it causes urinary tract infections, typhoid fever, hepatitis, gastroenteritis, dysentery ear infections and many other deadly ailments (NSDWQ, 2007). From the result therefore, only three out of the ten sachet water samples collected meets the requirement for the water drinking standard. This shows a very poor compliance to the regulations of producing portable water to the public.

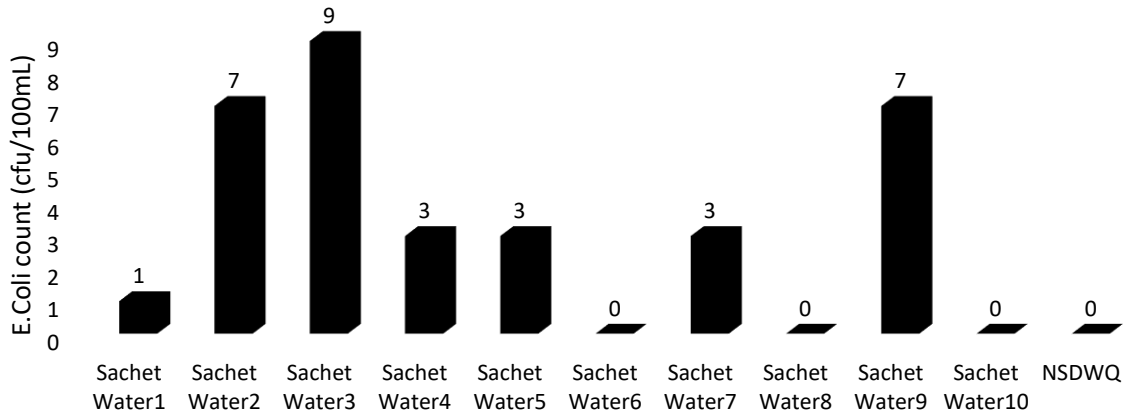

Figure 9: E-coli readings of the water samples

4.0 Conclusions

The findings showed that level of compliance with the laid down regulations by NAFDAC for the setting up of a sachet water factory were poor. The non-compliance with the regulations can be seen in most factories visited through non adherence to the regulations of engaging educated and skilled officials; not meeting the organisational structure and personnel regulations; inability to adhere strictly to the regulations of sighting their source of raw water far from a conspicuous source of pollution; and other unethical approach to the production of the sachet water, and as such, this resulted in production of unsafe water for public consumption. Also, some factories do not make use of the approved dosing scale and resort to dosing chemicals on their personal discretion. However, the result of the water quality showed that the selected sachet water samples produced was within the range of the Nigerian Standard for Drinking Water Quality except for pH and the E-coli count which does not fall within the allowable range of standards with slightly high value than standards. Therefore, the water produced from most of the factories visited are not safe for consumption.

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5.0 Recommendations

The study recommends the following for betterment:

1) NAFDAC and SON should conduct routine checks on the compliance with the regulations for sachet water factories and not only be limited to before registration of companies.
2) NAFDAC and SON should enforce laws that will compel the factories owners to engage only skilled and educated personnel for their water productions.
3) Sachet water factories must realise the detrimental effect of unsafe water on human health and as such provide clean and safe water.
4) Maintenance of hygienic and clean environment that promotes hygiene values; hand washing, general cleanliness of storage environment and vendor containers should be embarked upon.
5) Stiff punishment should be melted on any sachet water factories found culpable of compromising the regulation compliance and the production of quality water.
6) Standard Operating Procedures (SOPs) should be strictly adhered to in the production of quality sachet water.

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