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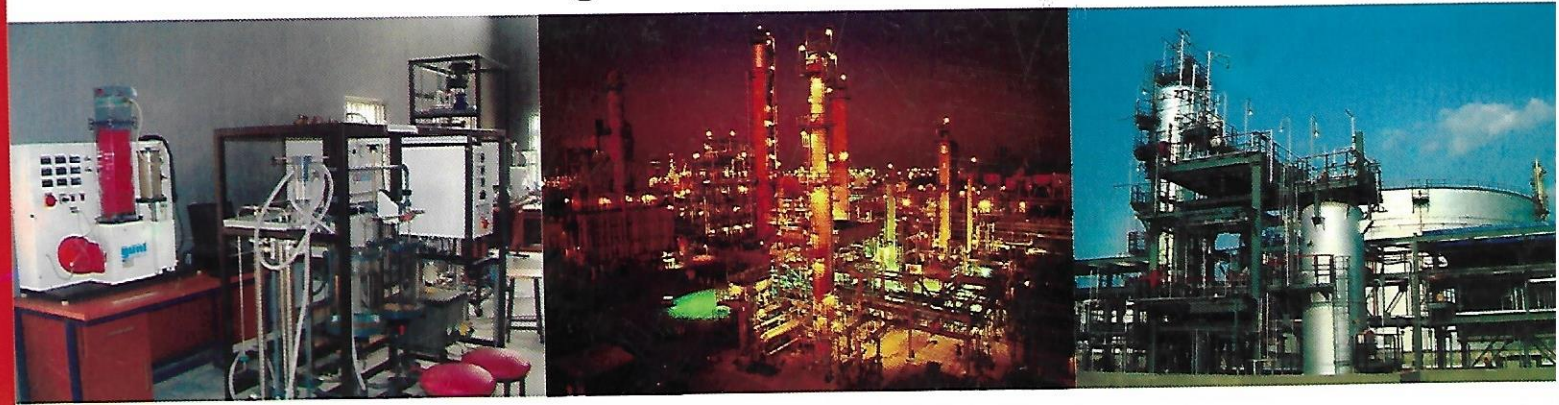
With Focus on Nigeria's Industrial Revolution Plan



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PREFACE

In addition to the professional development of Chemical Engineers, the Nigerian Society of Chemical Engineers has been making enormous contributions through its annual conferences to address the vexing issues confronting Nigeria. This year, the theme of its 44th Annual Conference held at Owerri, Imo State, Nigeria was **"Chemical Engineering and the Nigerian Economy" with focus on Nigeria's Industrial Revolution Plan.** In line with this theme, the Conference sought solutions on how the industrialization gaps in the Nigerian economy can be bridged through the use of professional skills available in Chemical Engineering discipline in synergy with other professions.

Papers were arranged and presented according to the under-listed sub-themes:

i. Trends in Chemical Engineering

ii. Chemical Engineering Education

iii. The Role of Small & Medium Enterprises in the Nigerian Economy

iv. Oil and Gas Industry

v. Agro- Allied Industries/ Food Security

vi. Manufacturing and Industrial Capacity Building

vii. Engineering Entrepreneurship, Job Creation and Leadership

viii. Safety, Environment and Energy

ix. Chemical Engineering Research and Development

The papers presented were peer- reviewed and carefully selected to ensure that burning issues on Nigeria's Industrialization status as reflected in the Conference Sub-themes were covered. The key deliverable from the Conference is the evolution of NSChE's recommendations to Government to bridge the country's industrialization gap.

The Proceedings would also prove suitable to the broadest readership and it is recommended to all stakeholders in Nigeria's industrial sector, government and academia. It would prove to be an invaluable tool for those formulating policies in the Nigerian industrial sector.

Prof. Kenneth Okpala,FNSChE

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QUALITY ASSESSMENT OF SACHET WATER IN MINNA METROPOLIS OF NIGER STATE, NIGERIA

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ABSTRACT

The proliferation of packaged water production factories in Minna, Nigeria was investigated in this study. It involved evaluation of the physical, chemical and microbial properties of the most popular sachet water brand sold and consumed by the populace. Physiochemical parameters which include temperature, pH, electrical conductivity, total dissolved solid, total hardness and alkalinity of the samples were determined. The experimental data obtained were compared with those of NAFDAC, NIS, WHO, FEPA and SON. The physical examination of the sampled packaged water products revealed the non-compliance of producers in indicating vital information on their label, such as manufacturing and expiry dates, batch number and nutritional information of the products. The physiochemical parameters investigated had some variations but were within the acceptable range according to standards except for the total coliform content. The total coliform of the samples ranges from 0 to 47 which indicated faecal pollution and unsafe for consumption. The study revealed that most sachet water floating Minna metropolis during the period of study possess risks, unsafe, disease causing and not good for food grade quality.

INTRODUCTION

Water is an important ingredient for the sustenance of lives in the eco system. It plays a vital role in the prevention of many diseases; It was reported that the act of drinking eight glasses of water on daily basis can greatly help in minimising the risk of cancerous diseases about 45- 50 % (Oparaocha *et al.*, 2010). Water to be used for domestic purposes must be abundant in supply and must conform to some specific properties which will attest to its quality. These properties include microbial population, chemical parameters (cations and anions) and physical properties including true colour, taste, turbidity, pH, temperature, electrical conductivity, total dissolved solids, total suspended solids and total alkalinity. Drinking water is said to be polluted its properties threshold level does not conform to the World Health Organization (WHO) standard (Nana Asamoah and Amorin, 2011).

Despite the relative abundance of water in nature, it is still quite despicable that water is still not readily accessible; especially for safe drinking. In most developing countries like Nigeria the government negligence and insufficient investment in water infrastructure development has made the epileptic public water unsafe for human consumption (Dada, 2009). The insufficiency of water supply on the part of government has given rise to the involvement of number private individuals in the production of packaged drinking water commonly known as pure water to augment the lapses created by government. This portable packaged sachet water is usually about 50 – 60 ml contained in polyethylene leather (Edema *et al.*, 2011). The packaged water business is booming in Nigeria and it is capable of producing about Hundred millions of litres of water annually for the Nigerian populace. It is presently seen as an upgrading over the former types of drinking water sold to consumers in tied polythene bags, it is cheaper than bottled water and also thought to be of good quality. Although most sachet water manufacturer in Nigeria obtains there raw water from mostly local, municipal pipe water or well water (Oyedeji *et al.*, (2009).The adherence to standard water production technology and analytical techniques during the process of production of this water are faced with uncertainties. This is because a number of the factories lack the proper technology for producing a wholesomely clean and safe drinking water. The standard of hygiene in the various production stages of bottle and sachet water tends to vary significantly among the numerous manufacturers. While some use the modern classical techniques such as ozonation and reverse osmosis greater number are known to use the common method of boiling the underground water, removal of particles through the use of unsterilized filtration membrane. Apart from environmental contaminants, improper vendor have been identified as a source of infection in food and water borne diseases in many countries of the world (Dada, 2009, Omalu *et al.*, 2010). Water pollution has continued to create negative impacts on health and economic development of many developing countries; Nigeria inclusive (Edema *et al*, 2011). The National Agency for Food & Drugs Administration and Control (NAFDAC) is mandated to enforce compliance with internationally defined drinking water guideline. The agency was reported to declare a nationwide ban of sachet water to enable producers of this commodity transit from polythene packaging to bottle packaging. The execution of this pronouncement did not manifest as the sachet water business is on the rise at an alarming rate among poor and middle-class people (Dada, 2009). According to Onweluzo *et al.*, (2010) the quality of sold water in most public places may not be to be wholesomely clean. The authors however, added that the Institute of Public Health Analyst (IPA) reported that 50 % of the "pure water" sold in the streets of Lagos may not be fit for human consumption and that there are possibilities that the same scenario may be very applicable to other cities/ town in the country.

A lot of studies have reported that over 50 % of "Sachet water" produced from filtered groundwater (A major sources of raw water for most manufacturers)and sold in some Nigerian cities were analyzed to be unfit for human consumption (Ogan, 1992, Olayemi, 1999, Onweluzo *et al.*, 2001, Adekunle *et al.*, 2003, Oyedeji *et al.*, 2009, Edema *et al*, 2011).

Hence, there is the need to assess the quality of water suitable for domestic purposes and identifying potential sources of pathogenic bacteria. This study is aimed at evaluating microbial, physical and chemical properties of the "pure water" sold within Minna

Metropolis, North-Central Nigeria.

METHODOLOGY

Study Area

Study area: Niger state metropolis is located between latitudes 8°20' and 11°30'North and longitudes 3°30' and 7°20' East. It lies within the northern central geopolitical zone of Nigeria otherwise known as middle belt and occupies a total land area of about 68,925sq kilometers. The metropolis has an estimated population of 3,950,249 (http://zodml.org/Nigeria/nigeria_geography_content_articles.php?article_id=nokmjtlw urqvyozsrxp). The major climatic seasons are rainy season or wet season (March or April to October) and dry season (November to March or April). And rainfall ranges varying from 1,100mm in the Northern part of the State to 1,600 mm in the southern parts (http://nigerstate.blogspot.com/). Minaa is the State Capital Minna which comprises of four (4) local governments (Microsoft Encarta premium, 2009). The municipal is one among the three (3) main areas that make up the State. The population is predominantly dominated by Nupe, Gbagi, Hausa, Yoruba and Igbo people.

Sampling location

The research was conducted between the month of June and December 2013 at Minna. The ten (10) most popular brand of sachet water sample sold and consumed in Minna Metropolis were obtained. The samples collected were collected daily (once) at each location. The established, preservative and Storage methodology were used to ensure the samples were at their prime quality. The sampling areas were randomly collected with emphasis on densely populated areas

PHYSIO-CHEMICAL ANALYSES OF WATER SAMPLES

The ten (10) brands or samples for the physiochemical analyses collected were of the same volume (50cl). The temperature and pH of the sample was determined at the commencement of the experiment using a common mercury-glass thermometer and pH meter respectively. Electrical conductivity (EC) was determined with a self-contained conductivity bridge with a suitable conductance cell of constant of 1 to 2. The total dissolve solid (TDS) was determined by multiplying the Electrical conductivity readings (EC) with a conversion factor. The total hardness (THD), Alkalinity were determined by the using analytically method (Musa *et al.*, 2014).

MICROBIOLOGICAL ANALYSES OF WATER SAMPLES

RESULTS AND DISCUSSION

Physical Examination of Sachet Labeling Compliance

The physical examination were carried out using a model developed by Dada, 2008 as shown in Table 1 where positive (+) and negative(-) signs were used to denote the presence or absent of the parameter.

Table 1: Physical Examination Analysis.

Samples	NAFDAC number	Best before Date	Manufacturing date	Nutritional information	Batch Number	Producer's Name And Contact Address
A1	+	-	-	-	-	+
A2	+	-	-	-	-	+
A3	+	-	-	-	-	+
A4	-	-	-	-	-	+
A5	-	-	-	-	-	+
A6	+	-	-	-	-	+
A7	+	-	-	-	-	+
A8	+	-	-	-	-	+
A9	+	-	-	-	-	+
A10	+	-	-	-	-	+

Table 2: P hysio -Chemical Parameter of Sachet W ater

Brand code	Temp.(° C)	Cond. (uS/cm)	Ph	T.Hard. (mg/L)	Alkal (mg/L)	Na (mg/L)	K (mg/L)	TDS (mg/L)
A1	27.10	114	7.02	67	25.33	10.66	11.38	74.92
A2	27.26	100	7.44	73.33	32.33	8.96	9.44	66.26
A3	27.7	108.66	6.60	58.66	33	13.5	13.73	74.47
A4	27.3	118.66	6.76	75.33	133.33	8.19	8.39	67.08
A5	27.06	115.33	7.17	74	35	13.70	14.09	76.40
A6	27.26	101.33	6.93	58	29.33	11.64	11.81	67.13
A7	28.2	137.33	7.13	71.33	32	9.8	9.2	83.09
A8	27.96	116	6.83	65.33	41.66	11.7	11.53	77.73
A9	27.06	106.66	7.11	61.33	42.33	11.55	11.99	70.65
A10	28.33	264	7.15	105.33	148.33	11.46	11.56	155.86
Mean	27.52	128.147	7.014	71.96	55.26	11.12	11.01	81.36
SD	0.47	49.30	0.24	13.68	45.52	1.77	1.88	26.29
Minimum	27.06	101.33	6.60	58	25.33	8.19	8.39	66.26
Maximum	28.33	264	7.44	105.33	148.33	13.70	14.09	155.86
Median	27.5	114.67	7.07	69.17	34	11.51	11.55	74.70
Range	27.06-28.33	100-264	6.60-7.44	58-105.33	25.33-148.33	8.19-13.70	8.39-14.09	155.86-74.70
WHO	28±2	1000	6.5-8.5	150	100-200	200	82	500
WHO*	@20	900	6.5-9.5	100	200*	NS	150	500
NIS	NS	1000	7.0-8.0	NS	100	NS	NS	500
NSDWQ	30-32.5	1	6.5-8.5	150	100	NS	NS	500
FEPA	NS	NS	6.5-9.2	500	100	NS	NS	1500
SON	NS	NS	6.5-8.5	150	NS NS	200	NS	NS

Physical Examination of the Sachet Water

The National Regulatory agency in the country requires the labeling of food and drugs to be informative and accurate. The physical examination of the ten (10) brand of sampled sachet water were examined based on the minimum NAFDAC standard requirement of the labeling details which includes Producers name, Contact information, Batch number, Nutritional information, Expiration date (Best before date), Manufacturing date and NAFDAC registration number. Among the ten (10) brands of sachet water sampled the percentage compliance for NAFDAC registration Number, producers name and contact information were 80, 100 and 100% respectively, while the remaining parameters had 0 % compliance as presented in Table 3 below. It implies that the sachet water sold in the market did not meet the labeling requirement prescribed by the NAFDAC guidelines and standards.

Table 3: Percentage Compliance of Physical examination of sachet water

Label Requirement	Number of Sample		Percentage compliance (%)
	Positive	Negative	
NAFDAC number	08	02	80
Manufacturing date	00	10	0
Best before date	00	10	0
Nutritional information	00	10	0
Batch Number	00	10	0
Producer s Name	10	00	100
Contact Address/information	10	00	100

Temperature

Temperature determination is important because of its effect on other physical phenomena such as rate of biochemical and chemical reaction in the water body, reduction in solubility of gasses and amplification of tastes and odors of water (Olajire and Imeokparia, 2000). The temperatures for all the sachet water samples analyzed were within the range 27.06-28.33 with average value of 27.52. The value obtained for this study is reasonably within the ambient temperature. According to Sunday *et al.*, 2011 temperatures within this range are conducive for optimal growth for mesophyll bacteria including human pathogens; hence this temperature has the potential to enhance the growth of micro-organism thereby promoting the development of unpleasant odour and taste in water. The higher the temperature of water, the lower the level of dissolved oxygen as well as survival rate of micro-organisms. However there are no guideline value recommended for temperature of drinking water (Oparaocha *et al.*,2010).

Conductivity

Electrical conductivity is a measure of total dissolved solids in water (Bongumusa, 2010). The result obtained from this study shows that the sachet water samples were within range of 100 to 264 μS/cm with an average value of 128.147 μS/cm . The values obtained in this study shows appreciable consistency within the relevant standard values. .

Total Hardness

Hard water contains calcium and magnesium ions and the estimation of these ions are importance for determining the hardness of water. Water samples may contains calcium and magnesium ions that might elude from walls of storage tank if made of cement or lined with compounds containing calcium like lime or mortars (Ababio, 2007). Total Hardness obtained from the analysis ranged from 58-105.33 mg/l, with the average value 71.96 mg/l, compared with the Standard values of 0-150 mg/l. All the samples had the total hardness concentration within the WHO, permissible limit 150mg/l

Sodium and Potassium

The presence of cation in sachet beyond tolerable level has significant health implication. Sodium concentration from the study of the water sample analyzed ranged between 8.19-13.70mg/l with the average of 11.12mg/l. This result falls within the WHO and SON Standard limit of 200mg/l. While the value for potassium in this study was within the range of 8.39-14.0 g with an average value of 11.01 g . The result is in compliance with the WHO standard limits. According to Sunday et al., 2011 potassium level in water increases when the micro-organism dies. The value tends to decrease with increase in the number of week. The finding from study shows the presence and active nature of the micro-organism with time for all the samples.

Total Dissolved Solids

The Total Dissolved Solids is defined as the quantity of solid matter remaining in the water sample after drying. In this study, the total dissolved solids ranged from 66.26-155.86 mg/l, with the average value of 81.36 mg/l. The result falls within the WHO Standard of 500 mg/l implying that the water is also safe for consumption and for other domestic uses.

pH (Potential Hydrogen)

pH is a measure of alkalinity and acidity of water (WHO). pH of all the ten brand sachet water range from 6.60-7.44 with an average value of 6.14. The pH obtained from these sachet water falls within the WHO set standard of 6.50-8.50 the result also compares favourably with the result of Sunday *et al,* 2011. The pH of this study tend to fluctuate from week 1 to week 8, pH is an important parameter that is used to ascertain water quality. According sunday*et al,* 2011 the author also added that microorganisms frequently change their pH by producing acidic or basic metabolic substance as waste.

Table 4.0: Total Coliform (cfu/100ml)

Samples	pH	Mean	S.D Range
A_1	7.02	3.25	3.7750 – 7
A_2	7.44	4.00	5.2280 – 11
A_3	6.60	5.00	3.4642 – 10
A_4	6.76	24.25	17.4627 – 45
A_5	7.17	1.25	2.5000 – 5
A_6	6.93	4.75	6.8980 -15
A_7	7.13	15.75	21.5620 -47
A_8	6.83	13.75	10.3725 – 27
A_9	7.11	1.50	1.7320 – 4
A_{10}	7.15	3.50	3.3170 – 8

Total Coliform

Total coliform are widely used as indicator of general sanitary quality of treated drinking water (Sunday *et al.*, 2011). The total coliform for all the sachet water analyzed ranges from 0-47. However, throughout the period it was observed that all the sachets water are above set limit. The WHO stipulate that the total coliform should be absolutely zero. For the period under investigation the total coliform tends to decrease from week 1 to week 8 in all samples. This results is very consistent with the report of WHO which stated that total coliform counts do not increase in sachet water sample. The presence of this coliform was an indicator of faecal pollution of portable which is usually not acceptable. The results clearly show that the pure water samples wide is potentially unsafe for human consumption. This is clearly obvious from the number pathogens enumerated and identified. Presences of these organisms are unusually responsible for odour, tastes, cloudiness and sliminess in the water samples.

Table 5: Result of the Faecal Coliform (cfu/100ml)

Samples Range	pH	Mean	S.D
A_1 0 1	7.02	0.25	0.500
A_2 0 0	7.44	0.00	0.000
A_3 0 1	6.60	0.25	0.500
A_4 1 - 45	6.76	18.75	17.933
A_5 0 0	7.17	0.00	0.000
A_6 0 - 2	6.93	0.50	1.000
A_7 0 -35	7.13	11.25	16.338
A_8 1 24	6.83	8.25	10.720
A_9 0 0	7.11	0.00	0.000
A_{10} 0 2	7.15	1.000	1.000

Faecal Coliform are sub-group of total coliform bacteria. The presence of faecal coliform in a driking water denotes greater risks to disease causing pathogens. For all sachet water analyzed (A_1 to A_{10}), only A_2, A_5 and A_9 had a zero count. It was however, clear that about 70 % of the sachet water analyzed are not fit for human consumption. This is because the presence of faecal coliform is an indication of the poor water quality. It is very important to add that for all sachet water analyzed throughout the period of investigation the total coliform tends to decrease with time. These result was consistent with the report of World Health Organization who stated that microorganism lose their variability in fresh water with time

CONCLUSION

Studies carried out on this research work, it conclusively indicate that safe and well packaged sachet water stored for up to eight weeks do not undergo major physiochemical changes. The result shows that the "pure waters" were found to be acceptable for consumption as all the parameters determined were within the WHO acceptable limit. However based on the bacteriological analysis of the sachet water sampled are fit for consumption. This is based on the fact that the result of faecal coliform show that only three samples are safe, this means that most of the sachet waster (About 70%) are potentially unsafe for human consumption. On the contrary the result total coliform for all the sample analyzed fell of the WHO/NAFDAC standard, making the sachet water unsafe for drinking.

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