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An assessment of sachet water quality in Zaria Area of Kaduna State, Nigeria

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In this study, Physico-chemical analysis of 21 brands of sachet water packaged within Zaria metropolis was evaluated to compare their compliance with World Health Organisation (WHO) and Nigerian Industrial Standard (NIS) threshold limits using standard analytical methods. The parameters evaluated include: colour, taste, odour, pH, chloride, potassium, calcium, electric conductivity, oxygen demand (OD), biological oxygen demand (BOD) and total dissolve solid (TDS) while coliform counts were only determined for sixteen brands using standard methods. The results from the laboratory analysis showed that all samples were tasteless, colourless and odourless; most of the physico-chemical parameters conform with WHO and NIS permissible limits except coliform count in which 100% of the sachet did not conform to the WHO threshold limits. Only 25% of sachet water did not conform to NIS threshold limits. The t-test result reveals that there is no significant difference between the sachet water properties with the WHO and NIS standard. The results of this study indicate that sachet drinking water produced or sold in Zaria is relatively of good quality for human consumption but there is need to improve the biological treatment to perfect its portability.

Key words: Sachet water, analysis, Zaria, Kaduna State.

INTRODUCTION

Water is one of the indispensable resources for the continued existence of all living things including man and adequate supply of fresh and clean drinking water is a basic need for all human beings (Edema et al., 2011). In nature, all water contain impurities; as water flows in streams, accumulates in lakes and filters through layers of soil and rock in the ground, it dissolves or absorbs substances it come in contact with, which may be harmful or harmless (Ogamba, 2004).One of the major and critical problems in most developing countries today is the provision of an adequate and safe drinking water to its populace (Kulshershtha, 1998). Drinking water that is safe and aesthetically acceptable is a matter of high priority to National Agency for Foods and Drugs Administration and Control (NAFDAC) and other regulatory agencies in Nigeria and is expected to meet the Nigerian Industrial Standard. Furthermore, drinking water that is fit for human consumption is expected to meet the World Health Organization and be free from physical and chemical substances and microorganisms in an amount that can be hazardous to health (Denloye, 2004). It is a known fact that no single method of purification can

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eliminate 100% contaminants from drinking water. However, water can be and should be made safe for consumption within acceptable limits (Denloye, 2004).

Sachet water is any commercially treated water, manufactured, packaged and distributed for sale in sealed food grade containers and is intended for human consumption. The production of sachet water in Nigeria started in the late 90s and today the advancement in scientific technology has made sachet water production one of the fastest growing industries in the country. Water consumers are frequently unaware of the potential health risks associated with exposure to water borne contaminants which have often led to diseases like diarrhoea, cholera, dysentery, typhoid fever, legionnaire's disease and parasitic diseases (Omalu et al*.*, 2011). The continuous increase in the sale and indiscriminate consumption of packaged drinking water in Nigeria is of public health significance, as the prevalence of water related diseases in developing countries is determined by the quality of their drinking water (Ezeugwunne et al*.*, 2009).

The safety of drinking water in poor and deprived communities has in the last decade been in jeopardy as a result of the introduction of refuse and sewage into sources of water supply. The intake of unwholesome water could have devastating effects on our health as unsafe drinking water is a key determinant of many microbial diseases with serious complications in immune-competent and immune-compromised individuals. The introduction of sachet water was aimed at providing safe, hygienic and affordable instant drinking water to the public and to curb the magnitude of water related infections in the country (Ezeugwunne et al*.*, 2009).

Earlier investigations conducted in Owerri, Ibadan and Lagos on the safety of drinking water have shown that bottled water has good microbiological quality while the quality of some factory-bagged sachet and hand-filled/hand-tied polythene-bagged drinking water was noted to be doubtful. This observation was based on studies carried out on water samples to ascertain the presence of heterotrophic bacteria, indicators of faecal contamination (total coliforms, faecal coliforms and enterococci) and for lead, manganese and iron (Mustapha et al*.*, 1991). Lack of information on pathogenic or parasitic organisms associated with drinking water creates some uncertainties in our understanding of the overall quality of drinking water in our markets. Some Sachet waters have been reported to contain bacteria such as Bacillus sp., Pseudomonas sp., Klebsiella sp., Streptococcus sp., and oocysts of Cryptosporidia sp. Apart from environmental contaminants, improper storage and handling by vendors also poses a serious threat to the health of the ignorant consumers (Omalu et al*.*, 2011).

Pure water is colourless, odourless and tasteless with high boiling and melting points as well as high heat of vapourization. Pure water can be slightly ionized reversibly to yield hydrogen and hydroxyl ions. Therefore, water is not just a solvent in which the chemical reactions of the living cell occur (Talwar, et al., 1989). It is very considered often in direct participation in those reactions (Nelson and Cox, 2005). Quality of drinking water is evaluated on the basis of its chemical components. This is done by assessing the pH, hardness, total alkalinity, dissolved oxygen, carbondioxide, heavy metals and organic constituents (Denloye, 2004).

Consumption of sachet water in Nigeria is on the increase irrespective of whether they have NAFDAC Certification or not. However, despite the strong effort by NAFDAC in the regulation and quality assessment of sachet water, there are a growing number of reported public illnesses after drinking sachet water. There are a number of reported cases of typhoid, diarrhea and other water borne diseases arising from consumption of sachet water (Ogamba, 2004). Sachet water serves as a major source of potable/drinking water to communities around Zaria Area of Kaduna State.

Several studies have been carried out on water quality of varying degrees and coverage. Some were carried out on the chemical quality of the water, some the micro-biological quality, some the physical quality and some on the physiochemical quality of the water. For example Alhassan et al. (2008), in their study of sachet water packaged within Kano metropolis, analysed the physico – chemical characteristics; colour, taste, odour, alkalinity, total hardness, pH, chloride, sodium, potassium, calcium, lead, zinc, chromium, copper, cobalt, nickel and manganese using standard methods. All samples were tasteless, colourless and odourless. The pH, alkalinity and total hardness are within WHO (1983) permissible limit. The concentration of sodium, potassium and calcium was found to be within the acceptable limit and the chloride of most of the samples is above the WHO acceptable limit. Of the heavy metals analysed lead, chromium, and nickel concentrations were found to be above the WHO permissible limit, while concentrations of copper and zinc were below the WHO (1983), permissible limit. Manganese concentration was found to fall within WHO permissible limit in 70% of the total samples, while 17%of the samples have concentrations above the WHO standard and four of the samples have concentration below the WHO recommendation.

Obiri-Danso et al. (2003) examined the microbiological quality of sachet drinking water and bottled water sold on the streets of Kumasi, Ghana and concluded that bottle water in the Ghanaian market is of good microbiological quality. Adediji et al. (2005), for instance, studied the relationship between ground (well) water quality and refuse dumpsites in Zaria, Emmanuel et al (2011) studied the quality of sachet and bottle water in Boltanga municipal of Ghana, Uduma et al (2014) studied the physiochemical quality of sachet water consumed in Kano metropolis.

In this study an attempt is made to provide more information on the quality of sachet water in Zaria, Northern Nigeria, by establishing the spatial distribution of sachet water production points in Zaria, collecting samples from the different production points, analysing them in the laboratory and assessing their quality in comparison with the WHO and NIS water quality standard.

MATERIAL AND METHOD

Sachet water samples collected was kept in a clean sterile container to avoid contamination. Twenty one (21) sachet water companies were sampled in the study Area. The samples collected were stored in the refrigerator on reaching the laboratory before the analysis took place. Analysis for the following parameters was carried out: pH, total hardness, BOD, calcium, chloride, magnesium, iron, sulphate, DO, TDS, EC, turbidity and coliform count using standard laboratory techniques. The analysis was carried out at the departments of Micro-biology, Soil Science and Water Resources, Ahmadu Bello University, Zaria, Nigeria. The results obtained were compared with the secondary data got from publications of the World Health Organization (WHO) and Nigerian Industrial Standard to ascertain conformity with the national and international guidelines. The properties of the sachet water were compared with the WHO and NIS standard using t-test to check if there is significant difference between them.

RESULTS AND DISCUSSION

The spatial distributions of the sachet water company in Zaria are shown in Figure 1. The result of the physico-chemical analysis of the twenty one brands of sachet water and that of the coliform count for sixteen sachet water using most probable number (mpn) is presented in Tables 1 and 2 respectively.

Result of physical analysis (RPA)

The result of the physical analysis shows that the samples were colourless, odourless, tasteless. Turbidity which measure cloudiness is within the acceptable value of WHO and NIS of less than 5NTU except Baruch which is slightly high with a value of 5.58.

Result of chemical analysis (RCA)

The chemical analyses show that the pH level for all the samples falls within the accepted range, same goes for the potassium level for all the samples. The calcium level for all the samples also falls within the confines of the WHO and NIS standard. The dissolved oxygen for all the samples is lower than that of the WHO and NIS.

The result of pH value falls within the WHO and NIS limit of 6.5 – 8.5. The result obtained for the chloride (Cl-) ion as contained in Table 2 was observed to be relatively low when compared to the WHO and NIS maximum value of (5) mg/L. The importance of chlorine in drinking water cannot be overemphasized. It gives a measure of protection against any contamination which may occur. The low state of this ion in these water samples according to Suleiman (2006) implies that they cannot be kept for a long period before consumption because there are chances of them being polluted. Levels of the mineral elements sodium, potassium and calcium in the samples studied are within acceptable limits of (125-250mg/L). The level of electric conductivity is also within the WHO and NIS limit of (≤ 1000dsm), likewise the total dissolves solid (TDS).

Result of biological analysis (RBA)

The biological parameter analysed include oxygen Demand (OD) and biological Oxygen Demand (BOD). The results of BOD and OD are all within the WHO and NIS limit of ≤10 and ≤5 respectively. The results show that none of the sixteen (16) samples analysed for coliform count meet up with the WHO standard for drinking water but 12 of the sachet water meet up with NIS of 10 coliform count. It means that all the water samples contain coliforms. This implies that there could be some health implications pending on the type of coliform found and even the coliform found could be due to the poor sanitary nature of the places of production.

The result of the t-test indicates that the p-value was greater than the 0.05; as such, it was concluded that there is no statistical significant difference between the sachet water properties with the WHO and NIS standard for drinking water (Tables 3 and 4).

DISCUSSION OF PHYSICAL ANALYSIS (DPA)

This research work analysed physical properties of some sachet water purchased from the study areas even though their consumption are not limited to these areas. All the companies were NAFDAC approved. The assessment of organoleptic attributes (colour, taste and odour) showed all the samples to be clear with no taste or smell. These determine the aesthetic value (i.e. pleasantness, palatability and acceptability of the water) (Denloye, 2004). These is expected as many of the industries get their water supply from boreholes and pass it through industrial and micro-filters, this finding also agree with the result of Denloye (2004) and Alhassan et al. (2008). Turbidity which measures cloudiness is within the acceptable value of WHO and NIS of less than 5NTU except Baruch which is slightly high with a value of 5.58. This is also similar to the result of Alhassan et al. (2008).

Discussion of Chemical Analysis (DCA)

The pH values of most samples were found to fall

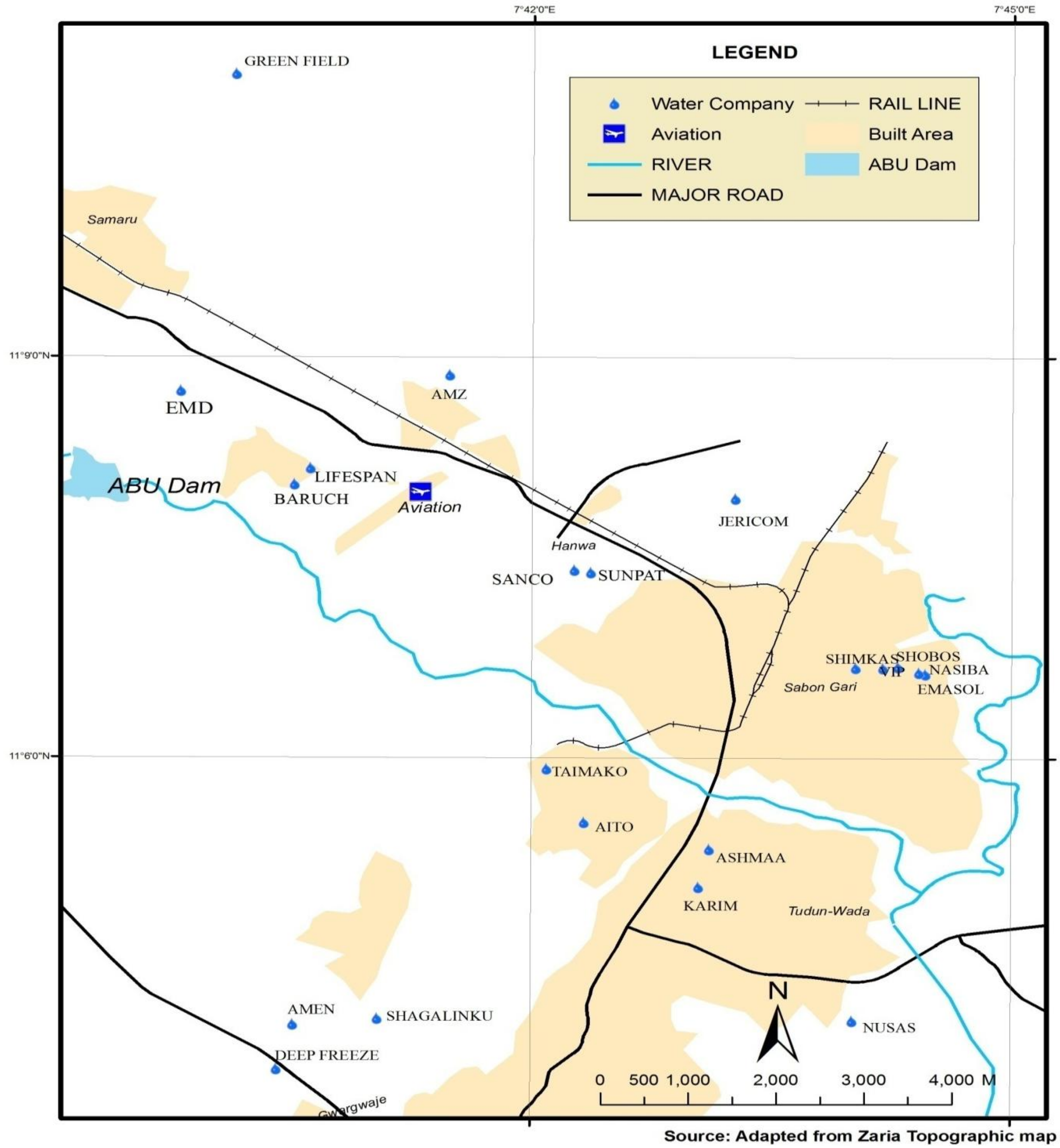

Figure 1. Map of Zaria showing the location of all the sachet water company.

between 6.4 – 8.1, which agrees with the report of Alhassan et al. (2008); John et al. (2010); Samuel (2013). This shows that almost all the samples fell within the WHO and NIS acceptable limit (6.5 – 8.5). The analysis of exchangeable cations (potassium and calcium) shows that their concentrations fall within acceptable limits of WHO and NIS (≤ 200mg/l) for Calcium and (≤10) for potassium, this is similar to the report of Alhassan et al. (2008). Potassium is a major mineral of the intracellular and extracellular fluid respectively. They are responsible for the maintenance of the body fluid osmolarity and are also important for nerves and muscle function. Calcium is the major mineral cations of the bones. It is required for impulse transmission, blood clotting, and mediation of hormonal signals, muscular contraction and function as cofactor in many enzymes. The result of dissolved oxygen (DO) is also in line with WHO standard. This is similar with the findings of Langeneger (1994) that the

Table 1. Physico-chemical analysis of twenty one brands of sachet water.

S/N	Name of company	pH	Electric conductivity(Ee)	Turbidity(NTU)	Chlorine(Cl) (mg/l)	Calcium (Ca) (mg/l)	Potassium (k) (mg/l)	(TDS) (mg/l)	(BOD) (mg/l)	(OD) (mg/l)
1	Green Field	7.55	0.100	0.600	0.50	3.30	3.00	62.6	0.3	0.6
2	E M D	6.75	0.170	0.523	1.25	4.70	6.50	100.6	0.4	0.7
3	A M Z	7.18	0.090	2.830	0.45	5.10	2.50	38.8	0.9	1.3
4	Life Span	7.33	0.100	0.266	0.50	2.10	3.00	62.5	0.3	0.7
5	Baruch	6.90	0.180	5.580	1.25	2.9	28.00	63.8	0.2	0.6
6	SHAMAKS	7.88	79.2	2.21	3.99	48.58	6.5	35.2	1.2	2.7
7	VIP	7.86	75.5	1.56	2.49	32.38	6.0	35.4	1.6	2.8
8	NASIBA	7.93	77.4	1.66	2.99	24.29	8.0	34.8	1.8	3.4
9	SANCO	8.09	69.3	0.56	2.49	28.33	5.5	33.9	0.7	2.7
10	JERICOM	7.89	137.2	2.42	7.99	36.43	6.0	69.0	0.3	2.2
11	SHOBOS	7.07	71.6	0.72	2.99	32.38	1.5	35.7	0.8	2.5
12	SUNPAT	6.68	73.4	1.52	3.49	24.29	4.5	36.1	0.4	2.7
13	EMASOL	6.65	70.1	2.00	2.99	32.38	5.0	36.2	0.8	3.2
14	Shagalinku	7.69	123.4	0.12	5.49	20.24	6.0	58.9	0.9	1.6
15	Karims	6.93	208	0.51	9.49	16.19	4.5	104	0.6	1.7
16	Alternative	6.60	96.5	1.11	7.99	12.14	4.5	48.2	0.4	2.1
17	Deep freeze	6.62	50.4	0.16	4.49	16.19	5.5	23.2	0.7	2.3
18	Amen	6.43	45.6	0.62	4.99	16.19	4.5	23.1	0.9	2.1
19	Nusas	6.51	92.0	1.00	4.49	32.38	8.0	48.0	0.5	2.0
20	Taimako	7.57	189	1.45	3.94	27.3	3.5	115	0.8	1.9
21	Ashma'a	6.99	86.9	1.05	6.7	21.8	6.5	77.1	0.11	2.4
	WHO standards	6.5-8.5	1000	5.00	250	10-200	12	1000	10.0	5.0
	NIS standard	6.5-8.5	1000	5.00	250	10-200	12	500	10.0	5.0

Source: Authors' findings 2014.

Table 2. Results of coliform count for sixteen sachet water using most probable number (mpn) no. of 5 tubes giving positive reaction.

S/N	Samples	10ml	1ml	0.1ml	Mpn/100ml
1	SHOBOS	2	0	0	5
2	EMASOL	1	0	1	4
3	VIP	1	0	0	2
4	SHAMAKS	3	0	0	8
5	NASIBA	0	0	0	< 2
6	SUNPAT	0	0	0	< 2
7	DESANCO	0	0	0	< 2
8	JERICOM	5	2	0	49
9	Shagalinku	5	0	0	23
10	Karims	2	0	0	5
11	Nusas	1	0	0	2
12	Deep Freeze	3	0	0	8
13	Amen	2	0	0	5
14	Alternative	3	0	1	11
15	Taimako	5	2	0	49
16	Ashma'a	3	0	0	8
	WHO standards	-	-	-	0
	NIS standard	-	-	-	10

Source: Microbiology lab ABU, 2014.

Table 3. One-sample test for the sachet water and WHO standard.

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Sachet water properties	2.305	9	.047	18.3928	.338	36.448
WHO Standard	1.854	9	.097	239.4500	-52.643	531.543

Table 4. One-Sample test for sachet water and NIS standard.

	Test Value = 0					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Sachet water properties	2.305	9	.047	18.3928	.338	36.448
NIS Standard	1.843	9	.098	190.4500	-43.338	424.238

concentration of DO in groundwater from hand pump equipped wells in West African sub-region is usually between 0.7 and 4.5 mg/L

Discussion of Biological Analysis (DBA)

The BOD values were also within the WHO and NIS standard (10mg/L). This result is in line with the findings of Adekole et al. (2008); John et al. (2010) and Samuel (2013). The results of the coliform count show that none of the sixteen (16) samples analysed meets up with the WHO standard of zero (0) for drinking water, as all the water samples contain coliforms range of 2 – 49; while based on NIS 75% of the samples fall within its standard of 10, 25% contain coliforms range of 11 to 49.

Conclusion

The study was carried out to assess the physical, chemical and biological properties of sachet water in Zaria Area of Kaduna State. A total of twenty one samples were selected for the analysis. The samples collected were analysed in the departments of Soil Science, Micro-Biology and Water Resources laboratories respectively. The results from the laboratory analysis showed that most of the physical, chemical and biological parameters conform with WHO and NIS standards except coliform count which did not conform to the WHO standard, while 75% of the samples conform to NIS standard. The t-test result reveals that there was no significant difference between the sachets water value with the WHO and NIS standard.The overall results showed that the sachet water produced in the study area were relatively safe for drinking according to the World Health Organisation standards for potable water while 75% of the sachets water was safe for drinking according to Nigerian Industrial standard. The biological analyses of coliform count shows that all the samples are biologically unfit based on WHO while only 25% were unfit based on NIS. Since the biological quality of water is a hidden attribute that impacts seriously on public health, it is pertinent to note that the various sachet water packaged in the study area could have some health implications depending on the type of coliform found and there is therefore the need to improve on their biological treatment. These findings conform to those of the Institute of Public Health Analyst (IPAN) according to Osibanjo et al. (2000), that 50% of the "pure water" sold in the streets of Lagos are not fit for human consumption and Mustapha et al. (1991), that the quality of some factory-bagged sachet and hand-filled/hand-tied polythene-bagged drinking water is doubtful.

Conflict of Interests

The authors have not declared any conflict of interests.

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