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Full Length Research Paper

Quality of sachet water produced and marketed in Minna metropolis, North Central Nigeria

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Microbiological and micronutrient quality of sachet water samples sold in Minna metropolis Niger State, Nigeria was analyzed using micro filter membrane and atomic absorption spectrophotometer. The metropolis was divided into four clusters and sachet water was collected from the factories within each cluster. Total bacteria count (TBC), total coliform count (TCC) and presence of fecal coliforms were evaluated. Bacteria count ranged from 7.00 ± 0.19[a] to 166.67 ± 0.38[d] colony-forming units (cfu/ml). The fecal coliform ranged from 2.33 ± 0.50[a] to 15.00 ± 0.77[f] cfu/100 ml. Fecal coliforms were isolated from sachet waters from zones A and C. *Salmonella* and *Shigella* spp were not detected in the samples. Micronutrient examination of the samples showed that the sachet water samples differed significantly (P ≤ 0.05) in their micronutrient composition. However, lead (Pb) was not detected in the samples from any of the clusters. While the TBC of the water samples were within the acceptable regulated limits, the presence of feacal organisms in the samples from some clusters was indicative of gross contamination. Absence of heavy metals showed that sewages though rampant in the metropolis may not be sipping into bore holes or are not chemically contaminated. The need for proactive surveillance by regulatory agencies is advocated.

Key words: Sachet water, quality, marketed, Minna metropolis.

INTRODUCTION

Traven (2000) defined water as a liquid substance that is clear, colourless and odourless, capable of existing in a liquid, solid and gaseous (that is, vapour) phase. It is a basic necessity of life, second to air, because it serves as a source of nourishment to man, animal, microorganisms and even plants. According to Biswas (2005), water is considered to be an essential ingredient for human survival and development throughout history. For example, more than two and halve millennia ago, the Greek philosopher, Thales of Miletus concluded that "best of everything is water", while, the world has changed dramatically since the time of Thales, the fact still remains that human survival continues to depend on water.

Okonkwo et al*.* (2008) reported that in many developing countries, availability of water has become a critical and urgent problem and it is a matter of great concern for families and communities depending on non-public water supply system. According to them, this critical demand for water may be due to increase in human population, which exerts an enormous pressure on the provision of safe drinking water especially in developing countries.

Water related diseases continue to be one of the major health problems globally. The high prevalence of diarrhea among children and infants can be traced to the use of unsafe water and unhygienic practices (Tortora et al., 2002). Similarly, Hughes and Kaplan (2005) reported that unsafe water is a global public health threat, placing

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Abbreviations: TBC, Total bacteria count; **TCC,** total coliform count.

persons at risk for a host of diarrhea and other diseases as well as chemical intoxication. Unsanitary water has particularly developing effects on young children in the developing world. They further reported that each year, greater than 2 million persons, mostly children less than five years of age, die of diarrhea disease. For children in this age group, diarrhea disease accounted for 17% of all death from 2000 to 2003 (WHO, 2005), ranking third among causes of death, after neonatal causes and acute respiration infections.

The inability of government to consistently provide adequate water contributed to the proliferation of the so-called ‘pure water’ manufactured under questionable hygienic conditions. Production and sale of packaged sachet water had become a thriving business in Nigeria.

The sale and consumption of packaged water continues to grow rapidly in most countries of the world (Gardner, 2004). The increased demand for these drinking water products is attributed largely to factors such as inadequate or non availability of reliable, safe municipal water in urban areas; impression that high quality natural spring water and portable drinking water offer a healthy, refreshing and great tasting alternative to high calorie soft drinks; and convenience which has made the products meet the requirements of any lifestyle when needed (Gardner, 2004).

According to Ogundipe (2008), the sachet packaged drinking water was introduced into the Nigerian market as a less expensive means of accessing drinking water than bottled water. It also acts as an improvement over the former types of drinking water packaged for sale to consumers in hand filled, hand tied polythene bags. He further reported that the easy accessibility to drinking water in packaged form has resulted in a big and thriving water industry with several hundreds of million liters’ of these water products consumed every year by Nigerians.

Part of the problem of safe and portable water is the presence of heavy metals in the water. Depending on the nature of the soil and rock in the area and also largely on the amount of sewage sludge, industrial wastes (from refuse dump sites), fertilizers and impurities, which may contain heavy metals like cadmium (Cd), lead (Pb), chromium (Cr), nickel (Ni), silver (Ag), etc. that eventually percolates into the groundwater (Oluyemi et al., 2008) result to water pollution. This pollution by heavy metals has become a matter of considerable public health and scientific concern in the light of evidence of their extreme toxicity to human health and to biological systems. With recent out break of water borne diseases like cholera, typhoid and diarrhea etc. around Minna metropolis, it became necessary to investigate the quality of packaged sachet water sold in the metropolis.

The aims of the present study included: 1) The determination of the microbial quality of packed sachet water sold in Minna metropolis and 2) The assessment of the micro nutrient status of packed sachet water sold in the metropolis.

MATERIALS AND METHODS

Cluster sampling

Packaged sachet water was collected from manufacturers in the metropolis by use of cluster sampling technique (Wikipedia, 2010).

According to this technique, cluster sampling is used when "natural" groupings are evident in a statistical population. In this technique, the total population is divided into groups (or clusters) and a sample of the groups is selected. Then the required information is collected from the elements within each selected group. This may be done for every element in these groups or a subsample of elements may be selected within each of the groups. The technique works best when most of the variation in the population is within the groups, not between them.

Collection of water samples

Twenty-four (24) samples of packaged sachet water produced in Minna metropolis (Figure 1) were collected from the factories in four different zones (clusters) (Figure 2) (six samples) from each cluster. The zones comprised of Dutsekura Hausa and Gwari (zone A), Bahago roundabout and Bosso (zone B), Barikin sale, Kpakungu and Keterin Gwari (zone C), and Tunga, Trade fair and Chanchaga (zone D). The samples were subjected to microbial and mineral content analysis.

The microbial evaluation was carried out according to the membrane filter technique (MFT) as reported by Division of Environmental Health (2010).

Sample (100 ml) was poured to pass through membrane (0.7 µm) using a sterilizable filter funnel through a porous disk filter, polyester cellulose acetate (97%). Since coliform bacteria are from 1 to 4 µ in length, they are retained on the filter when the water passes through. Due to the fact that the pores of the filter are so small, the water will not pass through the filter by gravity. Therefore, a vacuum source must be available to enable the water to penetrate the filter. This was achieved by use of a hydrosol with a power vacuum source. After the water sample was filtered, the filter was incubated in contact with membrane lauryl sulphate broth (MLSB) in a Petri dish.

Total aerobic microorganisms were enumerated on nutrient agar (LAMB) (International Diagnostic group Popley house. 52 Washlanbury Landeshire, B l96UA, U.K.). Total coliforms were enumerated on Maconkey agar enriched with salt (Biotec Laboratories Limited Ipswich suffolle IP53 – RG, U.K.) Coliform bacteria were incubated at 37°C for 24 h, while faecal coliform bacteria were incubated at 44°C for 24 h. Colonies were then counted using a simple hand magnifier. Results were reported as colony-forming units (cfu) per 100 ml. The total of the counts for each cluster were gotten and reported as total (cfu) for that cluster.

Spread or surface plate method was used to determine the total bacteria count (TBC) as well as *Salmonella* / *Shigella* counts. *Salmonella* and *Shigella* counts were plated out on bismuth sulphite agar (Alpha chemika and Biochemika LTD India) and incubated for 18 to 24 h at 37°C. Results were reported as cfu/ml.

Micronutrient analysis

Mineral content of the sachet water samples were determined according to the method described by AOAC (2000) and presented in Table 2. The samples were not digested since they were already in liquid form. Treated water samples (100 ml) was measured and analyzed directly in an Atomic Absorption Spectrophotometer machine, BULK 211, BULK SCIENTIFIC INTERNATIONAL, USA.

This spectrophotometer is self-aspirating and equipped with a

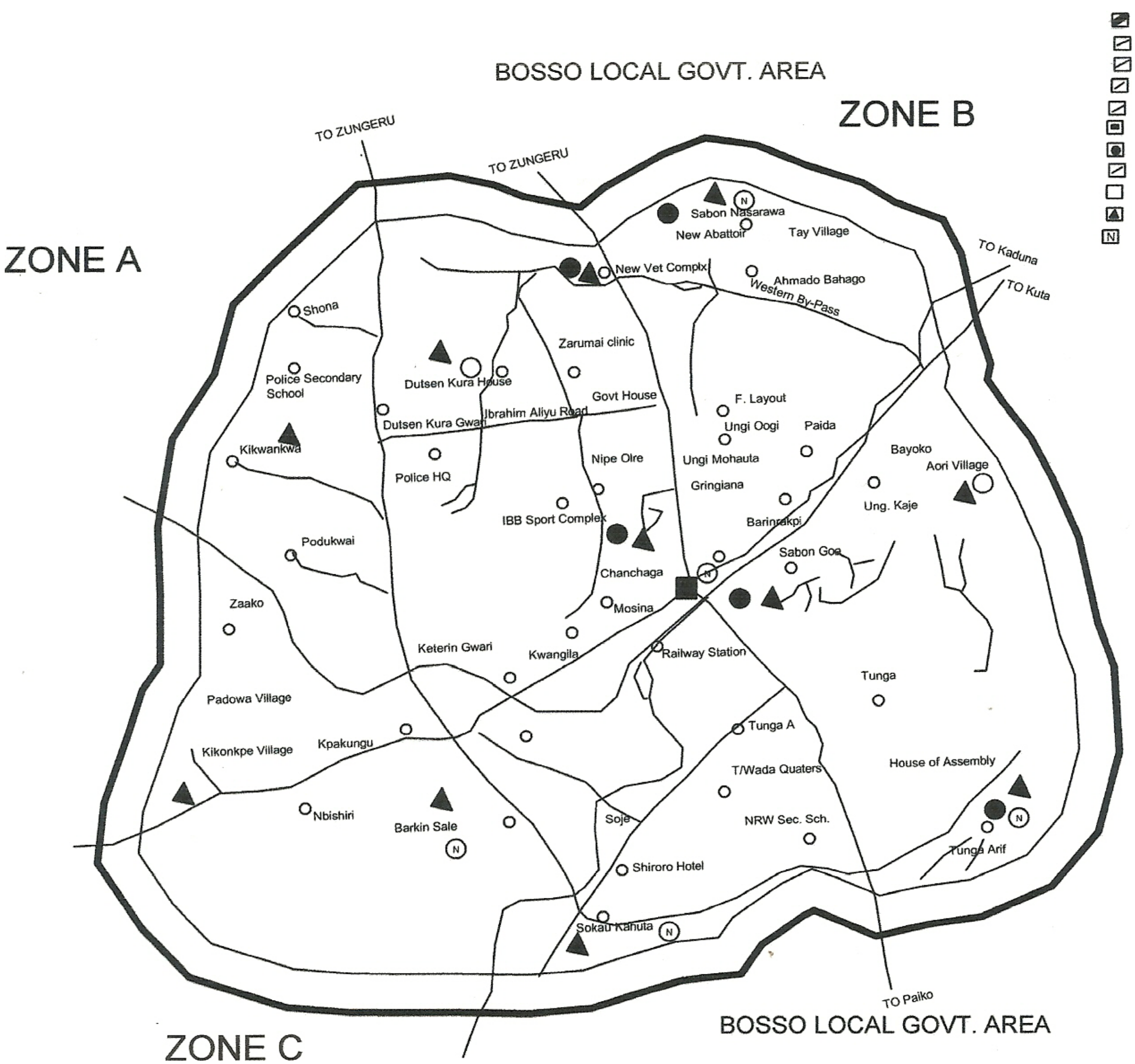

Figure 1. Map of Minna metropolis before clustering. Scale, 1:100,000.

pressure chemical (PC), which read and automatically calibrates and calculate the percentage mineral content. For the following minerals, calcium (Ca), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), Pb and zinc (Zn), the flame type used for their estimation was Air - C_2H_2 gas, while nitroxide - C_2H_2 flame type was used in quantifying Ca. The spectrophotometer lamp current was 75% while the measuring time and flame stabilization times were 4 s. Na and K were determined using a flame photometer. Measurements were taken in triplicate.

Statistical analysis

Analysis of variance (ANOVA) was used to test levels of significance. Means of significant values ($P \leq 0.05$) were separated using Duncan multiple range test.

RESULTS AND DISCUSSION

Results obtained from this study show that sachet drinking water sold in various parts of Minna metropolis, Niger State, Nigeria exhibited variable characteristics in terms of their microbiological quality and mineral content composition. All the brands of sachet drinking water (Table 1) from the four zones were contaminated with

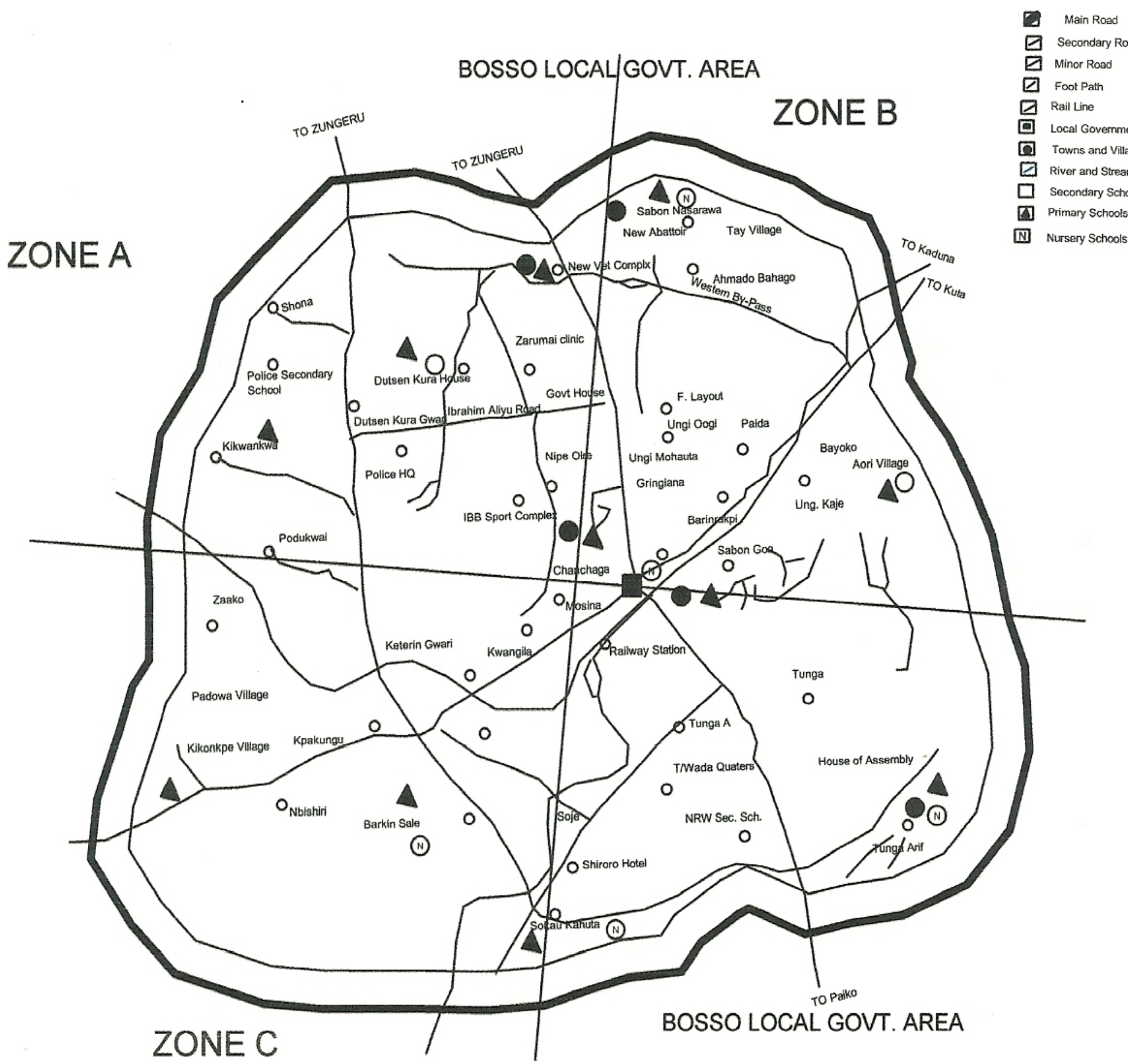

Figure 2. Map of Minna showing the clusters. Scale, 1:100,000.

coliform bacteria. Two zones (A and C) were positive to fecal coliform which made them unfit for human consumption and also failed to meet the Standard Organization of Nigeria (SON, 2007) quality of zero *Escherichia coli* per 100 ml.

Ajayi et al. (2008) had reported an earlier study of packaged drinking waters in Ibadan, Nigeria in which larger proportions of sachet water tested were found to show positive coliform counts compared to bottled water. *E. coli* is regarded as the most sensitive indicator of fecal pollution. Its presence in the borehole water samples is of a major health concern and calls for remedial attention (Petridis et al., 2002). Its presence is also an indication of the likely presence of other enteric pathogens. Previous studies (al-Lahham et al., 1990; Bonner et al., 2001; Viedma Gil de Vergara et al., 2000; Michaels, 2002) have identified handling as the source of infection in food and water-borne diseases in several countries and for different types of microorganisms. These results confirm the earlier observations of pollution of sachet water by Edema et al. (2001). Contamination was attributed to bursting of pipes along distribution lines and unhygienic handling of water right from the treatment plant.

Mineral content of the sachet water analyzed showed

Table 1. Microbiological quality of sachet water samples in Minna metropolis.

Microbial parameter	Cluster 1	Cluster 2	Cluster 3			Cluster 4		
	1	2	3i	3ii	3iii	4i	4ii	4iii
TBC (cfu/1 ml)	40.66 ± 1.20[c]	10.66 ± 0.51[d]	45.55 ± 12.24[c]	88.33 ± 1.57[b]	166.67 ± 0.38[a]	14.33 ± 0.58[d]	13.66 ± 0.00[d]	7.00 ± 0.19[d]
TC (cfu/100 ml)	2.33 ± 0.50[f]	7.00 ± 0.58[cd]	4.33 ± 0.58[e]	2.33 ± 0 .39[f]	15.00 ± 0.77[a]	5.66 ± 0.67[de]	12.33 ± 0.5[b]	7.66 ± 0.84[c]
FC (cfu/100 ml)	1.33 ± 0.19[b]	ND	ND	ND	2.33 ± 0.19[a]	ND	ND	ND
SS (cfu/1 ml)	ND	ND	ND	ND	ND	ND	ND	ND

Cluster 1, Zone A (Dutsenkura); Cluster 2, zone B (Bosso); Cluster 3, zone C (I, Barikin sale; ii, Kpakungu; iii, Keterin Gwari); Cluster 4, zone D (I, Tunga; ii, Trade fair; iii, Chanchaga); ND, not detected; FC, faecal coliform; TBC, total bacteria count; SS, *Salmonella* / *Shigella*; TC, total coliform.

Table 2. Micronutrient of sachet water samples in Minna metropolis.

Mineral (mg/L)	Cluster 1	Cluster 2	Cluster 3			Cluster 4		
	1	2	3i	3ii	3iii	4i	4ii	4iii
Ca	58.53 ± 3.63[a]	3.42 ± 0.16[b]	3.87 ± 0.24[b]	5.64 ± 0.39[b]	3.62 ± 0.48[b]	3.40 ± 0.37[b]	3.52 ± 0.44[b]	4.26 ± 1.09[b]
Cu	0.02 ± 0.01[b]	0.04 ± 0.04[ab]	0.01 ± 0.00[b]	0.04 ± 0.01[ab]	0.09 ± 0.01[a]	0.04 ± 0.02[ab]	0.03 ± 0.01[ab]	0.06 ± 0.00[ab]
Fe	0.23 ± 0.03[a]	0.23 ± 0.10[ab]	0.12 ± 0.05[abc]	0.06 ± 0.03[c]	0.06 ± 0.01[c]	ND	0.03 ± 0.03[c]	0.09 ± 0.04[bc]
K	6.00 ± 0.00[ab]	5.50 ± 0.00[bc]	5.67 ± 0.33[b]	5.83 ± 0.17[b]	5.00 ± 0.00[cd]	4.67 ± 0.17[d]	6.50 ± 0.00[a]	4.67 ± 0.33[d]
Mg	7.33 ± 0.38[a]	4.07 ± 0.28[b]	5.30 ± 0.38[b]	5.73 ± 0.64[ab]	4.63±072[b]	3.93 ± 0.53[b]	4.90 ± 1.11[b]	5.10 ± 0.71[b]
Mn	0.14 ± 0.05[a]	0.23 ± 0.04[a]	0.19 ± 0.04[a]	0.12 ± 0.04[a]	0.15 ± 0.05[a]	0.18 ± 0.03[a]	0.12 ± 0.07[a]	0.14 ± 0.03[a]
Na	21.00 ± 1.00[a]	4.67 ± 0.33[b]	3.50 ± 0.00[bc]	4.67 ± 0.33[b]	3.00 ± 0.00[cd]	2.00 ± 0.00[d]	3.83 ± 0.17[bc]	3.83 ± 0.73[bc]
Pb	ND	ND	ND	ND	ND	ND	ND	ND
Zn	0.08 ± 0.02[bc]	0.05 ± 0.10[cd]	0.18 ± 0.04[a]	0.08 ± 0.01[bc]	ND	0.03 ± 0.00[cd]	0.12 ± 0.04[ab]	0.04 ± 0.01[cd]

ND, Not detected; Cluster 1, zone A (Dutsenkura); Cluster 2, zone B (Bosso); Cluster 3, zone C (I, Barikin sale; ii, Kpakungu; iii, Keterin Gwari); Cluster 4, zone D (I, Tunga; ii, Trade fair; iii, Chanchaga).

significant differences (P≤ 0.05) in statu s among the samples in the clusters, except for Mn. However, Pb was not detected in any samples in all the clusters.

The concentration of Cu, Fe and Na were found to be lower when compared with SON standard (2007) in all samples analyzed, except for Mg that was higher than the recommended levels in drinking water. The concentration of Zn was generally low and safe for consumption when compared to the recommended levels for human consumption. Zn is known to be less toxic to humans at low concentrations (Ayenimo et al., 2006). The results therefore, show that several of the sewage sites in the metropolis may not be sipping into bodies of drinking water or may be devoid of presence of heavy metals or both.

Conclusion

Minna metropolis suffers from acute drinking water shortage giving rise to many entrepreneurs of packaged sachet water. The results of this study show that sachet water would be a source of waterborne infection if not closely monitored by the authorities. The spread of contamination may even be more if sampling is to be extended to wholesalers, retailers and final consumers of sachet water. The results were indicative that the monitoring of the sachet water quality distributed in the metropolis may not be efficient and hence, may lead to significant compromise of the water quality as it moves from the manufacturer to the consumer through the retailers.

The results also show that heavy metals (indicating sewage contamination) were not detected in the sachet water sold in the metropolis. It is therefore, concluded that while the mineral content of brands of sachet drinking water sold in the metropolis met regulated standards, contamination of some brands with fecal pathogens poses serious problem of quality.

It is therefore recommended that serious surveillance and monitoring by appropriate government agencies be carried out to avert outbreak of waterborne disease in the metropolis.

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