http://dx.doi.org/10.4314/jpb.v7i2.3
Vol. 7 no. 2, pp. 55-64 (September 2010)
http://ajol.info/index.php/jpb

Journal of
PHARMACY AND BIORESOURCES

Bacteriological quality of public water sources in Shuni, Tambuwal and Sokoto towns in North-Western Nigeria

Mudasiru I. O. Raji[1*], Yakubu K. E. Ibrahim[2] and Joseph O. Ehinmidu[2]

[1]*Department of Animal Health and Production, College of Agriculture and Animal Science, Bakura, Zamfara State, Nigeria.* (***Postal address:*** *P. O. Box 243, Gusau, Zamfara State, Nigeria*)
[2]*Department of Pharmaceutics and Pharmaceutical Microbiology, Ahmadu Bello University, Zaria. Nigeria.*

Received 1st May 2010; Accepted 30th July 2010

Abstract
The bacteriological quality of various drinking waters in Sokoto, Shuni and Tambuwal towns in Sokoto State was investigated. Tap, well, borehole and sachet water samples were collected and analysed for bacterial counts, coliform count and presence of some water-borne bacterial pathogens using standard microbiological techniques. A total of 280 drinking water samples obtained from 7 taps, 3 boreholes, 15 wells and 10 sachet water sale points on weekly basis for 8 weeks in the study area were analysed. Bacterial counts ranged between $1.0x10^4$ cfu/ml and $1.0x10^7$cfu/ml while coliform counts ranged from $1.0x10^3$cfu/ml - $1.0x10^6$cfu/ml. Raw water from Sokoto Water Board had highest coliform count while treated water at the treatment plant had the least count. A total of 131 water-borne bacterial pathogens including faecal coliforms comprising 45 numbers of *E. coli*, 30 *Salmonella spp*, 32 *Shigella spp* and 24 *Vibrio cholerae* were isolated. Generally, all the sampled waters in this study not only contained high levels of bacteria and coliforms, they also contained pathogens and therefore, unsuitable for drinking.

Keywords: Bacteria, Coliforms, Pathogens, Shuni, Tambuwal, Sokoto, Water Sources.

Introduction

Of all natural resources available to man and vital to man's existence and survival, none is as abundant as water. The importance of water to man is aptly summarized in the words of Kofi Annan, immediate past Secretary General of United Nations, who said: "access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity" (WHO, 2002). In spite of the essential role played by water in supporting human life, it also has great potential for transmitting a wide variety of diseases and illnesses (Hutton, 1983). Pathogenic micro-organisms have repeatedly altered the course of human history. From the earliest examples of art, literature and scientific writing, the devastating consequences for the populations gripped by diseases of different kinds and severity have been documented in great detail (Encarta Encyclopedia, 2005). For example, the influenza pandemic between 1918 and 1920 resulted in an estimated 70 million deaths worldwide. Even today, the overall burden of infectious disease remains high (Kindhauser,

* Corresponding author. *E-mail*: rajimuda@gmail.com Tel: +234 (0)8032845124 .
ISSN 0189-8442

2003). In 2001, infectious diseases accounted for an estimated 26% of deaths worldwide (Kindhauser, 2003).

Globally, diseases that are waterborne and sanitation related infections are some of the major contributions to disease burden and mortality (Hunter, 2003). Water is so essential to man and animals that it is often termed as the source of life. The human body is 85% water. Although 70% of the earth is water, they are usually not available in a form that is readily available for use by man for its various needs. On a global scale, 25,000 people die each day as a result of poor water quality (Encarta Encyclopedia, 2005). Water related diseases such as cholera, diarrhoea, dracunculosis (guinea worm), filariasis, malaria, onchocerciasis (river blindness), schistosomiasis (bilharziasis), trypanosomiasis (sleeping sickness), and typhoid fevers still represent the single largest cause of human morbidity and mortality (Encarta Encyclopedia, 2005). Therefore, inadequate water and sanitation services adversely affect the health and socioeconomic development of a community (Nanan *et al*., 2000). The proportion of people with access to adequate water and sanitation has not increased due to population growth, insufficient continued investment and systems, and lack of training and spare parts to maintain systems in working order (Cheesbrough, 2000). This account for the increased incidence of fatal and life threatening gastrointestinal illness majority of which occur in the rural areas of developing countries (Cheesbrough, 2000).

Several incidences of water-borne or water associated outbreaks of diseases were reported in the United Kingdom in the 20th Century (Water Quality and Public Health, 2002). Decline in water-borne infections outbreaks in U.K. has been attributed to improvements in water treatment and the widespread use of chlorine as water disinfectant (Galbraith, 1994). In the United States of America (USA), contamination of water in the distribution system (from 1991 to 1996) was responsible for 22% of the reported outbreaks; caused by corrosion, cross-connections, backflow, improperly protected storage or repairs to water mains and plumbing (Craun, 1986; Craun and Calderon, 1999). Reports also showed that from January to March 1993, 107,297 people in Bangladesh contracted cholera, with an estimated 1,473 deaths (Albert *et al*., 1993). In Ethiopia, over 60% of the communicable diseases were reported to be due to poor environmental health conditions arising from unsafe and inadequate water supply, poor hygienic and sanitation practices (Abebe, 1986).

In Nigeria, contaminations of drinking water with pathogens have also been reported in several towns (Ogunsanya *et al*. 1989; Ogbondeminu *et al*. 1994; Ibrahim *et al*. 2000; Agbogu, 2004). Water related diseases are among the five leading causes of death in children under five years of age (FAO, 1994). Waterborne outbreaks of enteric disease have occurred either when public drinking water supplies were not adequately treated after contamination with surface water or when surface waters contaminated with enteric pathogens have been used for recreational purpose (Johnson *et al.,* 2003). The grazing of cattle and land application of animal waste may lead to the occurrence of enteric pathogens in nearby surface and ground waters (Yang *et al.,* 2004). Hubbard *et al.,* (2003) reported that grazing animals and pasture production can affect water quality both positively and negatively often posing serious threat to public health.

The most common and widespread health risk associated with drinking water is microbiological contamination. In nearly all epidemics of water borne diseases, it has been observed that the bacteriological quality of water was unsatisfactory (Galbraith, 1987). Also there was evidence of contamination or failure of terminal disinfections. Though these

findings are not limited to developing countries, they are more critical with greater dire consequences than in advanced countries of the world.

Sokoto state has been facing a lot of water supply problems, some of which are of great public health significance (Junaidu *et al.*, 2001). The findings of earlier studies showed significant pollution of the pipe borne water within Sokoto metropolis. Incriminated microorganisms were *E. coli*, *Klebsiella*, *Salmonella*, *Shigella*, *Enterobacter*, *Clostridium* and *Streptococcus* species. The commonest causes of pollution was attributed to improper treatment of water at the Sokoto Water Works, and broken down pipes. Responses to questionnaires distributed to residents of Sokoto, Shuni and Tambuwal showed that only 30.6% of the populace had access to potable pipe-borne water. The majority of the populace resort to wells and sachet waters for their water drinking needs. Previous studies on water bacteriological quality of pipe borne have been limited to Sokoto metropolis. The bacteriological qualities of these other sources of water in Sokoto metropolis and other towns in Sokoto State have not been investigated. This study set out therefore, to assess the bacteriological quality of all sources of drinking water not only in Sokoto, but also in Shuni and Tambuwal towns of the State.

Experimental

The area of study is Sokoto, Shuni and Tambuwal towns of Sokoto State. Sokoto, which is the capital of Sokoto State, is located near the confluence of the Rima and Sokoto rivers. Sokoto State falls within the savannah zone. Rainfall starts in May and ends in early September or October with mean annual rainfall ranging between 500mm to 1,300 mm (Ibrahim *et al.*, 2000). Based on the 2006 population census, Sokoto metropolis has a population figure of 427, 760, while Shuni (Dange) has a population of 194,546 and Tambuwal has a population of 224,931 (National Population Commission, 2006). Wells, boreholes, rivers, tap and sachet waters serve as drinking water sources for the populace.

Collection of samples. A total of 280 samples of drinking water were collected for microbiological analyses from the three study towns. Thirty five water samples were taken, each from one sampling point on weekly basis for 8 weeks. Local collecting vessel was used to fetch water from the wells and poured into 250ml sterile bottles, carefully covered and assigned a label each. The bottles kept in an iced cooler were transported to the laboratory for microbiological analysis within 6 hours of collection. Tap water samples were collected from 7 different tap outlets in Sokoto town. 1-litre sterile containers containing sodium thiosulphate (5mg/litre), to neutralize residual chlorine, were used to collect tap water after the tap had run for 15-30 seconds. The samples were labeled and transported to the laboratory in an iced cooler for further analysis within 6 hours of collection. The water samples were collected from tap outlets connected to the boreholes (1 in Shuni and 2 in Tambuwal) as described for tap water without adding sodium thiosulphate. Sachet water samples were bought from 10 different sale points (5 in Sokoto town, 3 in Shuni and 2 in Tambuwal). They were of different brands, with some samples bearing NAFDAC registration numbers. The water samples were labeled and placed in an iced cooler for onward transportation to the laboratory for analysis.

Estimation of bacterial count. Ten-fold serial dilutions of the water samples were prepared using sterile distilled water. 0.1ml of the sample was taken from 10^{-4} and 10^{-6} dilutions and aseptically transferred on to the centre of a prepared Plate Count Agar medium (Oxoid, Basingstoke, UK). The plates made in duplicate were swirled for an even distribution of the inoculum and were

incubated (Gallenkamp Incubator, Model IH – 150, England) at 37^{o}C for 24 hours. Colonies formed were counted with the aid of Colony Counter (OSA, Model ST15, Staffordshire, England) and the results reported as cfu/ml. The values were multiplied by the reciprocal of the dilution factors to get the actual bacterial count.

Estimation of coliform count. Ten-fold serial dilutions of water samples were prepared using sterile distilled water. From all the dilutions, 0.1ml of the sample was aseptically transferred to the centre of a prepared E.M.B. agar (Oxoid, Basingstoke, UK) and the plates swirled for an even distribution of the inoculum. The plates were made in duplicates and incubated (Gallenkamp Incubator Model IH – 150, England) at 44.5^{o}C for 24 hours. Characteristic lactose fermenting colonies formed were counted as faecal coliform and reported as cfu/ml.

Isolation and Identification of Water-borne Bacterial Pathogens

Isolation of Escherichia coli. E. coli was isolated from water samples using Trypticase soya broth (TSB) as pre-enrichment and incubated at 44.5^{o}C as described by Lejeune *et al*., (2001). Twenty (20) milliliter of water samples was combined with equal volume of sterile double strength trypticase soya broth in cotton plugged 150ml Erlenmeyer flask and incubated (Gallenkamp Incubator model IH – 150, England) at 44.5^{o}C for 24 hours. After the enrichment, a loopful of the broth was streaked on Eosin Methylene Blue (E.M.B) Agar (Oxoid Basingstoke, UK) and incubated at 44.5^{o}C for 24 hours. Mixed cultures were transferred to fresh E.M.B. Agar plates (Oxoid Basingstoke, UK) to obtain pure colonies. Discrete, 4-5 typical lactose fermenting small, almost black-centred colonies which were confirmed Gram negative using a standardized gram staining procedure (Claus, 1992), were picked and streaked on to slants of Nutrient Agar, incubated (Gallenkamp Incubator model IH - 150, England) at 37^{o}C for 24 hours and stored in a refrigerator for further identification.

Isolation of Salmonella sp. One milliliter (1ml) of the stock sample was mixed with 9ml of buffered peptone water (BPW) as pre-enrichment for *Salmonella* and incubated (Gallenkamp incubator Model IH -150, England) at 37^{o}C for 24 hours. The pre-enriched culture (1ml) was sub cultured into 9ml Selenite-F broth for selective enrichment (Kent *et al.*, 1981). This was plated out on *Salmonella-Shigella* agar. All non-lactose fermenters were isolated on Nutrient Agar slant for further identification.

Isolation of Shigella sp. Five(5) milliliter of the water sample were inoculated on to ten (10) millilitre Selenite F- broth, and incubated (Gallenkamp Incubator model IH – 150, England) at 37^{o}C for 24hrs. After incubation, a loopful of the broth culture was streaked on to the surface of MacConkey Agar (Oxoid Basingstoke, UK) and incubated at 37^{o}C for 24hours (Cheesbrough, 2002).

Isolation of Vibrio sp. One milliliter (1ml) of water sample in alkaline peptone water (pH 8.6) was incubated (Gallenkamp Incubator Model IH – 150, England) at 37^{o}C for 5-8 hours. This was subcultured into Thiosulphate Citrate Bile Salt (TCBS) agar, and incubated at 37^{o}C for 24 hours. Growth from this was subjected to further confirmation using serological tests (Cheesbrough, 2002).

Results

The results in Table I below showed that a high numbers of the water samples are laden with pathogenic organisms with *E. coli* constituting the highest proportion of isolates (34.35%) and *Vibrio cholerae*, the least proportion (18.32%). Relatively higher proportion of water samples in Sokoto town had *Salmonella* and *Shigella* organisms while *Vibrio* organisms were less frequent among water samples collected from Sokoto town.

Table II below indicated that all the water sources were heavily laden with pathogenic organisms with sachet (pure) water having the highest percentage of 54.29%, followed closely by well water (53.13%). It could be deduced from this that some of the pure water sold in Sokoto, Shuni and Tambuwal towns of Sokoto State were untreated well water.

The distribution of enterobacteriaceae isolated from various drinking waters in the three towns studied according to source of water is shown in Table III.

Table I: Distribution of water-borne infection causative organisms isolated from the various water samples

Organism	Number of Isolate in Water Samples from			Total
	Shuni (n=72)	Sokoto (n=136)	Tambuwal (n=72)	
E. coli	12	20	13	45(34.35)
Salmonella sp	5	17	8	30(22.90)
Shigella sp	4	21	7	32(24.43)
Vibrio cholerae				
Inaba	9	5	7	21(16.03)
Ogawa	0	1	2	3(2.29)
Total	30	64	37	131

* Percentage in bracket n = number of sample analyzed.

Table II: Distribution of Pathogens among the Various Sources of Waters

Pathogens	Sources of Water				Total
	Tap (n=56)	Well (n=96)	Borehole (n=35)	Sachet water (n=70)	(257)
E. coli	8	16	7	14	45
Salmonella sp	7	14	2	7	30
Shigella sp	8	10	4	10	32
Vibrio cholerae					
Inaba	2	9	3	7	21
Ogawa	1	2	0	0	3
Total	26(46.43)	51(53.13)	16(45.71)	38(54.29)	131

* Percentage in bracket n = number of sample analyzed.

Table III: Distribution of Enterobacteriaceae isolated from various drinking waters in Sokoto, Shuni and Tambuwal towns of Sokoto State

Sources of water	isolates		
	E. coli n(%)	*Salmonella sp* n(%)	*Shigella sp* n(%)
Borehole (n=24)	7(29.17)	2(8.33)	4(16.67)
Sachet water(n=80)	13(16.25)	7(8.75)	10(12.50)
Tap(n=56)	8(14.29)	7(12.50)	8(14.29)
Well(n=120)	17(14.17)	14(11.67)	10(8.33)
Total(n=280)	45(16.07)	30(10.71)	32(11.43)

* Percentage in bracket n = number of sample analyzed.

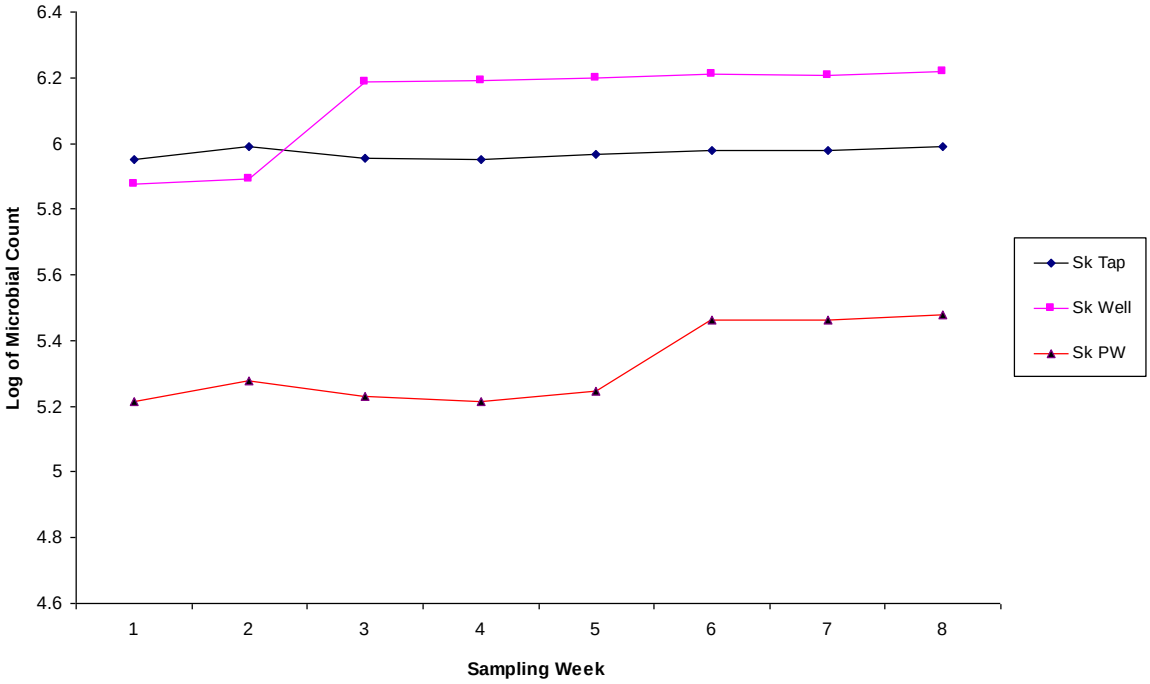

Fig. I: Bacterial levels of various drinking waters in Sokoto town over 8-week sampling period.

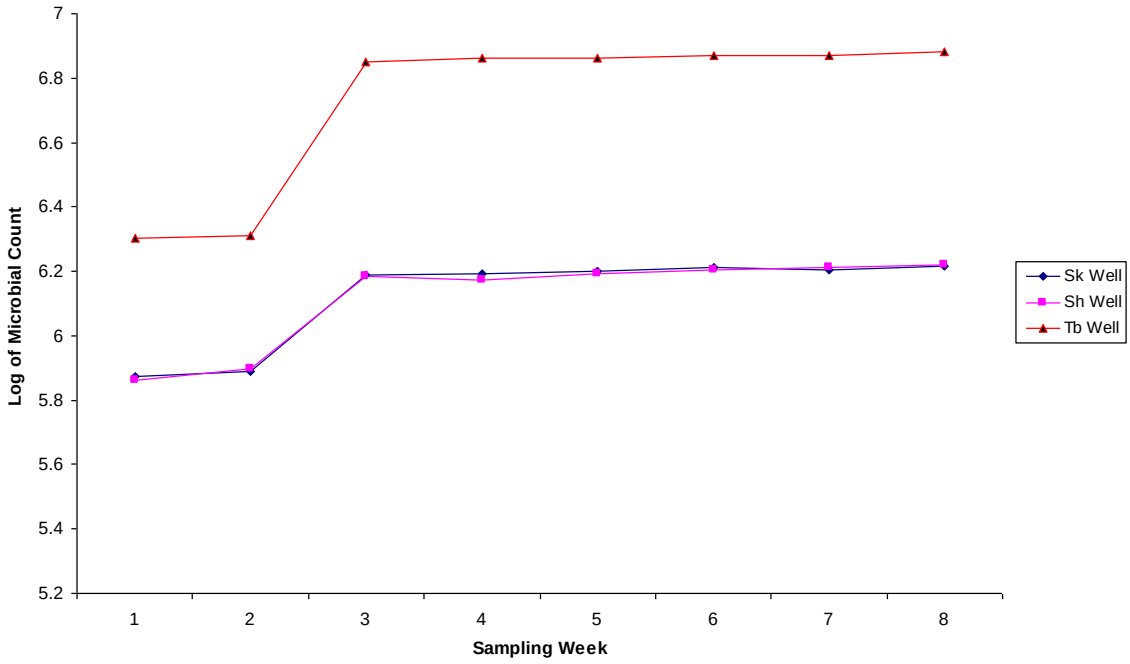

Fig. II: Bacterial levels of well waters in Sokoto, Shuni and Tambuwal towns over 8-Week sampling period.

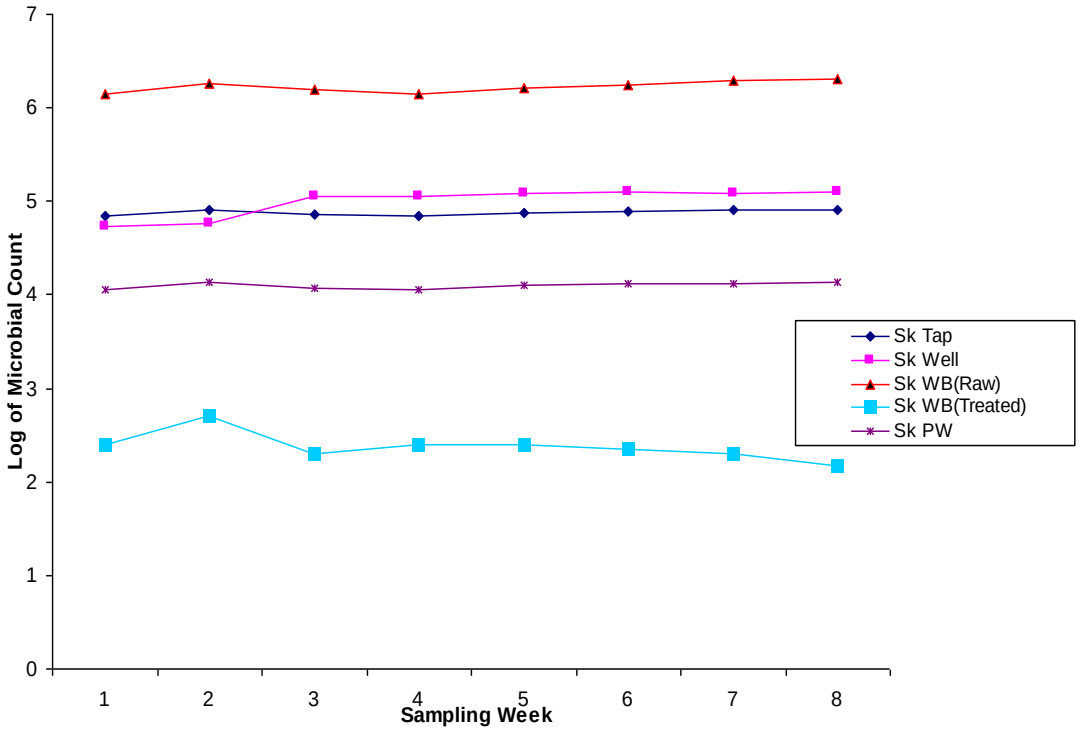

Fig. 3: Coliform count of tap, well, pure water, raw and treated water in Sokoto Town Over 8-week sampling period.

Discussion

As depicted in table III, *E. coli* consistently had the highest percentage in sachet, tap and well water, this is suggestive of faecal contamination. Among the various type of drinking water served in the three studied towns, well water was the most contaminated with *E. coli* (Table III). This poses the health of the inhabitants to danger as well water is mostly used as drinking water. The isolation of high numbers of water-borne pathogens such as *E. coli, Salmonella*, *Shigella* and *Vibrio cholerae* also points to the unhygienic nature of the various sources of drinking waters in the towns. The *Vibrio* species encountered in this study are 01 serogroup *Ogawa* and *Inaba*, with *Inaba* having higher frequency than *Ogawa* in the three towns studied. This is in agreement with the findings of Yahaya (2006) in his study of well waters in some parts of Zaria.

Physical observations showed that in Sokoto town, taps, boreholes and wells were mostly located in public areas, some being sited in open areas where municipal solid wastes are openly deposited. Some of the pipes carrying drinking water were laid in gutters, with attendant hazards e.g. leakage on the pipe which could lead to contamination of drinking water. The environments of the taps and the wells were commonly littered with wastes and lacked proper drainage. The situation worsens as the waste materials which accumulate on daily basis are washed into rivers, streams and some wells following heavy rainfall. It was observed that the litter,

rubbish (bottles, can, plastic, polythene waste, rags, etc.) and the runoff carrying wastes tend to impair on the quality of water. Faecal matters were seen around the taps and wells. Children and animals were frequently observed defecating and urinating around the wells. The only river that supplies Sokoto Water Board with raw water was not left out of the abuse. People openly bathed and washed their belongings in this river. Herds of animals also patronize the river as drinking source, during which they pass their faeces and urine into the water.

A study by Ogbondeminu *et al* (1994) had shown that the occurrence in water sources of *Salmonella spp, Klebsiella spp* and *Shigella spp,* which cause a variety of human diseases, is a further evidence of bacterial contamination of the water sources with potential human hazards. This further proofed that the drinking waters served in the three towns studied were unhealthy as *Samonella* and *Shigella* species were also isolated from them. Contamination of wells with faeces could lead to greater number of Salmonella and other indicator microorganisms being isolated (Goyal *et al*, 1977). Goyal *et al* (1977) stated that for every 45 total coliforms and 13 faecal coliforms, there is 1 *Salmonella* species in water. It was noted that most of the sachet waters in use in these towns are not registered by NAFDAC and hence, not regulated. Figure I below showed a constant high level of bacterial contamination of the different sources of water for Sokoto town which indicated that there is continuous pollution from a point source as well as diffuse sources as regards tap and sachet waters. This might be as a result of the practice of some packaged water producers packaging already contaminated tap water (as well as well water) for sale, and selling without further processing.

Well water samples from the three towns studied had high number of bacteria as shown in Figure II and therefore not met the WHO (2003) minimum microbiological standards for drinking water. WHO stipulates that, for drinking water, bacterial count should not exceed 500 cfu/ml and no coliform should be found in 100ml of the water sample. The relatively high level of coliform bacteria in the untreated (raw) water compared with treated ones (Figure III) is expected when one considers the uses to which such waters are subjected like dumping of refuse, bathing, drinking water for animals, etc. However, other water samples also contained number of coliform above WHO (2003) recommendation.

Since all the water samples had their values above WHO's recommended values for both bacterial and coliform counts, they are therefore not suitable for drinking. One factor that is thought to contribute to the occurrence of elevated number of coliform bacteria and other pathogens is the bottom sediments as stated by Okafo *et al.* (2003). LeJuene *et al* (2001) implicated cattle and animal faeces as the main source of contamination of water, and ascribed the high presence of *E. coli* 0157 in surface water to human, cattle and other domestic animals.

In conclusion, all the drinking waters sampled from Sokoto, Shuni and Tambuwal towns were found to contain *E. coli, Salmonella, Shigella* and *Vibrio* species far above the WHO (2003) allowable limit and therefore not potable. Government should endeavour to provide good potable water to the citizenry and people should be enlightened on the need for personal hygiene.

Acknowledgement

The authors acknowledge the support of the entire staff of Microbiology Postgraduate Laboratory, Usmanu Danfodiyo University, Sokoto in general and especially Malam Yakubu Dabai.

References

Abebe, L. S. (1986); *Hygienic water quality; Its relation to health and the testing aspects in tropical conditions*, Department of Civil Engineering, Tempe ere University, Finland.

Agbogu, V. N. (2004); *Public Health Implications of the Pollution Levels and Contamination of Surface Waters with Pathogenic E. coli in Parts of Zaria*. An M.Sc Thesis, Ahmadu Bello University, Zaria, Nigeria, pp. 22-50.

Albert, M. J.; Ansaruzzaman, M.; Bardhan, P. K.; Faruque, A. S. G.; Islam, M. S.; Mahalanabis, D.; Sack, R. B.; Salam, M. A.; Siddique, A. K.; Yunus, M. and Zaman, K. A. (1993); A large epidemic of cholera-like disease in Bangladesh caused by *Vibrio cholerae 0139. Lancet* 342:387-390.

Claus, D. (1992); A standardized gram staining procedure. *World Journal of Microbiology and Biotechnology*, 8:451-452.

Cheesbrough, M. (2000); *District Laboratory Manual for Tropical Countries*, Cambridge University Press, U. K. 143-147.

Cheesbrough, M. (2002); *Medical Laboratory Manual for Tropical Countries.* 2nd Edn. University Press Cambridge. Pp 200-360.

Craun, G. F. (1986); *Waterborne diseases in the United States*. CRC Press Inc., Boca Raton, Florida, USA.

Craun, G. F. and Calderon, R. L. (1999); Waterborne disease outbreaks: their causes, problems, and challenges to treatment barriers. *AWWA manual M-48: waterborne pathogens*. American Water Works Association, Denver, USA.

Encarta Encyclopedia, 2005 edition. Microsoft Corporation, Redmond, Washington.

Galbraith, N. S. (1994); *Historical Review of Microbial Disease Spread by Water in England and Wales.* Water and Public Health Eds. Golding.

Goyal, S. M.; Gerba, C. P. and Metnick, J. L. (1977); Occurrence of bacterial indication and pathogens in canal communities along Texas coast. *Applied and Environmental Microbiology*, 34: 139-149.

Hubbard, R. K.; Newton, G. L. and Hill, G. M. (2003); Water Quality and Grazing Animal. *Journal of Animal Science* 82 (E. Suppl.): E255-E263.

Hunter, P. R. (2003); Climate Change and Waterborne Disease Pathogens in the Environment and Changing Ecosystems. *Applied Microbiology Symposium Supplement* 94: 375-465.

Hutton, L. G. (1983); *Field Testing of Water in Developing Countries*. Medmenham: Water Research Centre.

Ibrahim, M.; Odoemena, D. I. and Ibrahim, M. T. (2000); Intestinal Helminthic infestations among primary school children in Sokoto. *Sahel Medical Journal* 3(2): 65-68.

Johnson, J. Y. M.; Thomas, J. E.; Graham, T. A.; Townshends, I.; Byrne, J.; Selinger, L. B. and Gannon, V. P. J. (2003); Prevalence of *Escherichia coli* 0157:H7 and *Salmonella* spp. In Surface

Waters of Southern Alberts and Its Relation to Manure Source. *Canadian Journal of Microbiology* 49: 326-335.

Kent, P. T.; Thomason, B. M. and Morris, G. K. (1981); *Salmonella in Foods and Feeds*: Review of Isolation Methods and Recommended Procedures. Atlanta, GA: Public Health Service, CDC.P6.

Kindhauser, M. K. (2003); *Global defence against the infectious disease threat*. World Health Organization, Geneva.

Lejeune, J. T.; Besser, T. E.; Rice, D. H. and Hancock, D. D. (2001); Method for the isolation of water borne *Escherichia coli 0157:H7*. *Letters in applied microbiology*, 32:316-320.

Nanan, D.; White, F.; Azam, I.; Afsari, H. and Hozhabri, S. (2000); Evolution of water Sanitation and hygiene Education on diarrhoea in Northern Pakistan. *International Journal of Public Health* (World Health Organisation). 32: 218-224.

National Population Commission (2006); Population Census in Nigeria.

Ogbondeminu, F. S.; Gomwalk, N. E. and Okurfu, C. E. (1994); Faecal Contamination of a Tropical River in Nigeria and Possible Health Risks, *International Journal of Environmental Health Research* 4: 000-000.

Ogunsanya, T. I.; Rotimi, V. O. and Adenuga, A. (1989); A study of the aetiological agents of childhood diarrhea in Lagos, Nigeria. *J. Med. Microbiol.* 40:10-14.

Okafo, C. N.; Umoh, V. J. and Galadima, M. (2003); Occurence of Pathogens on Vegetables Harvested from Soils Irrigated with Contaminated Streams. *The Science of the Total Environment.* 311:49-56.

Sokoto State Government (2004); Great leap forward: Five years of His Excellency Alh. (Dr.) Attahiru Dalhatu Bafarawa as the Excecutive Governor of Sokoto State; Ministry of Information, Sokoto.

Water Quality and Public Health (2002); *The Microbiology of Drinking Water-Part 1*. Environmental Agency, Nottingham.

WHO (2002); *Evaluation of the H2S method for detection of faecal contamination of drinking water*, pp1-40.

WHO (2003); *Guidelines for Drinking-water Quality*. 3rd ed. Chapter 8, DRAFT. Geneva, World Health Organization.

Yahaya, O. (2006); *Microbiological and Physicochemical Properties of Water from Wells Located Near Municipal Waste Dump Sites in Parts of Zaria*. An MSc. Thesis, Ahmadu Bello University, Zaria, Nigeria, pp 51-58.

Yakasai, I. A.; Salawu, F. and Musa, H. (2004); The Concentration of Lead in Ahmadu Bello University Dam, Raw, Treated (tap) and ABUCONS Pure Waters. *ChemClass Journal*, 1: 86-90.

Yang, H.; Vinopal, R. T.; Grasso, D. and Smets, B. F. (2004); High diversity among Environmental *Escherichia coli* isolates from a bovine feedlot. *Applied and Environmental Microbiology* 70: 1528-1536.