Coliforms Contamination of Households Drinking Water in some parts of Kano Metropolis, Nigeria.

[1]Dalha Wada Taura, [2]Auwalu Hassan, [2]Musa Dahiru.

[1]Department of Microbiology, Bayero University, P.M.B. 3011, Kano-Nigeria.
[2]Department of Biological Sciences, Federal University, Kashere, P.M.B. 0182, Gombe-Nigeria.

Abstract- The association between water, sanitation, hygiene and health are well known. Many diseases are associated with contaminated water which man consume directly or indirectly through cooking, washing utensils, bathing, etc. Such circumstances results in various infections and diarrheal diseases. The aim of the research was to determine the relationship between hygiene practices and microbiological qualities of household drinking water in some parts of Kano, Nigeria. Coliforms were isolated by using membrane filter method with subsequent cultivation on differential and selective media. A total of 212 water samples were collected and 167 questionnaires were administered to each participating household. Of these 212, 83.0% of water samples used had coliform bacteria. A total of 143 (67.5%) households store their drinking water while only 69 (32.5%) collect and use their water without storage. Post-collection contamination was found to vary according to certain parameters like container used in collection and storage of the water, storage duration, number of children and wives and mode of collection.

Index Terms- Coliforms, Contamination, Drinking water, Households, Hygiene.

I. INTRODUCTION

Water is essential to life and health; however, over one billion people worldwide do not have access to safe drinking water (WHO, 2000). Waterborne diseases have been estimated to cause more than two million deaths and four billion cases of diarrhea disease annually (WHO, 2000). Infectious diarrhea is responsible for the greatest burden of this morbidity and mortality (Pruss *et al*., 2002) and children less than five years of age are the most severely affected (WHO, 2000). In 2001, infectious diseases accounted for an estimated 26% of deaths worldwide (Kindhauser, 2003). Gastro - intestinal water – borne infections are among the most emerging and re-emerging infectious diseases throughout the world. They are infections that affect mainly the stomach and the gastrointestinal tract. They are mostly endemic with a worldwide distribution and they have a heterogeneous aetiology (Onyango and Angienda, 2010). In Africa, it has been estimated that every child has five episodes of diarrhea per year and that 800,000 children die each year from diarrhea and dehydration. According to Wittenberg (1998), infective diarrhea is predominantly a disease of poverty, overcrowding and environmental contamination. He noted that within the southern African subcontinent, large-scale epidemics involving *Shigella dysenteriae* type 1 and *Vibrio cholerae* have occurred. In Nigeria, contaminations of drinking water with pathogens have also been reported in several towns (Biu *et al*., 2009; Adekunle *et al*., 2007; Ibrahim *et al*., 2000). 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). One of the major strategies for tackling this problem is the installation of protected sources such as boreholes, standpipes or wells to provide water of better quality. However, such communal facilities are located some distance from the home, requiring collection and transport from the source and subsequent storage of water within the household. It has frequently been observed that the microbiological quality of water in vessels in the home is lower than that at the source, suggesting that contamination is widespread during collection, transport, storage and drawing of water (Van Zijl 1966; Lindskog & Lindskog 1988). Clearly, point-of-use water quality is a critical public health indicator (Trevett, *et al*., 2005; Gundry, *et al*; 2004). Boiling of drinking water is an intervention in the "domestic domain" of infectious disease transmission.

Ideally, drinking water should not contain any microorganism known to be pathogenic or any bacteria indicative of fecal pollution, since the presence of these microorganisms has been traditionally seen as an indicator of fecal contamination, tests are useful for monitoring the microbiological quality of water used for consumption. Recognition that water is source of pathogenic microorganisms dates back to 1800 A. D. (Doestch, 1960). Because it is very expensive and time consuming to test for all pathogens, it is suggested that a single group of microorganisms that come from the same source as human

pathogens can be used to indicate the presence of pathogens (Wyn, *et al.*, 2000).

II. MATERIALS AND METHODS

1.1. Study area

The study was conducted in four local government areas of Kano State viz: Dala, Gwale, Kumbotso and Ungogo within Kano metropolis.

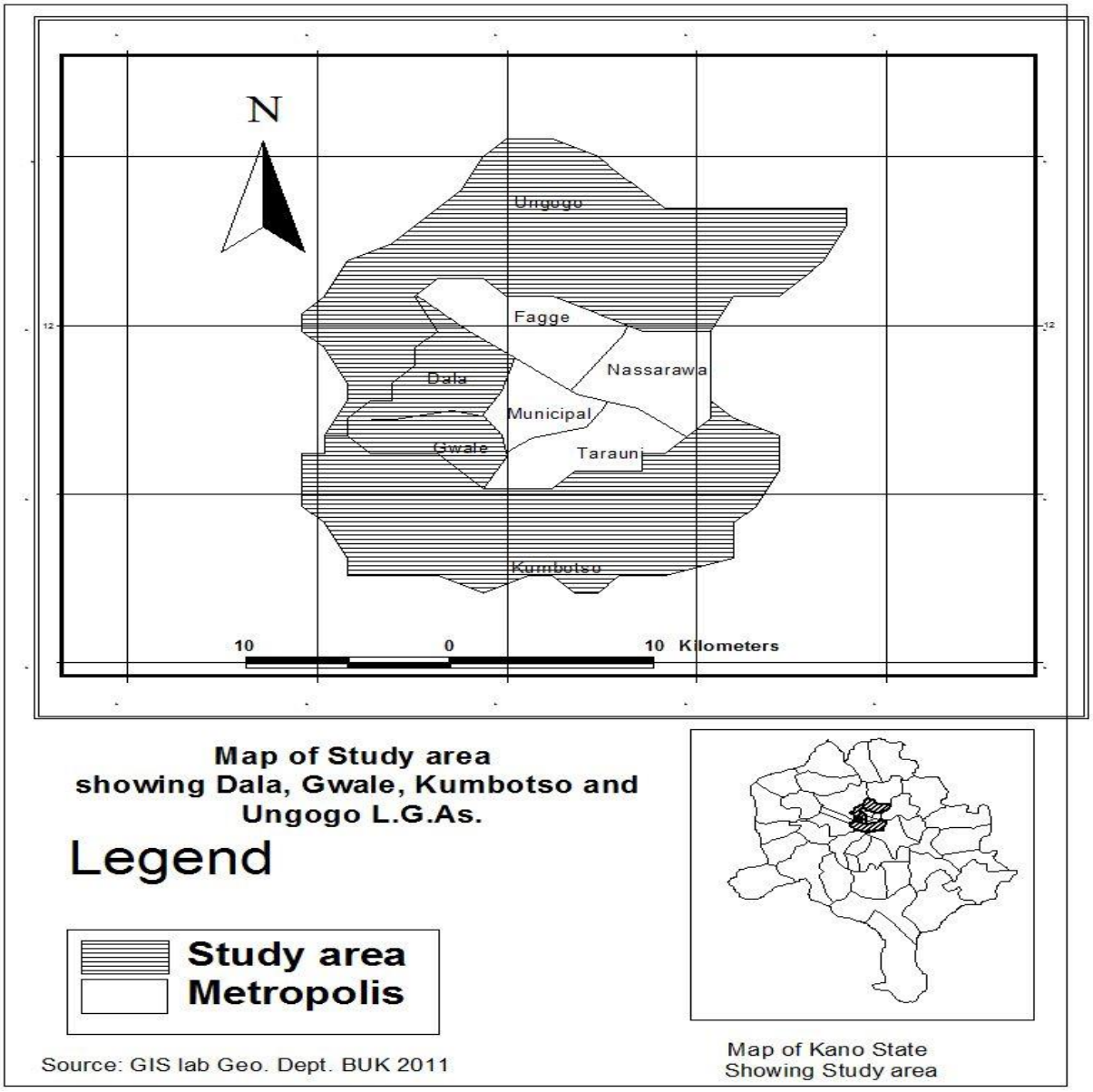

Figure 1: map of Kano metropolis showing study areas.

1.2. Sample size

A total of 212 water samples were collected and 167 questionnaires were administered for the study. Collection of the samples was done in four local governments and in each selected local government; communities were visited very early in the morning before households left the houses.

1.3. Sample collection

Standard method described by American Public Health Association (APHA, 1999) was used for the collection of samples. During collection of samples, in each targeted house, 300ml of water was poured aseptically in to 300ml sterilized bottles. For tap water and borehole, the samples were collected by allowing the water to run to waste for 2 or 3 minutes and then aseptically collected in sterile bottles. Water from wells was collected by means of a sterilized bottle fitted with a weight at the base. All samples collected were then labeled with sample number, date of collection, and sample source for analysis purposes, and then sealed. After sampling, a structured questionnaire was administered to each participating household. The questionnaire included variables such as family size, location of the source of water within the house, method of collection, devices used to collect and store water, storage duration and water treatment. Samples collected were then transported to the laboratory in an iced cooler for storage as soon as possible.

1.4. Sample filtration

Membrane filter assembly was set up by inserting the glass funnel bottom in to the opening of arm jar flask. At the side of the flask, there is narrow opening; this was then connected to the vacuum pump machine through rubber tubing. During filtration, membrane filter was placed in to the funnel using sterile forcep. Sample was shaken vigorously at least 25 times up and down to mix the sample and then 100ml of sample for coliforms was poured in to the funnel and the vacuum pump was then turned on to drain the sample through the sterile 47mm, and 0.45µm membrane filters (Whatman, Maidstone, Japan). After filtering the sample, the funnel walls were rinsed three times with 20-30ml of sterile peptone water, then the vacuum pump was turned off and the funnel top was lifted up to remove the membrane filter using sterile forcep and the filter was placed on MacConkey agar, followed by incubation at 35^0C for 24hours (APHA, 1999).

1.5. Microbial enumeration

Bacterial colonies from membrane filter on MacConkey (Applichem Biochemica. Germany) agar were counted based on lactose fermentation (APHA, 1999).

1.6. Isolation and identification of bacteria

After incubation at 35^oC for 24hours, colonies were counted based on lactose fermentation. The colonies that appear pink in color were sub cultured by using straight wire loop on to lactose broth as a presumptive test. Colonies that produce gas in the Durham tubes were sub cultured on to Brilliant green lactose bile broth (BGLB) to confirm the presence of coliforms because it suppresses the growth of anaerobic lactose farmenters like *Clostridium perfringens* which may give rise to false positive on MacConkey (APHA, 1999). Colonies that produce gas on BGLB were subjected to biochemical tests to identify the species. Motility-Indole-Ornithine medium was used to detect motility, indole and ornithine production (Macfaddin, 1980). Other biochemical tests such as triple sugar iron agar, Voges – proskauer, citrate, urease and methyl red were also used to differentiate coliforms.

III. RESULTS

Of 167 households studied, 8 (4.79%) had no wife and only 4 (2.4%) had the highest number of wives, that is 4 wives (Table 1). From this table, those with highest number of wives 4 (2.4%) reported the highest level of coliforms contamination 4 (100%) than those with no with no wife 4 (50%). On the basis of the number of children, out of the 167 households examined, 61 (38.4%) had 0-5 children while only 8 (5.0%) had the highest number of children that is ranging from 21-25. Of the 61 households that have 0-5 children, 32 (52.5%) were contaminated with coliforms while for those with 21-25, out of those 8, only 1 (12.5%) did not report contamination, the rest of the 7 (87.5%) were contaminated (Table 2). In case of location of the source of water within the households, only 72 households had their own private water supply. Of these, 54 (75%) of the sources are some meters away from the source of contamination and 18 (25%) are few meters away from the source of contamination, and out of these, those that are few meters away reported the highest the highest level of contamination 15 (83.3%) than those some meters away 35 (64.8%) (Table 3).

For mode of collection, of the 167 households examined, water collected by children were more contaminated than those collected by self and vendors. In this, out of 65 (38.9%) collected by children, 58 (82.2%) were found to contain coliforms (Table 3). In terms of collection devices, water collected using buckets were found to be less suitable for drinking than those collected using basins and jerry

cans in which out of 91 (54.49%), 62 (68.1%) were found to contain coliforms (Table 4). With regards to storage facilities, water stored using buckets reported the highest level of contamination followed by those of clay pots. In this, out of 48 (28.7%) and 51 (30.5%) of those that are stored in buckets and clay pots, 45 (93.8%) and 39 (76.5%) were contaminated with coliforms respectively (Table 5). With respect to storage duration, those that store water within the range of 2 days and above, reported the highest contamination 42 (77.8%) (Table 6).

Table 1. Level of coliforms contamination based on number of wives.

Microorganism	No. of houses (167)									
	Single		1 Wife		2 Wives		3Wives		4Wives	
	Ps %	As %	Ps %	As %	Ps %	As %	Ps %	As %	Ps %	As %
Coliforms	4 (50)	4 (50)	37 (42.5)	50 (57.5)	39 (70.9)	16 (29.1)	8 (61.5)	5 (38.5)	4 (100)	0 (0)

Key: Ps = present, As = absent, % = percentage

Table 2: level of coliforms contamination based on number of children.

Microorganisms	**No of houses (167)**									
	0-5		**6-10**		**11-15**		**16-20**		**21-25**	
	Ps (%)	**As (%)**	**Ps (%)**	**As (%)**	**Ps (%)**	**As (%)**	**Ps (%)**	**As (%)**	**Ps (%)**	**As (%)**
Coliforms	32 (52.5)	29 (52.5)	30 (47.6)	33 (52.4)	13 (65.0)	7 (35.0)	5 (71.4)	2 (28.6)	7 (87.5)	1 (12.5)

Table 3. Occurrence of coliforms in relation to location of the source water in houses and mode of collection.

Macroorganisms	**Locations (n=72)**				**Mode of collection (N=167)**					
	S. meters (%)		F. meters (%)		Self (%)		Children (%)		Vendors (%)	
	Ps	As	Ps	As	Ps	As	Ps	As	Ps	As
Coliforms	35 (64.8)	19 (35.2)	15 (83.3)	3 (16.7)	32(72.7)	12 (27.3)	58 (89.2)	7 (10.8)	43(74.1)	15 (25.9)

Key: n = number of households with private water supply.

N = Total number of houses, S. meters = some meters away from the source of contamination only within the household

F. meters = few meters away from the source of contamination only within the household

Table 4. Occurrence of coliforms in relation to collection facilities.

Microorganisms	Devices for collection (N = 167)					
	Bk		Bs		Jr	
	Ps %	As %	Ps %	As %	Ps %	As %
Coliforms	62 (68.1)	29 (31.9)	2 (20)	8 (80)	40 (60.6)	26(39.4)

Key: Bk = Bucket, Bs=Basin, Jr=Jerry can, N = Total number of houses.

Table 5. Occurrence of coliforms in relation to storage facilities.

Microorganisms	Devices for storage (N=167)											
	Ct		Cp		Br		Bk		Jr		Nn	
	Ps %	As %	Ps %	As %	Ps %	As %	Ps %	As %	Ps %	As %	Ps %	As %
Coliforms	3 (75)	1 (25)	39 (76.5)	12 (23.5)	14 (73.7)	5 (26.3)	45 (93.8)	3 (6.3)	15 (71.4)	6 (28.6)	7 (29.2)	17 (70.8)

Key: Ct = Cistern, Cp=Clay pot, Br = Barrel, Bk = Bucket, Bs=Basin, Jr=Jerry can, Nn = none, N = Total number of houses.

Table 6: Occurrence of coliforms in relation to storage duration.

Microorganisms	Number of households that store water (n=143)							
	<24 Hours		24 hours		<or>2 days		<1 week	
	Ps (%)	As (%)	Ps (%)	As (%)	Ps (%)	As (%)	Ps (%)	As (%)
Coliforms	2 (66.7)	1 (33.3)	40 (61.5)	25 (38.5)	42 (77.8)	12 (22.2)	18 (85.7)	3 (14.3)

Key: n = number of households that store their water

< = lessthan, > = greater than

IV. DISCUSSION

In this study, 167 households were examined for the presence of coliforms based on the number of population and their level of hygiene practices and sanitation. From this study, household population had significant influence on the occurrence of microorganisms in drinking water, in that, for household that had highest number of wives (3 and 4) reported the highest level of contamination, this is because all of the four households that had 4 wives reported the occurrence of coliforms and eight out of thirteen households with 3 wives reported the occurrence of coliforms in their drinking water. Number of children also influences the occurrence of microorganisms in drinking water for the fact that as the number of children increases also the occurrence of coliforms increases. This might be associated to the chances for the children to contaminate the drinking water more frequently through their dirty hands. However, there was no significant difference in the quality of water between number of children and wives (p=0.7791).

In case of location of the source of water within the household, there was statistically significant difference between sources that are some meters and few meters away from the source of contamination, in that sources that are few meters

away from the source of contamination were more contaminated than those some meters away from the source of contamination (p=0.0059). This might be due to the infiltration of contaminated water (sewage) through cross connection, leakage points and back siphonage. However, some studies have associated the occurrence coliform bacteria with rainfall events (Stukel *et al*., 1990). This results was not in agreement with the work conducted by Nguendo – yongsi, (2011) in which he reported no significant difference between improve and non improve water sources.

From the results, water collected by children were more contaminated than those collected by households and vendors with significant increase in the occurrence of microorganisms (p=0.0427), this could be attributed to the chances of children to contaminate the water with their dirty hands either during collection or on their way to home. The results show that collection devices had significant influence on the quality of water used for drinking. This might be because when comparing water collected using buckets and jerry cans, those collected using buckets were more contaminated than those collected using jerry cans(p=0.01). This shows that container type is also a strong predictor of fecal contamination. Water is safer from contamination in containers with a small opening than in those with a wide opening (Vanderslice and Briscore 1993; Jensen *et al*., 2002; Roverts *et al*., 2001; Trevett *et al.*, 2004; Deb *et al*., 1986; Yeager *et al*., 1991). Fecal contamination increased as water was followed from its sources to drinking water storage containers. In addition, longer storage time implies more opportunity for contamination, because hands and the handle or outer surface of collecting devices frequently carry fecal pathogens. Also Use of uncovered water containers is likely to increase water contamination between source and point-of-use as hands are dipped into vessels to scoop a cupful of water (Chidavaenzi *et al*., 1998). Furthermore, the decline in water quality between source and household has been shown to be greater when source water is clean (Wright *et al*., 2004). In comparisons of health impacts due to water source and household level interventions such post-source contamination has been shown to increase diarrhea risk (Clasen *et al.,* 2006). This highlight the need for improved personal and domestic hygiene practices. The detection of these microorganisms might be mainly associated with post treatment contamination from outside sources or from microorganisms growing within biofilms or other materials in the distribution of system (in the case of tap water), or the contamination was from the source. Detection of these organisms could be possible because majority of the households do not treat their drinking water; in fact only one household out of 167 was treating his drinking water after collection. Ideally, in-house water connections would provide chlorinated water directly from the tap to the drinker, eliminating the need for storage. However, as long as water storage remains a fact of life in communities like these; interim measures will be needed to address these problems. In addition, long storage time implies more opportunity for contamination.

V. CONCLUSION AND RECOMMENDATIONS

These results enabled us to understand the relationship between sanitation, hygiene practices and water quality and also show that fecal contamination is becoming common in some part of Kano state, Nigeria. In general, the quality of household water examined was poor and this is an indication that whenever basic sanitation and hygiene are lacking, there is more likely hood of indicator bacteria from feces to be introduced in to stored water. On the basis of these results, the following recommendations are necessary. People should ensure that their source of water is not close to source of contamination (pit latrines or septic tanks); they should ensure effective post collection and storage treatment which will help to reduce significantly the risk of waterborne diseases, there should be effective hygiene and sanitation, when collecting water, effective precautions should be taken in order not to contaminate the water, collection and storage devices should have proper coverings to avoid contamination by wind, and lastly government should intervene in creating awareness to people regarding the dangers associated with waterborne diseases.

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REFERENCES

[1] Adekunle, I., M., Adetunji, M., T., Gbadebo, A., M., Banjoko, O., B. (2007). Assessment of ground water quality in a typical rural settlement in southwest Nigeria. *Int. J. Environ. Res. Public Health,* 4(4): 307-318.

[2] American Public Health Association (APHA, 1999). *Standard methods for the examination of water and waste waters.* American Water Works Association and Water Environment Federation. USA. Parts 9010 – 9030, 9050 – 9060.

[3] Biu, A., A., Kolo, H., B., Agbadu, E., T. (2009). Prevalence of *Schistosoma haematobium* infection in school aged children of Konduga Local Government Area, Northeastern Nigeria. *Int. J. Biomed. Hlth. Sci.*, 5(4): 181-184.

[4] Chidavaenzi, M., T., Jere, M., Nhandara, C., Chingundury, D., Bradley, M. (1998). *An evaluation of water urns to maintain domestic water quality*. 24th WEDC Conference, Islamabad, Pakistan. (ed. J Pickford) WEDC, Loughborough, pp. 249–253.

[5] Deb, B., C., Sincar, B., K., Sengupta, P., G., De, S., P., Mondal, S., K., Gupta, D., N., Saha, N., C., Ghosh, S., Mitra, U., Pal S., C. (1986). Studies on intervention to prevent E1 Tor cholera transmission in urban slums. *Bull World Health Organ* 64: 127-131.

[6] Doestch, R., N. (1960). *A history of the people and events that led to the science of microbiology*. Rutgers university press, New Jersey. U.S.A.

[7] Gundry, S., Wright, J., Conroy, R. (2004). A systematic review of the health outcomes related to household water quality in developing countries. *J Water Health 2:* 1–13.

[8] Ibrahim, M., Odoemena, D., I., Ibrahim, M., T. (2000). Intestinal Helminthic infestations among primary school children in Sokoto. Sahel. *Med. J*., 3(2): 65-68.

[9] Jensen, P., K., Ensink, J., H., Jayasinghe, G., van der Hoek, W., Cairn-cross, S., Dalsgaard, A. (2002). Domestic transmission route pathogens. The problem of in-house contamination of drinking water during storage in developing countries. *Trop Med Int Health* 7:604-609.

[10] Johnson, J., Y., M., Thomas, J., E., Graham, T., A., Townshends, I., Byrne, J., Selinger, L., B., 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 J. Microbiol*., 49: 326-335.

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

[12] Lindskog, R., U., & Lindskog, P., A. (1988). Bacteriological contamination of water in rural areas: an intervention study from Malawi. *Journal of Tropical Medicine and Hygiene* 91, 1–7.

[13] MacFaddin, J.F., (1980). *Biochemical Tests for identification of medical bacteria, 2nd ed.*, Williams, Baltimore. Pp. 1 – 2.

[14] Nguendo – yongsi, H., B. (2011). Microbiological evaluation of drinking water in a Sub-Saharan urban community (yaounde). *Am. J. Biochem. Mol. Biol.*, 1:66 – 81.

[15] Onyango, D., M., Angienda, P., O. (2010). Epidemiology of Waterborne Diarrhoeal Diseases among Children Aged 6-36 Months Old in Busia - Western Kenya. *Int. J. Biol. Life Sci*., 6(2): 92-99.

[16] Prüss, A., Kay, D., Fewtrell, L., Bartram, J. (2002). Estimating the burden of disease from water, sanitation, and hygiene at the global level. *Environ. Health Perspec.*, 110: 537-542.

[17] Roverts, L., Chartier, Y., Chartier, O., Malenga, G., Toole, M., Rodka, H. (2001). Keeping clean water clean in a Malawee refugee camp. A randomized intervention trial. *Bull World Health Organ* 79: 280-287.

[18] Stukel, A., Greenberg, E., R., Dain, R., J., Reed, F., C., Jacobs, N., J. (1990). A longitudinal study of rainfall and coliform contamination in small community drinking water supplies. *Environ. Sci. Technol.*, 24: 571 – 575.

[19] Trevett, A., F., Carter, R., C., Tyrrel, S., F. (2005). The importance of domestic water quality management in the context of faecal oral disease transmission. *J Water Health 3:* 259–270.

[20] Trevett, A., F., Carter, R., C., Tyrrel, S., F. (2004). Water quality deterioration: a study of household drinking water quality in rural Honduras. *Int J Environ Health Res.* 14 : 273-83.

[21] Vanderslice, J., and Briscoe, J. (1993). All coliforms are not created equal. A comparison of the effect of water source and in-house water contamination on infantile diarreal disease. *Water Re-sour Res* 29: 1983-1995.

[22] Van Zijl, W., J. (1966) Studies on diarrhoeal diseases in seven countries by the WHO Diarrhoeal Diseases Advisory Team. *Bulletin of the World Health Organisation* 35, 249–261.

[23] WHO. (2000). Water *Supply and Sanitation Council*, Global Water Supply and Sanitation Assessment 2000 Report. New York: UNICEF.

[24] Wittenberg, D., F. (1998). *Diarrhoeal Disease in Africa*. Paper presented at the Rotavirus Workshop: A seminar in basic molecular characterisation and typing techniques of Rotaviruses. MRC/MEDUNSA Diarrhoeal Pathogens Research Unit/WHO. South Africa, pp. 18-29.

[25] Wright J, Gundry S, Conroy R, 2004. Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Trop Med Int Health 9:* 106–117.

[26] Wyn, A., P., Pallin, R., Deboussis, C., Shore, J., and Sellwood, J. (2000). The detection of small round structured viruses in water and environmental materials. *J. Virol. Methods*, 87: 99 – 117.

[27] Yeager, B., A., Lanata, C., F., Lazo, F., Verasstegui, H., Black, R., E. (1991). Transmission factors and socioeconomic status as determinants of diarrheal incidence in Lima, Peru. *J Diarrheal Dis Res* 9: 186-193.

AUTHORS

First Author- Dalha Wada Taura, Department of Microbiology, Bayero University, Kano-Nigeria. dalhawt@gmail.com.

Second Author- Auwalu Hassan, Department of Biological Sciences, Federal University, Kashere, Gombe-Nigeria. auwal_hssn@yahoo.com.

Third Author- Musa Dahiru, Department of Biological Sciences, Federal University, Kashere, Gombe-Nigeria. musahanifa@yahoo.com.