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Spatial Assessment of Public Water Supplies in Densely Populated Areas of Ilorin Metropolis, Kwara State, Nigeria

***Agbabiaka, T. O., Sule, I.O. and Oyeyiola, G.P.**

Department of Microbiology, University of Ilorin, P.M.B. 1515, Ilorin, Nigeria

Abstract
Water samples collected from public tap supplies at densely populated areas within Ilorin metropolis were analyzed for potability and safety. The study covered a period of twenty-four months. Physicochemical parameters such as pH, turbidity, residual chlorine, colour, suspended solids and total hardness were determined. The pH of the samples ranged from 7.0 - 7.90 while the range for residual chlorine was 0.5 - 10 mg/l. The suspended solids and total hardness ranged from 0.79 - 46.0 mg/l and 7.0 - 34mg/l respectively. Turbidity of the samples ranged from 0 – 5 NTU, while the colour range was 0 - 5 HU and temperature range was 21 - 30^{0}C. The results show that only four (20%) of the twenty samples were potable and free from pathogens while *Escherichia coli, Klebsiella* sp., *Salmonella* sp., *Pseudomonas aeruginosa, Shigellla* sp. and *Enterobacter aerogenes* were detected in sixteen (80%) of the samples. The viable total bacterial count ranged between 0.00 – 2.6 x 10^{2} cfu/ml, total coliform count ranged from 0 – 75 MPN/100ml while faecal coliform count ranged from 0.00 – 2.3 x 10^{2} cfu/ml. The presence of coliforms in the samples is indicative of faecal and non-faecal contamination along the supply network, which in some cases could be due to leaching from contaminated environment into corroded pipes along the distribution network used for conveying the treated water that passed through drainage system.

Key words: Coliforms, contamination, safety, bacteriological, physicochemical parameters.

Introduction

WHO (2008) indicated that there are still a lot of cases of diarrhoea in sub-Saharan Africa. Even fewer Africans had access to adequate sanitation facilities, with rural coverage rates estimated at 20 - 35% (Hart, 2000). Water, the most essential commodity in human life is becoming very scarce due to human activities. The availability of potable and safe water is a problem in developing countries of Africa especially Nigeria. Water for human consumption should be free from microbiological contamination; must not have chemical concentrations greater than prescribed limits; be available in sufficient

*Corresponding author - agbabiaka.toyin.toyin@gmail.com

quantities to enable adequate hygiene; meet local standards for taste, odour and appearance (WHO, 2000).

Most Africans do not have access to safe potable water, water is said to be unsafe due to microbiological contamination which is determined by the presence of faecal coliforms used as indicator bacteria (Hart, 200).

Effective chlorination is usually sufficient to achieve this, although the water sometimes becomes recontaminated within the piped distribution system. In many African cities, household re-treatment of tap water is required to ensure that it is safe.

Escherichia coli is the major gram-negative bacterium colonizing human intestine. *E. coli* is one of the major bacterial causes of diarrhoea diseases in children in tropical countries, causing over 25% of cases. *E. coli* causes diarrhoea by at least five distinct mechanisms: Enterotoxigenic *E. coli* produce secretory small bowel diarrhoea and a major cause of travellers' diarrhoea; Enteroinvasive *E. coli* cause inflammatory large bowel diarrhoea similar to that caused by *Shigella*; Enteropathogenic *E. coli* produces non-inflamatory diarrhoea by destroying the brush border; Enterohaemorrhagic *E. coli* (0157) are recently evolved pathogens that cause haemorrhagic colitis and haemolytic uraemic syndrome; the newly described Enteroaggregative *E. coli* produce chronic bloody diarrhoea, particularly in children (Ellen and Sydney, 1990; Pelzar *et al.,* 2005).

There are different forms of treatment of water in order to make it safe and potable for human consumption. Among the methods used for treatment of water is boiling to improve the quality of water which has been employed from the beginning of civilization. The introduction of chlorination led to a dramatic reduction in the incidence of typhoid fever in the United States (Payment, 1999; Harms *et al.*, 2000; Laughlin, 2000).

Water quality affects health and with an ever increasing population and greater environmental contamination, the risk of contamination of public water supplies increases.

The objectives of this study were to determine the bacteriological qualities of the water samples collected from densely populated areas within Ilorin metropolis for potability and safety of the water supply; evaluate the risk posed to the populace in the consumption of these presumed "safe, treated" public water supply; and to determine the physical and chemical qualities of the water supply.

Materials and Methods

Sources of samples

Treated public water supplies were collected from twenty different locations or serving points within the Ilorin metropolis including two treatment plants at Asa and Agba dams and eighteen other points along the distribution network in line with collecting points of Public Health Laboratory of Kwara State Ministry of Health: College of Education, Agbo-Oba, Sango, Offa Garage, Kuntu, Gambari, Adedo, Saboline, Opomalu, Omoda, Ajikobi, Shao Garage, Akerebiata, Agbabiaka, Oniyangi, Edun, Alanamu and Anifowoshe, all within Ilorin Metropolis. These points were used based on past occurrences of gastroenteritis in Ilorin over the years.

Collection of water samples

The samples were collected using standard methods as described by APHA (2002) into sterile sampling bottles. The mouth of the tap was surface-sterilized using cotton wool soaked in 70% alcohol and flamed. The tap was then allowed to run for about three minutes before collection of the water samples into the sterile sampling bottles.

Physicochemical parameters

Physicochemical parameters determined included

pH; this was determined using digital pH meter metrohm 632 standardized with buffer of pH 4, 7 and 9.

Temperature; a mercury-bulb thermometer was dipped into each water sample and left for about 5-10 minutes and the thermometer read and recorded in ^0C.

Residual chlorine; two ml of 5% potassium chromate was added to 100 ml of each sample and the mixture titrated with 0.1N $AgNO_3$ until its colour changed from yellow to red. Each ml of 0.1N $AgNO_3$ is equivalent to 3.55 mg/l of the residual chlorine.

Turbidity; turbidimeter 2100A was used with each sample cell of the turbidimeter filled with 25 ml of each sample and covered with light shield and turbidity read in NTU.

Colour; Fifty ml of each water sample was put in one tube of Lovibond Comparator and equal volume of distilled water was also put in the second tube. The colour was then read on the disc in HU.

Total hardness; two ml of ammonia solution was added to 50 ml of each sample and little quantity of Eriochrome Blue -Black indicator added. This was then titrated with 0.01M EDTA in the burette. Titre value x 20 = Total Hardness (mg/l) (APHA, 2002).

Bacteriological Quality Determination

Isolation of bacteria

This was carried out according to standard methods for the examination of water and waste water using pour plate method and nutrient agar as the medium of choice. The plates were incubated at 37^0C for 24 hours and viable bacterial counts were enumerated in cfu/ml (APHA, 2002).

Total coliform count

Multiple tube fermentation technique was used to determine the total coliform count per 100 ml of the samples (MPN) (Collins *et al.*, 1979; Fawole and Oso, 2001; Pelczar *et al.*, 2005).

Faecal coliform count

The faecal coliform counts were determined using Eosin methylene blue agar medium as described by Fawole and Oso (2001) and Pelczar *et al.* (2005). Organisms with greenish metallic sheen were assumed to be *E. coli.*

Characterization and identification of isolates

The bacterial isolates were characterized on the basis of their colonial morphology, cellular and biochemical characteristics. They were then identified using standard texts (Cowan and Steel, 1985).

Statistical Analysis

All the relevant data obtained were subjected to analysis of variance (ANOVA) and Duncan multiple range test (Norusis, 2006).

Results

Physicochemical parameters

The pH of the samples ranged from 7.05 in Agba

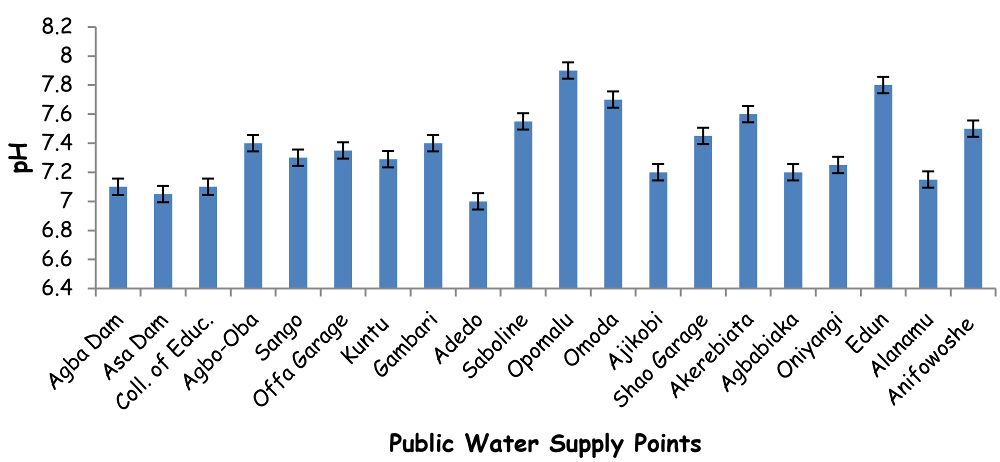

Figure 1: pH of some public water supplies in Ilorin Metropolis

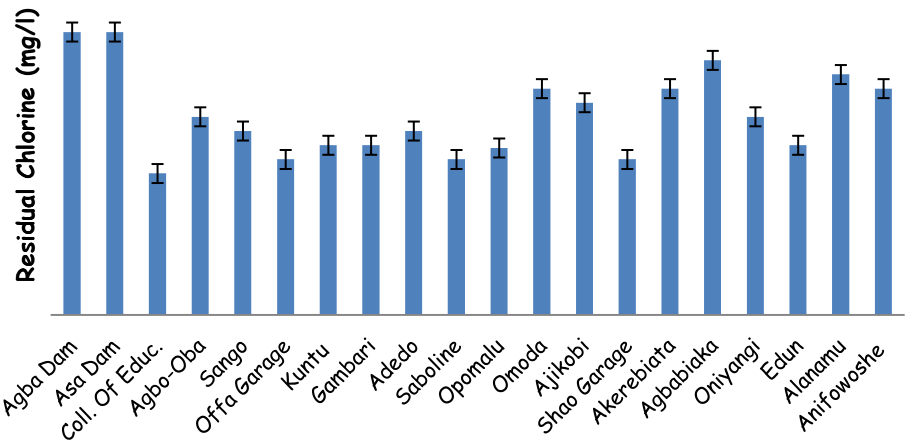

Figure 2: Residual Chlorine content of some public water supplies in Ilorin Metropolis

Dam - 7.90 in Opomalu (Figure 1) indicating slight alkaline nature of the water while the residual chlorine values ranged from 0.50 mg/l in College of Education - 1.0 mg/l in both Agba and Asa Dams (Figure 2). The suspended solids of the samples ranged from 0.79 mg/l in both Agba and Asa Dams - 46.0 mg/l in College of Education (Figure 3) and total hardness for the water samples ranged from 7.0 mg/l in Asa Dam - 34 .0 mg/l in Saboline (Figure 4).

Colour of the samples ranged from 5 HU in Agba and Asa Dams - 12 HU in Sango, Adedo and Alanamu respectively (Figure 5), all falling within the permissible level while the turbidity of the samples ranged from 0 in both Agba and Asa Dams - 5 NTU in College of Education, Adedo, Saboline, Edun, Alanamu and Anifowoshe respectively (Figure 6). Temperature of the samples ranged from 21 ^{0}C in Agba Dam - 30 ^{0}C in Adedo (Figure 7).

The bacterial counts of some public water supplies within Ilorin metropolis ranged from 0.00 – 2.6 x 10^2 cfu/ml, total coliform counts ranged from 0 – 75 MPN of coliform per 100ml of the

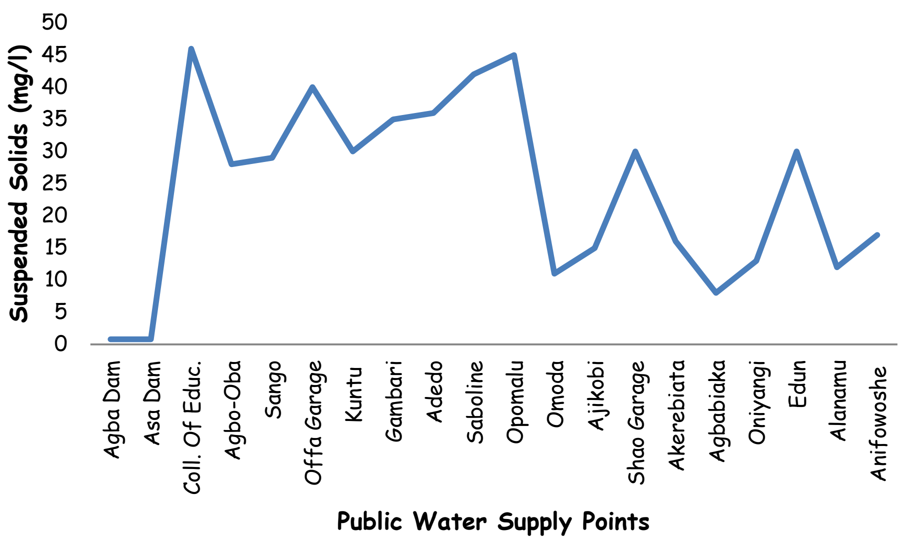

Figure 3: Suspended Solid contents of some public water supplies in Ilorin Metropolis

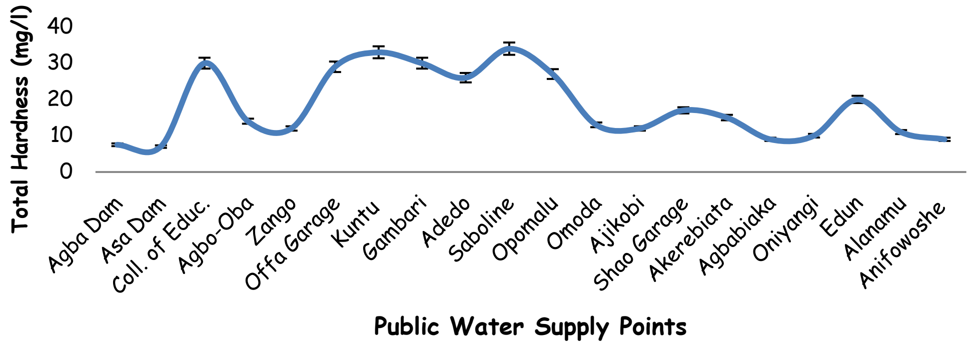

Figure 4: Total Hardness of some public water supplies in Ilorin Metropolis

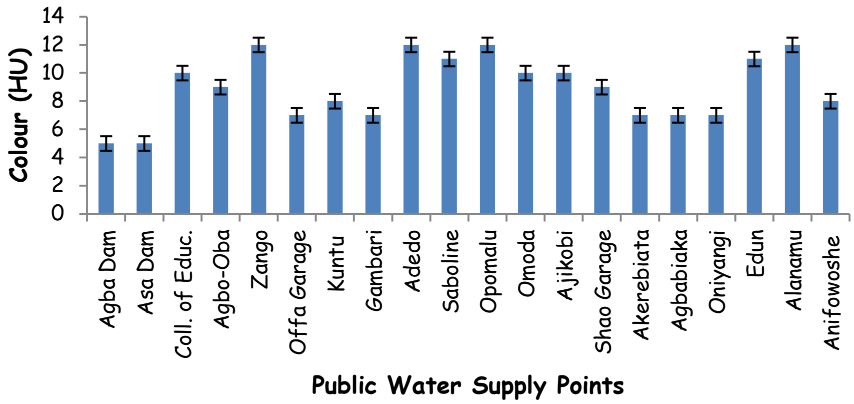

Figure 5: Colour of some public water supplies in Ilorin Metropolis

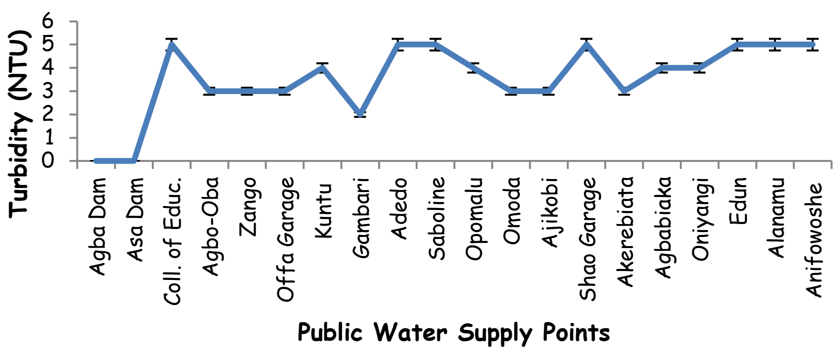

Figure 6: Turbidity of some public water supplies in Ilorin Metropolis

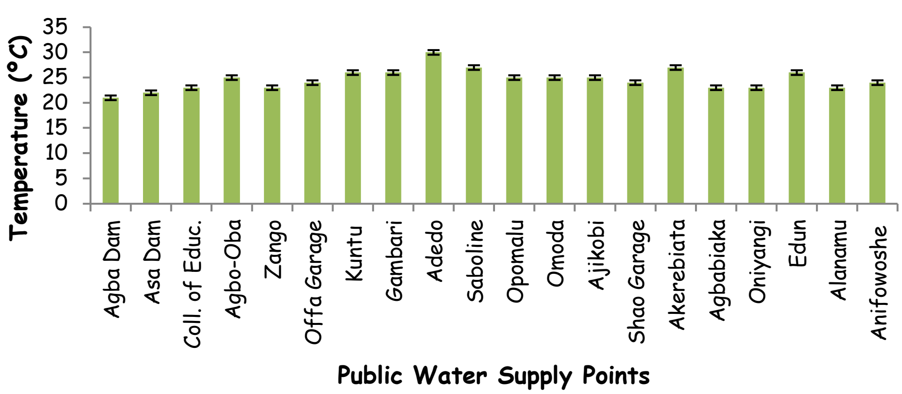

Figure 7: Temperature of some public water supplies in Ilorin Metropolis

Table 1: Bacteriological counts of some public water supplies in Ilorin metropolis

Sample	Location	Bacterial count (cfu/ml) x 10^2	Total coliform count (MPN/100ml)	Faecal coliform count (cfu/ml) x 10^2
1	Agba Dam	0.0 ±0.000[a]	0 ±0.000[a]	0.0 ±0.000[a]
2	Asa Dam	0.0 ±0.000[a]	0 ±0.000[a]	0.0 ±0.000[a]
3	Coll. Of Educ.	2.6 ±0.000[g]	75 ±1.000[j]	2.3 ±0.000[g]
4	Agbo-Oba	1.7 ±0.100[f]	23 ±1.000[f]	1.4 ±0.100[f]
5	Sango	1.2 ±0.050[f]	20 ±1.000[e]	0.0 ±0.000[a]
6	Offa Garage	1.3 ±0.000[e]	16 ±1.000[d]	1.0 ±0.000[e]
7	Kuntu	0.8 ±0.100[c]	4 ±1.000[b c]	0.6 ±0.100[c]
8	Gambari	1.5 ±0.100[f]	26 ±1.000[g h]	1.3 ±0.100[f]
9	Adedo	1.5 ±0.100[f]	29 ±1.000[i]	1.4 ±0.100[f]
10	Saboline	2.1 ±0.000[f]	53 ±1.000[i]	1.9 ±0.000[f]
11	Opomalu	1.5 ±0.050[f]	27 ±1.000[h]	1.2 ±0.050[f]
12	Omoda	0.8 ±0.100[b c]	6 ±1.000[b c]	0.4 ±0.100[b c]
13	Ajikobi	0.6 ±0.100[b]	4 ±1.000[b c]	0.3 ±0.100[b]
14	Shao Garage	0.0 ±0.000[a]	0 ±0.000[a]	0 ±0.000[a]
15	Akerebiata	0.8 ±0.100[c d]	6 ±1.000[c]	0 ±0.000[a]
16	Agbabiaka	0.0 ±0.000[a]	0 ±0.000[a]	0 ±0.000[a]
17	Oniyangi	0.8 ±0.100[b c]	4 ±1.000[b c]	0.5 ±0.100[b c]
18	Edun	1.7 ±0.100[f]	24 ±1.000[g]	1.4 ±0.100[f]
19	Alanamu	0.5 ±0.100[b]	3 ±1.000[b]	0.3 ±0.100[b]
20	Anifowoshe	0.9 ±0.100[d]	9 ±1.000[c]	0.7 ±0.100[d]

Values represent means ± Standard deviation of mean. Values in the same row followed by the same letters are not significantly different using Duncan's multiple range test at $p<0.05$

water samples while faecal coliform counts ranged from 0.0 – 2.3 x 10^2 cfu/ml (Table 1).

Bacterial isolates

Six bacterial species isolated in some of the public water supplies in Ilorin metropolis included *Escherichia coli, Shigella* sp., *Enterobacter aerogenes, Salmonella* sp., *Pseudomonas aeruginosa* and *Klebsiella* sp. were identified.The distribution of the bacteria varies from one sample to another as shown in Table 2.

Discussion

The pH range of 7 - 7.9 obtained for the water samples conform to 6.5 - 8.5 (WHO, 2000). The adverse effect of exceeding this standard is impartment of taste and corrosion of pipes (NWRI, 1997). The pH range obtained is similar to 6.59 - 7.43 obtained by Sule *et al.* (2009).

The suspended solids ranged from 0.79 - 46 mg/l for the water supplies and this range is far below the allowed limit of 500mg/l (NWRI, 1997) indicating that physical contaminants in the samples were very minimal after filtration.

Residual chlorine is important for disinfection of bacteria in the pipeline distribution system, and the higher it is, the safer is the water (Sule *et al.*, 2009). Enough chlorine must be added to leave a residual of it after saturation point or level is reached. The residual chlorine content represents a built-in safety factor against pathogens surviving the earlier treatment and causing recontamination. Micro-organisms that might be left out could be handled by residual chlorine provided that the contamination is not too much. In the

Table 2: Distribution of bacterial species in some public water supplies in Ilorin metropolis

Sample	Location	*Escherichia coli*	*Klebsiella* sp.	*Salmonella* sp.	*Pseudomonas aeruginosa*	*Shigella* sp.	*Enterobacter aerogenes*
1	Agba Dam	-	-	-	-	-	-
2	Asa Dam	-	-	-	-	-	-
3	Coll. of Educ.	+	+	-	-	-	-
4	Agbo-Oba	+	-	-	-	-	-
5	Sango	-	+	-	-	-	+
6	Offa Garage	+	-	+	-	-	-
7	Kuntu	+	-	-	+	-	-
8	Gambari	+	-	+	-	-	-
9	Adedo	+	+	-	-	-	-
10	Saboline	+	-	-	-	+	-
11	Opomalu	+	-	-	-	+	-
12	Omoda	+	-	-	-	+	+
13	Ajikobi	+	-	+	-	-	+
14	Shao Garage	-	-	-	-	-	-
15	Akerebiata	-	+	-	-	-	-
16	Agbabiaka	-	-	-	-	-	-
17	Oniyangi	+	-	+	-	-	-
18	Edun	+	-	-	-	+	-
19	Alanamu	+	-	+	-	-	-
20	Anifowoshe	+	-	-	-	+	-

Key: +, isolated; -, not isolated

samples analysed majority of the samples have residual chlorine with a range of 0.5 - 1.0 mg/l. This is in conformity with WHO standard of 0.2 – 1mg/l (WHO, 2000). The highest residual chlorine content was found at the two treatment plants of the two dams.

The total hardness of all the water samples ranged from 7.0 – 34.0 mg/l and it could be described as being soft since it is less than 50 mg/l (De Zuane, 1997).

A total of six bacteria were isolated and identified in sixteen (80%) of the samples while four (20%) of the twenty samples were found to be potable and safe for drinking in terms of faecal coliform count. However, sample from College of Education contain the highest bacterial counts of 2.6 x 10^2 cfu/ml while samples collected from the water treatment plants at Asa and Agba dams and Agbabiaka contained no viable bacterial count. The variation in bacterial counts along the distribution could be attributed to recontamination (Le Chevallier *et al*., 1996; Sule *et al*,. 2009).

With regard to bacterial quality, there should be no coliform which is the highest desirable level for Nigeria while the maximum permissible level is 10 per 100 ml for coliforms; there should be no *E. coli*, faecal Streptococi, *Clostridium perfringes*. The presence of *E.coli, K. pneumoniae*, *Salmonella* sp., *P. aeruginosa, Shigella sp.*, and *E. aerogenes* in some of the water samples supplied to the public for drinking speaks volume on the level of potability of public drinking water in Ilorin. It is also indicative of recontamination along the distribution system as obtained also by Sule *et al.* (2009) in a similar research.

Sanitary surveys of the distribution system of some water supply points were noted to be near sewage points and waste disposal facilities especially along drainage system. These are potential sources of contamination (Rickards and Bartram, 1993).

The presence of both *Salmonella* and *Shigella* species is instructive of contamination of the water samples as they have been implicated in diseases such as enteric fever, food poisoning, septicaemia and bacillary dysentery.

Also, the presence of *Pseudomonas aeruginosa* in some of the water samples may be attributed to soil contamination of the pipes (De-Victoria and Galvan, 2001).

Conclusion

Four of the water samples analysed were found to be potable and safe for drinking and domestic use, this figure represents twenty percent of the samples while sixteen of the samples were found to be faecally contaminated hence unsafe for human consumption because of the heath risk to human health.

Recommendations

The safety and potability of public drinking water supply in Ilorin metropolis is very important and the government of Kwara State, Nigeria has to improve upon the treatment of public drinking water in order to avert the outbreak of gastroenteritis in the city especially the densely populated areas and to protect health of the populace.

The pipeline distribution system has to be overhauled; the replacement of corroded iron pipes laid long ago with plastic or concrete ones is recommended.

Drainage system should be avoided when laying new pipes in the distribution system and there is the need to increase the amount of water supply on daily basis.

There should be a synergy between Ministries of Health, Environment and Water Resources in order to protect health of the populace.

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