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Microbiological Assessment of Well Water at Different Durations of Storage

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Abstract: Water is the most universally used single necessity of life. To attain a safe water quality to various communities, an understanding of water microbiology and chemistry is therefore imperative. In this study, well water at different storage durations of 0, 2, 4, 6 and 8 weeks were assessed for bacteriological quality using standard microbiological techniques. Black barrel-shaped plastic containers (300 liter capacity) were used for different storage durations. Water samples at the different storage durations were collected from each corresponding containers. Sterile swabs were used to sample the sides and bottom of the storage containers to determine the prevalence of specific bacteria present in the samples. The results obtained showed that 0 week storage had the highest (100.00 CFU mL^{-1}) coliform counts while the lowest (28 CFU mL^{-1}) was obtained for 8 weeks of storage. *Escherichia coli* were not found in 4, 6 and 8 weeks old water. 0 and 2 weeks old water contained *E. coli* and the mean values were $1.80\times10^{4}\pm0.03$ and $1.43\times10^{4}\pm0.01$ CFU mL^{-1}, respectively ($p<0.05$). *Salmonella* organisms were found in the 0 week old water but absent in the 2, 4, 6 and 8 weeks old water. *Shigella* count ($62.33\times10^{2}\pm45.30$ CFU mL^{-1}) was highest in 4 week old water while the lowest ($11.0\times10^{3}\pm1.00$ CFU mL^{-1}) was found in 6 week old water ($p<0.05$). Zero week old water had the lowest significant ($p<0.05$) value of $0.35\times10^{4}\pm0.05$ CFU mL^{-1} for mesophilic bacteria and the highest value of $50.00\times10^{4}\pm10.0$ CFU mL^{-1} was recorded in the 8 weeks old water. Sides and bottom samples were contaminated with *coliforms*, *E. coli*, *Salmonella* and *Shigella* organisms. It was concluded that the variously stored well water samples were contaminated with bacteria and the values obtained were above the recommended standards by the World Health Organization (WHO).

Key words: Microbiological composition, well water, storage durations, broiler chickens

INTRODUCTION

Water like air is one of the most indispensable requirements in life. It is only when we are deprived of these substances that their value is appreciated (Dada, 1996). For human consumption and good health, water must be free from pathogenic organisms, poisonous minerals and organic substances (Hutchinson and Ridgway, 1977).

Generally it has been recommended that water which is safe for human consumption may be supplied to livestock (Pond *et al*., 1995). Since young rapidly growing birds typically consume twice as much water as feed, it is important to ensure that the water given them is clean and to a good extent, free of pathogens (Scott *et al*., 1982). The quality of water one gives to the animal is important, since water quality affects the health and productivity of birds (Okafor, 1985).

When bird performance declines or there is outbreak of diseases, most farmers are quick to attribute these problems to other factors with the least consideration to water as a possible predisposing factor. The cause of such problem may be bacterial diseases such as colibacillosis, salmonellosis, pseudomoniasis, clostridial enteritis and bacterial enteritis (Mangash, 2002). Water borne infections remain economically important in poultry production industry because it reduces the profitability of the business. Whatever may be the source of contamination, every time bird drinks the water, it is exposed to the microbial load and immune challenge.

Ideal water meant for profitable livestock production must, in addition to passing the tests of sight, smell and taste (sensory evaluation), pass the microbial and chemical composition test (Pond *et al*., 1995). Therefore, water microbiology is becoming increasingly important, not only to improve the quality of the product, but also to achieve an economic and trouble free storage period of water. This study was designed to assess the microbiological content (assay) of well water at different storage durations (0, 2, 4, 6 and 8 weeks old) through the

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determination of total coliform counts, indicator organisms of faecal pollution and characterisation of the isolated organisms.

Well water was chosen because it is the commonest source of water. Almost all poultry farms in Nigeria, draw water from wells because of its availability, proximity and low cost.

MATERIALS AND METHODS

Water storage: Black barrel-shaped plastic containers (300 L capacity) were procured for the conservation of well water for different storage durations (0, 2, 4, 6 and 8 weeks old). The conservation of water was done at the Teaching and Research Farm of the Federal College of Agriculture, Akure, Nigeria.

Collection of water samples: Water samples at the different storage periods were collected from each corresponding containers with bottles previously sterilized with sodium thiosulphate. The stopper with the neck of the bottle was wrapped with sterile aluminium foil to protect it from contamination during transportation. This was done early in the morning because it has been reported that coliforms in water can increase in significant number especially in warm polluted water (Richard *et al*., 1979). The water samples after collection were taken to the laboratory for analysis.

Sample collection using swab: Sterile swabs were used to sample the sides and bottom of the water containers used for storing the water to determine the prevalence of specific bacteria present in the samples. The swabs were taken to the laboratory, streaked on MacConkey agar and incubated at 37°C for 18 h. The resultant colonies were purified by sub-culturing on freshly prepared nutrient agar.

Enumeration of viable bacteria in water samples: The enumeration of viable bacteria count was done using plate count techniques (Talaro and Talaro, 1996). The water sample was diluted serially and plated on nutrient agar (NA) using spread plate technique. The inoculated NA plates were incubated at 37°C for 24 to 48 h after which the plates were observed for bacteria growth and numbers of colonies were counted using a colony counter: (Model SC.5 Stuart Scientific Company Limited, Great Britain).

Enumeration of coliform bacteria: The coliform bacteria were enumerated in the water samples using the Most Probable Number (MPN) technique (Department of Health and Social Security, 1969). This involved the presumptive, confirmed and completed test for coliform bacteria.

Test for *Streptococci*: *Enterococcus* presumptive broth and *Enterococcus* confirmatory broth were used to identify and confirm the presence of faecal *Streptococci* in all the water samples. The media were used in the same way as described for coliform bacteria but with the exception of Durham tube in the fermentation tubes. The turbidity after 24 hours of incubation in the fermentation tubes indicated the presence of faecal *Streptococci*. Portions of the positive tubes were streaked on Pbizer Selective *Enterococcus* Agar (PSEA) and the plates were incubated at 37°C for 24 h. Brownish-black colonies confirmed the presence of faecal *Streptococci*.

Selective isolation of *Salmonella* and *Shigella*: Water samples from the positive presumptive test obtained during Most Probable Number (MPN) test was used. Deoxycholate Citrate Agar (DCA) plates were skeptically streaked with water samples using a wire loop. The plates were incubated at 37°C for 24 h. To confirm that the isolates obtained were species of *Salmonella* or *Shigella*, isolated colonies on DCA plates were stabbed in the butt and streaked on Triple Sugar Iron (TSI) agar slant and incubated at 37°C for 24 h. After the incubation, *Salmonella* species changed the TSI from red to black colour due to production of hydrogen sulphide. Bacteria isolate were characterized by microscopy, colonial morphology and biochemical test. They were subsequently identified according to the criteria of Holt *et al*. (1994).

The results obtained were statistically analysed using analysis of variance (ANOVA) and where significant difference was observed, the means were compared using Duncan Multiple Range Test.

RESULTS

The results of the bacteriological investigations of the samples of well water at different storage periods (Fresh and 2, 4, 6 and 8 weeks old) are shown in Table 1-7. Table 1 shows the result of the most probable number (MPN) of coliform bacteria per 100 mL of water samples at different storage periods. The coliform counts (using MPN) showed that the fresh, 2, 4, 6 and 8 weeks old water had 100, 93, 62, 46 and 28 MPN/100 mL coliform counts, respectively.

Table 1: Coliform counts in well water samples at different storage periods

Age of water (week)	Most probable number (MPN) of Coliform Bacteria per 100 mL of water
0	96
2	93
4	62
6	46
8	28

The occurrence of indicator organisms of faecal pollution in samples at the different storage periods are presented in Table 2-5. The results (Table 2) showed that *Escherichia coli* were not found in 4, 6 and 8 weeks old water. The fresh and 2 weeks old water were contaminated with *E. coli* and the mean values were $1.80x10^4$±0.03 and $1.43x10^4$±0.01 CFU mL^{-1} which were significantly different ($p<0.05$).

The results of *Salmonella* and *Shigella* counts (CFU mL^{-1}) of water samples at different storage periods are shown in Table 3 and 4, respectively. Table 3 revealed that *Salmonella* organisms were found in fresh water but absent in the 2, 4, 6 and 8 weeks old water. There were significant differences ($p<0.05$) in the mean *Shigella* counts of water samples at different storage periods (Table 5). The highest *Shigella* count (62.33×10^3+45.35 CFU mL^{-1}) was obtained in the 4 weeks old water and this was followed by 2, 8, 0 and 6 week old water samples, respectively.

The results of the viable count of mesophilic bacteria in water at different storage periods are shown in Table 5. There were significant differences ($p<0.05$) in the viable pooled means count of mesophilic bacteria of water samples at different storage periods. Fresh water had the lowest significant ($p<0.05$) value of $0.35x10^4$+0.05 CFU mL^{-1} for mesophilic bacteria. Two weeks old water had $3.47x10^4$+1.29 CFU mL^{-1} which was significantly lower ($p<0.05$) than the four weeks old water count ($4.0x10^4$+2.65 CFU mL^{-1}). Six weeks old water had $27.53x10^4$+1.00 CFU mL^{-1} and eight weeks old water had $50.0x10^4$+10.00 CFU mL^{-1} mesophilic bacteria, respectively ($p<0.05$).

The occurrence of specific bacteria on the sides and bottoms of plastic drum used in conserving water at different storage periods is shown in Table 6. The analysis of result indicates that coliform bacteria were present in all the samples taken from the sides and bottom of each of the plastic containers, at different storage periods of 2, 4, 6 and 8 weeks. *Escherichia coli* were present in the swab samples taken from the sides and bottom of the plastic containers having the two weeks old water. *Salmonella* organisms were found in the swab samples taken from the sides and bottoms of all the plastic containers used to conserve water at different storage periods. Similarly, the swab samples taken from the sides and bottoms of the plastic containers having the 2, 4, 6 and 8 weeks old water were contaminated with *Shigella* organisms. All the plastic containers used in storing water at different storage periods, were contaminated with *Shigella* organisms (Table 6).

The biochemical and morphological characteristics of bacteria isolates present on the sides and bottoms of plastic containers used in conserving water at different storage periods are shown in Table 7 and 8, respectively.

Table 2: *Escherichia coli* counts (CFU mL^{-1}) of water samples at different storage periods

Treatments					
Quantity of water used	0 week	2 week	4 week	6 week	8 week
10 mL	0.6×10^4	0.30×10^4	-	-	-
1.0 mL	0.3×10^4	0.50×10^4	-	-	-
0.1 mL	4.5×10^4	3.50×10^4	-	-	-
Total	5.4×10^4	4.30×10^4	-	-	-
Mean	1.80×10^4±0.03[a]	1.43×10^4±0.01[b]	-	-	-

Means±Standard Deviation, Means with different superscripts within the row are significantly different ($p<0.05$)

Table 3: *Salmonella* counts (CFU mL^{-1}) of water samples at different storage periods

Treatments					
Quantity of water used	0 week	2 week	4 week	6 week	8 week
10 mL	13.0×10^2	-	-	-	-
1.0 mL	15.0×10^2	-	-	-	-
0.1 mL	10.0×10^2	-	-	-	-
Total	38.0×10^2	-	-	-	-
Mean	12.67×10^2±2.52	-	-	-	-

Means±Standard Deviation

Table 4: Occurrence of specific bacteria in the drums used in storing water at different periods

Storage length of water	Coliform	*Escherichia coli*	*Salmonella*	*Shigella*
Side swab 2 week	+	+	+	+
4 Week	+	-	-	+
6 week	+	-	+	+
8 Week	+	-	+	+
Bottom swab 2 week	+	+	+	+
4 Week	+	-	+	+
6 Week	+	-	+	+
8 Week	+	-	+	+

-: Not present, +: Present

Table 5: *Shigella* counts (CFU mL^{-1}) of water samples at different storage periods

Treatments					
Quantity of water used	Fresh	2 weeks	4 weeks	6 weeks	8 weeks
10 mL	10.0×10^3	20.00×10^3	10.00×10^3	12.00×10^3	15.00×10^3
1.0 mL	10.50×10^3	25.00×10^3	90.00×10^3	11.00×10^3	11.00×10^3
0.1 mL	15.0×10^3	19.00×10^3	87.0×10^3	10.00×10^3	13.00×10^3
Total	36.20×10^3	64.00×10^3	187.00×10^3	33.00×10^3	39.00×10^3
Mean	12.07×10^3±2.98[d]	21.33×10^3±3.21[b]	62.33×10^3±45.35[a]	11.0×10^3±1.0[e]	13.0×10^3±2.0[c]

Means±Standard Deviation, Means with different superscripts within the rows are significantly different ($p<0.05$)

Table 6: Viable counts of mesophilic bacteria in water samples (CFU mL^{-1}) at different storage periods

Treatments					
Quantity of water used	Fresh	2 weeks	4 weeks	6 weeks	8 weeks
10 mL	0.3×10^4	4.0×10^4	2.0×10^4	26.7×10^4	50.0×10^4
1.0 mL	0.4×10^4	2.0×10^4	7.0×10^4	27.8×10^4	60.0×10^4
0.1 mL	0.35×10^4	4.4×10^4	3.0×10^4	28.1×10^4	40.0×10^4
Total	1.05×10^4	10.4×10^4	12.0×10^4	82.6×10^4	150.0×10^4
Mean	$0.35\times10^4\pm0.05^e$	$3.47\times10^4\pm1.29^d$	$4.0\times10^4\pm2.65^c$	$27.53\times10^4\pm1.00^b$	$50.0\times10^4\pm10.00^a$

Means±Standard Deviation, Means with different superscripts within the rows were significantly different ($p<0.05$)

Table 7: Biochemical characteristics of bacteria isolates on the sides and bottoms of storage containers

Isolate code	Catalase	Coagulase	Starch hydrolysis	Gelation hydrolysis	Indole production	Urease activity	Citrate utilization	MP	VP	Glucose	Sucroce	Mannitol	Arabinose	Lactose	Mactose	Identity
1	+	NA	-	-	-	-	-	+	-	A	AG	A	AG	-	AG	*Salmonella gallinarum*
2	-	NA	-	-	-	-	-	-	-	-	-	-	-	-	A	*Shigella dysenteriae*
3	-	NA	-	+	-	+	-	-	+	A	A	AG	AG	-	AG	*Enterobacter Liquefaciens*
4	+	NA	+	-	+	+	+	+	-	A	-	AG	A	A	A	*Bacillus* spp.
5	+	NA	-	-	-	+	+	+	+	-	A	A	-	A	-	*Klebsiella edwardsii*
6	+	NA	+	+	-	+	+	+	-	A	A	A	A	-	AG	*Bacillus megaterium*
7	+	NA	-	+	-	-	+	+	-	A	-	A	-	-	-	*Bacillus brevis*
8	+	NA	-	-	-	-	-	+	+	A	A	-	-	-	-	*Bacillus coagulans*
9	+	NA	-	-	+	-	+	-	-	-	-	-	-	-	A	*Bacillus lentus*
10	+	NA	+	+	-	+	+	+	+	A	A	-	-	-	-	*Bacillus cereus*
11	+	NA	+	+	+	+	+	+		AG	-	AG	-	-	-	*Bacillus* spp.
12	+	-	-	-	+	-	+	+		A	-	-	A	A	-	*Staphylococcus* spp.
13	+	-	+	-	-	-	+	+	-	AG	-	AG	AG	AG	-	*Micrococcus* spp.

+: Positive, 1: Fresh, 7: 2 Weeks bottom, -: Negative, 2: 2 Weeks, 8: 4 Weeks side, AG: Acid and Gas produced, 3: 4 Weeks, 9: 4 Weeks bottom, A: Acid only produced, 4: 6 Weeks, 10: 6 weeks side, NA: Not Applicable, 5: 8 Weeks, 11: 6 Weeks bottom, 6: 2 Weeks side, 12: 8 Weeks side, 13: 8 Weeks bottom

Table 8: Colonial, morphological characteristics of bacteria isolates on the sides and bottoms of storage containers

Isolate code	Colour	Shape	Edge	Elevation	Opacity	Surface	Gram reaction	Shape	Arrangement	Spore location	Mortility	Probable Identity
1	Cream	Rhizoid	Rhizoid	Flat	Transparent	Rough/dry	-	Rod	Single	-	-	*Salmonella gallinarum*
2	Cream	Circular	Entire	Convex	Opaque	Mooth/glistering	-	Rod	Chains	-	-	*Shigella dysenteriae*
3	Cream	Circular	Lobate	Raised	Opaque	Smooth glistering	-	Rod	Chains	-	-	*Enterobacter liquefaciens*
4	Cream	Circular	Entire	Convex	Opaque	Smooth glistering	-	Rod	Single	+C	+	*Bacillus* spp.
5	Cream	Circular	Entire	Convex	Opaque	Smooth glistering	-	Rod	Single	+C	-	*Klebsiella edwardsii*
6	Cream	Irregular	Lobate	Flat	Transparent	Smooth glistering	-	Rod	Single	+C	+	*Bacillu megaterium*
7	Cream	Irregular	Lobate	Flat	Transparent	Smooth glistering	-	Rod	Chains	+C	+	*Bacillus brevis*
8	Cream	Irregular	Rhizoid	Flat	Transparent	Dry Smooth	-	Rod	Single	+C	+	*Bacillus coagulans*
9	Cream	Irregular	Entire	Flat	Opaque	Smooth glistering	-	Rod	Single	+C	+	*Bacillus lentus*
10	Cream	Irregular	Fimbrate	Raised	Opaque	Smooth glistering	-	Rod	Single	+C	+	*Bacillus cereus*
11	Cream	Irregular	Fimbrate	Raised	Opaque	Smooth glistering	-	Rod	Single	+C	+	*Bacillus* spp.
12	Cream	Circular	Crenated	Convex	Opaque	Smooth glistering	-	Rod	Single	-	-	*Staphylococcus* spp.
13	Cream	Circular	Crenated	Convex	Opaque	Smooth gllistering	-	Rod	Single	-	-	*Micrococcus* spp.

+: Positive, -: Negative, C: Coci

The results revealed that *Salmonella gallinarum* was present in the 0 week old water. The two week old water contained *Shigella dysenteriae*. *Enterobacter liquefaciens* was recovered from the four week old water. *Bacillus* species were found in six weeks old water. The eight weeks old water contained *Klebsiella edwardsii*. *Bacillus megaterium* was obtained from the swab taken from the bottom of the plastic containers containing the two week old water. *Bacillus brevis* was found on the side of the plastic drum containing four week old water. The swab taken from the bottom of four week old water contained *Bacillus coagulans*. *Bacillus lentus* was found on the swab taken from the side of the plastic containers having 6 week old water.

The swab taken from the bottom of the plastic container used in storing six week old water contained *Bacillus cereus*. *Staphylococcus* species was present in the swab taken from the sides of the plastic containers having eight week old water. Also, the swab samples taken from the bottom of the plastic containers used to conserve water for eight week were contaminated with *Micrococcus* species.

DISCUSSION

The result of the microbiological analysis reveals the presence of bacteria in the variously stored water samples. Water samples from 0, 2, 4, 6 and 8 weeks old water had high coliform bacterial load (CFU mL^{-1}) compared with the standard value of zero count of faecal coliform per 100 mL. Also, the swab samples taken from the sides and bottom of the plastic containers used in storing water at different storage periods were found to be contaminated with coliform bacteria (Table 4 and 6). This implies that well water samples are probably contaminated and unsafe for drinking. The well water might have been contaminated from sewage treatment fields, resulting from poor well construction or poor maintenance, if well is not properly protected from surface drainage (Macrae *et al*., 1993).

The occurrence of coliform bacteria in the swab samples taken from the sides and bottoms of the various plastic containers used in storing water further confirms the level of pollution of the well water. WHO (1984), reported that coliforms are regarded as presumptive indicators of pollution and if found in drinking water, the water contain faecal contaminants and unsafe for use. The density of coliform group determines the degree of pollution and is used to judge the level of sanitary quality of water (David, 2001). Moreover, the source of water used for this study was a well, not treated with chlorine. Coliform bacteria tend to be sensitive to chlorine and cannot survive longer in chlorinated water (Winblad *et al*., 1980). The study shows that coliform bacteria counts decreased with increasing water storage duration (Table 1). This could be attributed to the fact that coliform bacteria do not live long in water (Macrae *et al*., 1993). The results obtained from this study revealed the presence of *Escherichia coli, Salmonella* and *Shigella* species in the water samples (Table 2, 3 and 4). These results are in line with those of Wheather *et al*.(1980) and Okafor (1985) who reported the recovery of conventional indicator bacteria from drinking water. According to standard bacteria quality of potable water (WHO, 1997), no sample should contain more than one *E. coli* per 100 mL of water. The mean values ($1.80\times10^{4}\pm0.03$ and $1.43\times10^{4}\pm0.01$CFU mL^{-1}) of *E. coli* in this study were higher than the stipulated limit recommended by the World Health Organisation (WHO, 1985), for potable water.

The higher value of *E. coli* obtained in this study might be as a result of the water source which was not routinely treated. *E. coli* had been reported not to survive in treated water (Macrae *et al*., 1993). The presence of *E. coli* in fresh and two weeks old water showed that they could have been contaminated by faeces of human or animal origin (Farmer, 1987). Contamination by human faeces or animal excrement was the greatest danger associated with drinking water (Olutiola *et al*., 1991). The occurrence of *E. coli* in the water samples agrees with the findings of Mentzing (1981) who reported the isolation of enteropathogenic *E. coli* in well water. The presence of *E. coli* in well water could be as a result of extensive use of the area where the well was sunk by livestock for grazing and watering. Similar observation was made by Adesiyun *et al*. (1983) who reported high faecal coliform counts in water from unprotected wells close to where animal grazes. However, *E. coli* was not found in the four, six and eight week's old waters as well as the swab taken from the sides and bottoms of the respective plastic containers used to conserve these waters (Table 2 and 6). This might be as a result inadequate nutrients in these water samples to support the growth of these organisms (Olutiola *et al*., 1991).

Salmonella organisms were found only in the 0 week old water sample (Table 3) and the swab samples taken from the sides and bottoms of the plastic containers used in storing the water (Table 6). This observation agrees with the findings of Saitanu *et al*. (1999), who isolated *Salmonella typhimurium* in well water. The occurrence of *Salmonella* organisms in the 0 week old water could be attributed to the fact that *Salmonella* organisms thrive well in polluted and untreated water source (Poppe *et al*., 1986). However, *Salmonella* organisms were not found in the two, four, six and eight week old water. This could be adduced to the fact that *Salmonella* organisms get destroyed after three week in water (Seifert, 1992). The isolation of *Salmonella* organism from water samples has serious public health implications as this organism is the cause of dreadful zoonotic diseases. It causes typhoid fever, gastro-enteritis and diarrhoea (Olutiola *et al*., 1991). Poultry meat and eggs represent the most important food sources of *Salmonella*e to man (Cowden *et al*., 1989; Humphrey, 1990).

The study also revealed the presence of *Shigella* organisms in the water samples and the swabs taken from the sides and bottoms of the plastic containers used in storing the water (Table 4 and 6). The occurrence of *Shigella* organisms in the water samples is in line with the findings of Dragas and Tratnik (1975), who reported the recovery of *Shigella flexneri* in well water. The occurrence of *Shigella* organisms in well water could be due to the impurities in the soil, microorganisms and eggs of insects which may have been washed down into the well water through surface run-off (Ross, 1979). Most bacteria in this category are very pathogenic to man and other animals. *Shigella* species, especially *S. dysenteriae*

have been commonly identified as the causes of acute diarrhoea (Bacillary dysentery) in poultry and infection can be occasionally contacted via water contaminated by human feaces (Christopher, 2002).

Moreover, the study revealed the presence of Mesophilic bacteria in the water samples (Table 6). This agrees with the report of David (2001) which stated that mesophilic bacteria such as *Bacillus* and *Clostridium* species are commonly found in polluted and untreated water sources and their presence in water indicates sewage pollution of long duration. The prevalence rate of mesophilic bacteria in the water samples was found to be increasing with successive increase in the storage periods (Table 6). This could be due to the fact that the spores of the mesophilic bacteria will survive in water for a long time and persists when all other faecal bacteria have gone (David, 2001).

A variety of water borne disease outbreaks have been attributed to untreated or poorly treated ground water containing pathogenic forms of bacteria (Geldreich, 1981).The biochemical and morphological characteristics of bacteria isolates (Table 7 and 8) revealed the occurrences of bacteria in the different swab samples taken from the sides and bottoms of the plastic containers used to store water. *Enterobacter liquefaciens* was found in the four weeks old water. The occurrence of *E. liquefaciens* in the water samples corroborates with the report of Tortora *et al.* (2000), who stated that *E. liquefaciens* are common inhabitants of untreated water, sewage and soil. *E. liquefaciens* can cause urinary tract and hospital-acquired infections (Pipes, 1981). Bacteria of the genus, *Bacillus* had been reported to be common in the soil (Cowan and Michie, 1978). This may explain the occurrences of the different *Bacillus* species found in the water samples and in the respective swabs taken from the side and bottoms of most of the plastic containers used in storing water, since the water source was a well.

Bacteria of the genus *Bacillus*, produce endospores and could be pathogenic to human (Bekemeyer and Zimmerman, 1985). For instance, *Bacillus megaterium* had been incriminated with the formation of gas, rancidity and separation of fatty foods (Frazier and Westhoff, 1991). *Bacillus brevis*, cultured from soil, had been reported to be involved in the production of two antibiotics called gramicidine and thyrocidine (Tortora *et al.*, 2000). *Bacillus coagulans* causes canned food spoilage (Baron and Finegold, 1990). *Bacillus lentus* had been implicated in food poisoning (Pennington *et al.*, 1976). *Bacillus cereus* has long been known as an important cause of food poisoning.

Some of the serious infections of *B. cereus* had been incriminated with septicaemia, endocarditis, necrotizing pneumonia, meningitis and wound infections (Bekemeyer and Zimmerman, 1985). *Klebsiella* organisms have been reported to be common in natural habitats worldwide, including soil and water (Tortora *et al.*, 2000). Miller and Farmer (1987), isolated *K. terrigena* from well water. *K. terrigena* are the predominant facultative flora in the human bowel, a site from which they can easily be disseminated. Lapses in personal hygiene, especially during periods of diarrhoea disease, can contribute to the feacal-oral route of transmission of the agents of gastro-enteritis and related diseases (Bamba, 1982). Countries with poor sanitation systems are more likely to have environmental reservoirs of the *K. terrigena*, from which disease is maintained in the population (Bamba, 1982).

Staphylococcus organisms are commonly found on the surface of primates and other mammals. Their presence as endogenous flora allows many species of *Staphylococci* the opportunity to cause infection under certain circumstances (Baron and Finegold, 1990). Some characteristics of *Staphylococci* account for their pathogenicity which explains why they can grow and survive in nasal secretion and on skin (Tortora *et al.*, 2000). Micrococci are widespread in nature but had been isolated most often from dust and water (Frazier and Westhoff, 1991). They are rarely identified as causes of infection (Falks and Guering, 1983).

CONCLUSION

The results of the microbiological analyses revealed the presence of bacteria in the variously stored well water samples. The well water samples either fresh or stored had bacteria load above the standard value recommended by W.H.O. suggesting better siting and management of wells.

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