Effects Of Containers And Storage Conditions On Bacteriological Quality Of Borehole Water

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ABSTRACT: Water from a borehole was collected into tap-fitted plastic buckets of different colours. A set of the buckets were stored indoor while duplicate were stored outdoor. The atmospheric conditions as indicated by sky condition, relative humidity, total radiation and aerosol optical depth were monitored during the storage period. The effects of colour of the container and storage conditions on the bacteriological quality of the stored water were studied by examining physicochemical (pH, temperature and total suspended solids) and bacteriological parameters (total bacterial count and total coliform count) indicative of water quality during the storage period. The atmosphere was generally cloudy with high relative humidity, while total radiation and aerosol optical depth were low; hence temperatures indoor and outdoor were not significantly different. The total suspended solid content and total heterotrophic bacterial counts declined with storage; decrease in bacterial counts was more pronounced in the transparent buckets stored outdoor. Eight bacterial species: *Bacillus subtilis, Citrobacter diversus, Enterobacter aerogenes, Klebsiella pneumonia, Micrococcus luteus, Proteus vulgaris, Pseudomonas aeruginosa* and *Staphylococcus aureus* were isolated; three of them survived the indoor and outdoor storage. [Nature and Science. 2007;5(4):1-6].

Keywords: borehole, radiation, aerosol optical depth, sky condition, relative humidity

INTRODUCTION

The supply of water in terms of quality, quantity, when and where it is needed continues to generate concerns. It plays a significant role in socio-economic development of human populations (Micheal, 1998). The erratic supply of piped water has occasioned the sourcing of water from underground sources. Groundwater sources: wells, boreholes and springs; that are properly located produce water of very good quality (Gerald *et al.,* 1992). However, it must not be taken for granted that groundwater will always meet the WHO standards for drinking water. Rogbesan *et al.* (2002) reported heavy bacterial load in water from some boreholes in Ilorin, Nigeria.

The erratic nature of piped water supply has made water storage a common practice among individuals and households, especially in areas where there is pressure on available water source. Maggy *et al.* (2003) indicated that the duration of storage affected the microbiological quality of stored ground water. Similarly, Olayemi *et al.* (2005) and Eniola *et al*. (2006) highlighted the importance of a few days of indoor storage in improving the physical and microbiological quality of water. In many communities in Nigeria, it is common to pump ground water into overhead storage-tanks. The most common household reservoirs are plastic tanks, usually of different colours, placed outdoor.

The outdoor location of the water tanks exposes them to solar radiation. In addition to generating heat, many forms of radiations are harmful to microorganisms. Low levels of ionizing radiations will produce mutations and may indirectly result in death, whereas higher levels are directly lethal. Even visible light, when present in sufficient intensity can damage or kill microbial cells (Prescott *et al.,* 1999). The amount of radiation available is affected by aerosol optical depth and cloud parameters (Sekiguchi *et al*., 2003). Climatic condition is affected by scattering or adsorption of radiation by aerosols, scattering of shortwaves, adsorption of solar and longwave radiations (King *et al*., 1999; Penner, *et al*., 2002; Takemura *et al*., 2002).

This study is an investigation of the effect the colour of container and condition of storage (indoor and outdoor) on the bacteriological quality of borehole water. Atmospheric conditions (the relative humidity, aerosol optical depth, total radiation sky condition and temperature) as well as physicochemical (pH, temperature, and total suspended solids) and bacteriological (total bacterial and total coliform counts) parameters indicative of water quality were examined at interval of four days.

MATERIALS AND METHODS

Sample collection and Storage.

Water was obtained from a borehole within the main campus of University of Ilorin, Ilorin into disinfected tap-fitted coloured (Green, red and transparent) plastic buckets as described by WHO (1997). A set of buckets of the three colours was stored indoor in the Environmental and Public Health Research (EPHR) laboratory of the Department of Microbiology, University of Ilorin. A duplicate set of the buckets was stored outdoor at the Baseline Surface Radiation Network (BSRN) station in the Department of Physics, University of Ilorin. The water samples were stored for 12 days and samples taken for analysis at an interval of 4 days.

Atmospheric condition, Physicochemical and Bacteriological Parameters.

The temperature and relative humidity were monitored by HMP45C temperature and relative humidity probe at the BSRN station, Ilorin Nigeria (8^o 28'N, 4^o 38'E to 8^o 31'N, 4^o 40'E). The sky condition was taken by the Synoptic observation. The aerosol optical depth and radiation were taken using Microtops II Sun photometer. The pH and total suspended solid content were determined as described by American Society for Test and Measurement Standards (1988). The total heterotrophic bacterial counts were determined by Standard plate Count (SPC) method employing the pour plate technique (APHA, 1990). The total coliform count was determined as Most Probable Number (MPN) using the multiple tube fermentation test (Olutiola *et al.,* 1991). The isolates were characterized on the basis of colonial morphology, cellular characters, staining reactions and biochemical tests (Olutiola *et al.,* 1991). They were subsequently identified using Cowan and Steel's Manual for the identification of Medical Bacteria (Barrow and Feltham, 1995).

RESULTS

Table 1 shows the atmospheric conditions during the storage period. The relative humidity ranged between 81.08 and 85.08, total radiation ranged from 156 to 196 Wm^{-2}. Variations in pH and temperature of the water samples during storage are shown in Tables 2 and 3. The pH ranged between 6.54 and 7.90, while the temperature ranged between 23.5 and 29^OC. The total suspended solids contents varied from 1.40 x 10^{-2} to 1.73 x 10^{-2} g/ml (Table 4). Total heterotrophic bacterial (THB) count ranged between 5 x 10^2 and 64 x 10^2 cfu/ml (Figure 1). The total coliform count of the borehole water was zero prior to storage. A total of eight (8) bacterial species: *Bacillus subtilis, Citrobacter diversus, Enterobacter aerogenes, Klebsiella pneumonia, Micrococcus luteus, Proteus vulgaris, Pseudomonas aeruginosa* and *Staphylococcus aureus* were encountered (Table 3). Their successions in the water samples during the storage period are shown in Table 4. Three of them survived the 12 days of indoor and outdoor storage.

Table 1. Atmospheric Condition during Storage Period

Storage period (Days)	Atmospheric Condition				
	Relative humidity (%)	**Sky condition**	**Aerosol Optical depth**	**Total Radiation (Wm^{-2})**	**Temperature (^{o}C)**
0	85.08	Cloudy	0.55	190	33
4	81.87	Cloudy	0.56	156	34
8	81.08	Cloudy	0.55	196	31
12	83. 84	Cloudy	0.63	190	32

Table 2. Variations in pH of water samples during storage

Storage period (Days)	**pH**					
	Green Bucket		**Purple Bucket**		**Transparent Bucket**	
	Indoor	**Outdoor**	**Indoor**	**Outdoor**	**Indoor**	**Outdoor**
0	6.54	6.54	6.54	6.54	6.54	6.54
4	6.60	6.82	6.61	6.81	6.60	6.81
8	7.30	7.40	7.20	7.60	7.00	6.80
12	7.40	7.80	7.80	7.90	7.80	7.90

Table 3. Variations in Temperature of water samples during storage

Storage period (Days)	**Temperature**					
	Green Bucket		**Purple Bucket**		**Transparent Bucket**	
	Indoor	**Outdoor**	**Indoor**	**Outdoor**	**Indoor**	**Outdoor**
0	29.0	29.0	29.0	29.0	29.0	29.0
4	25.0	28.0	25.5	28.8	25.4	28.0
8	24.3	26.0	24.5	26.1	24.0	26.0
12	23.5	24.0	23.5	24.0	23.8	24.5

Table 4. Succession of Bacteria in water samples during storage

Bacterial Isolates	**Occurrence of Bacterial Isolate**																							
	Green Bucket								**Purple Bucket**								**Transparent Bucket**							
	Indoor				**Outdoor**				**Indoor**				**Outdoor**				**Indoor**				**Outdoor**			
	0	**4**	**8**	**12**	**0**	**4**	**8**	**12**	**0**	**4**	**8**	**12**	**0**	**4**	**8**	**12**	**0**	**4**	**8**	**12**	**0**	**4**	**8**	**12**
Bacillus subtilis	+	+	-	-	+	-	-	-	+	+	-	-	+	-	-	-	+	+	-	-	+	-	-	-
Citrobacter freundii	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Enterobacter aerogenes	+	+	+	-	+	+	+	-	+	+	+	-	+	+	+	-	+	+	+	-	+	+	-	-
Klebsiella pneumonia	+	+	+	-	+	+	-	-	+	+	+	-	+	+	-	-	+	+	+	-	+	-	-	-
Micrococcus luteus	+	+	-	-	+	+	-	-	+	+	-	-	+	+	-	-	+	+	-	-	+	-	-	-
Proteus vulgaris	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pseudomonas aeruginosa	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Staphylococcus aureus	+	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-

Key: +: Present; -: Absent

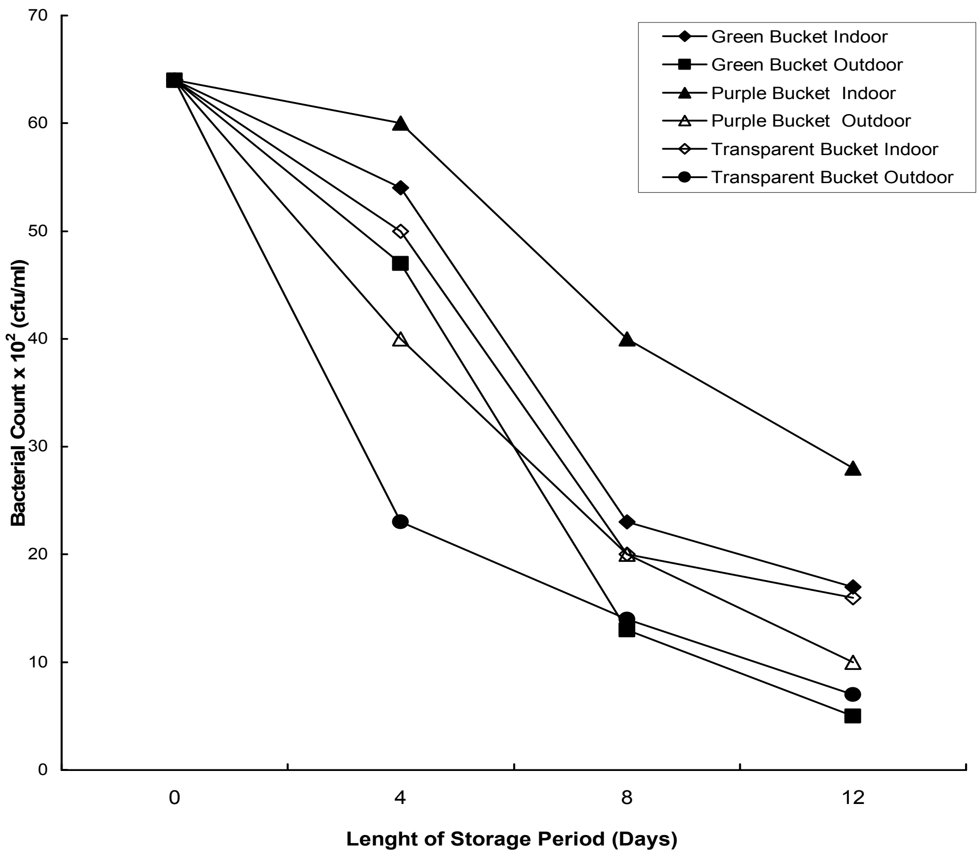

Figure 1. Variation in Total Bacterial Count during Storage.

DISCUSSION

The cloudy nature of the atmosphere during the storage period suggests possible absorption of radiation; the low aerosol optical depth suggests low scattering of radiation; hence more radiation is likely to reach the earth. The high relative humidity and cloud cover will result in high temperature due to retention of longwave radiations by water vapour (Penner *et al*., 2002; Takemura *et al*., 2002). The resultant effect is that there is no significant temperature gradient between indoor and outdoor conditions. This is further reflected in the temperature of the stored water samples (Table 2). Statistical analysis indicates a strong positive correlation between the relative humidity and temperature of the samples (r= 0.8647).

The pHs falls within the range that would favour bacterial proliferation (Atlas, 1995). The observed increases in pH during storage could be due to the activities of the resident flora and or their death, which results in the release of inorganic substances such as ammonia (Rogbesan *et al.,* 2002). The progressive reduction in suspended solid content is similar to the observations of Olayemi *et al*. (2005) and Eniola *et al*. (2006). It has been attributed to gravitational pull, which causes suspended materials to settle out of the water over time. It is likely that if the time of storage is increased, all suspended materials present in the water could settle out under gravitational pull. This is probably the basis for the influence of storage on bacteriological quality of water as observed by Maggy *et al*. (2003).

The zero total coliform count shows the borehole is free of fecal contamination, contrary to the observation by Rogbesan *et al.* (2002) that water from this borehole contained coliforms exceeding the WHO (2004) standard required of untreated drinking water. This is suggestive of an improvement in the handling of the borehole and its catchment. The presence of *Citrobacter freundii, Proteus vulgaris* and *Pseudomonas aeruginosa* in the water however shows it is not fit for consumption. *Pseudomonas aeruginosa* is an opportunistic pathogen. Members of the genus *Proteus* and *Citrobacter* are common causes of bladder, kidney and other body infections (Stanier *et al.,* 1987).The WHO (1996) standard requires that water intended for drinking should be free of pathogens and bacterial indicative of faecal contaminaation.

The reduction in population of total bacteria as the day of storage increased in similar to the observation by Payment *et al* (1985). Decline in the bacterial population can be attributed to death of the resident bacteria during the storage period due to depletion of nutrients (Olayemi *et al.,* 2005). Reduction in the bacterial load was more prominent in buckets stored outdoor. This is attributable to direct radiation from sunlight on the buckets outside. Among those outdoor, penetration by radiations would be more pronounced in the transparent bucket. Sedimentation of suspended material in the water due to gravitational force could also contribute to the decline in bacterial populations (Salle, 1973; Eniola *et al.*, 2006). It is possible in such a situation that the organisms remain in the biofilm produced. The survival of *Citrobacter freundii, Proteus vulgaris* and *Pseudomonas aeruginosa* after 12 days of storage portends some dangers to consumers of the water due to their pathogenic nature (Stanier, *et al*., 1987).

This study buttress that storage is valuable as a preliminary accessory stage of treatment but it cannot be relied on as a sole measure of purification. The colour of the bucket and fluctuation in light and radiation are also importance. There was no significant difference in effect of the different colour of buckets. This is attributable to cloud cover that creates a uniform temperature condition. In conclusion, outdoor storage of water in light coloured container was found to be desirable. It is therefore recommended that borehole water could be stored outdoors in light coloured container for about 10 to 14 days.

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