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EFFECT OF STORAGE ON BACTERIOLOGICAL QUALITY OF BOREHOLE WATER

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The effect of storage on the bacteriological quality of water from a borehole was investigated. Water samples drawn from the borehole were stored in covered tap-fitted buckets of different colours at room temperature. Physicochemical parameters (pH and suspended solids contents) as well as bacteriological parameters (total bacterial and total coliform counts) were monitored over 12 days of storage. Generally, there was an increase in pH during storage. Their suspended solid content reduced by 75.0%, 92.3% and 40.0% during storage in the purple, blue and transparent buckets respectively. A total of eleven bacterial species were isolated at onset but only three of them: *Pseudomonas aeruginosa, Escherichia coli*, and *Proteus vulgaris* survived till the twelfth day of storage. There was also reduction in the total bacteria count by 82.5%, 83.35%, and 58.82% from an initial 17 x 10^4 CFU/ml during storage in the purple, blue and transparent buckets respectively. The total coliform count decreased by 99.18%, 82.35% and 91.36% in purple, blue and transparent buckets respectively from an initial 1100 MPN/100ml during the period of storage. The significance of storage as a means of enhancing water purification was discussed and suggestion provided on proper storage of water intended for drinking.

INTRODUCTION

Since the beginning of recorded history, water has been recognized as a potential carrier of disease [1]. It has been suggested that drinking water should be aesthetically acceptable; it should be free from apparent turbidity and odour, and from any objectionable taste [2]. The World Health Organization guidelines for bacteriological water quality recommends that all waters intended for drinking should contain no coliform organisms in any 100ml sample taken and should be free from all hazardous odour as well as being tasteless [3].

It is usually taken for granted that piped water supplies received in homes and institutions satisfy this requirement. The irregularity of piped water supply has however made it necessary to seek alternative water sources. This is found in rainwater and groundwater such as wells and boreholes. The contribution of groundwater to the total water supply is greatest in arid and semi arid region and in some places where geological conditions favour groundwater storage [4]. Although ground water especially from deep sources are considered free of bacterial contamination, some study [5] have found that water from some boreholes do not meet the WHO standard for drinking water. This gives credence to the assertion that no water in nature is 100% pure [6].

It is common practice for individuals and households to store water for domestic use especially where there is pressure on the water source. It was reported that a few days of storage of surface water would improve the physical and microbiological characteristics of the water [7]. In water treatment, storage is valuable as a preliminary step to other processes, because it reduces the bacterial content of the raw water and also reduces the amount of suspended matter in it. However, it cannot be relied on as sole measure of purification. Storage acts in three ways; sedimentation, equalization, devitalization [8].

Several individuals and households collect water from boreholes into various types of container especially plastics. The collected water is usually stored sometimes for as long as two weeks depending on the size/number of collecting containers and/or the size of consumers. The storage of water could serve in checking the outbreaks of diseases associated with drinking of contaminated water.

This study investigates the effect of storage on the bacteriological quality of borehole water over a period of 12 days. In assessing the effect of storage, the total bacterial count, and total coliform count were examined at interval as well as some physicochemical parameters (pH, temperature and total suspended solids).

MATERIALS AND METHOD

Plastic buckets with lids were fitted with plastic tap at 5cm from the base. They were rinsed with 70% alcohol and then with sterile distilled water. Water was drawn from the borehole between the academic area, students' village and bus stop in University of Ilorin (Permanent Site) following the procedure described by WHO [3]. The buckets were carefully opened and filled with water to about 3cm from the top. They were tightly covered and moved into the laboratory for storage at room temperature in a stationary position. Samples of the water in each bucket were collected through the tap following the procedure of WHO [3]. The pH and suspended solids content of the water samples were determined according to the American Society for Test and Measurement Standards [9], while the total heterotrophic bacterial counts were determined using the pour plate method [10]. The total coliform counts were determined as Most Probable Number (MPN) using the multiple tube fermentation tests [11]. Bacterial species isolated were characterized and identified as described in Bergey's manual of determinative bacteriology [12].

RESULTS

The initial pH of the water samples was 5.5 however it increased during storage. Variation in mean pH of the samples is shown in Figure 1. Variation in the mean suspended solids content is shown in Figure 2. The initial mean value of 16×10^{-2} was reduced by 75.0%, 92.3%, and 40.0% during storage in the purple, blue and transparent buckets respectively. Eleven bacterial species were isolated initially, but as storage progressed it was observed that some bacterial species were not encountered subsequently and only three of them were recovered at the end of 12 day of storage.

Table 1 shows the identity of the bacterial species and their succession during storage. Reduction was recorded in the total bacterial counts and total coliform counts. Figure 3 shows the variation in the total bacterial and total coliform counts. Reduction in the total bacteria count was 82.35%, 83.35% and 58.82% from an initial 17×10^4 CFU/ml for the purple, blue and transparent buckets respectively. The reduction in total coliform count was 99.18%, 82.35% and 91.36% in purple, blue and transparent buckets respectively from an initial 1100 MPN/100ml.

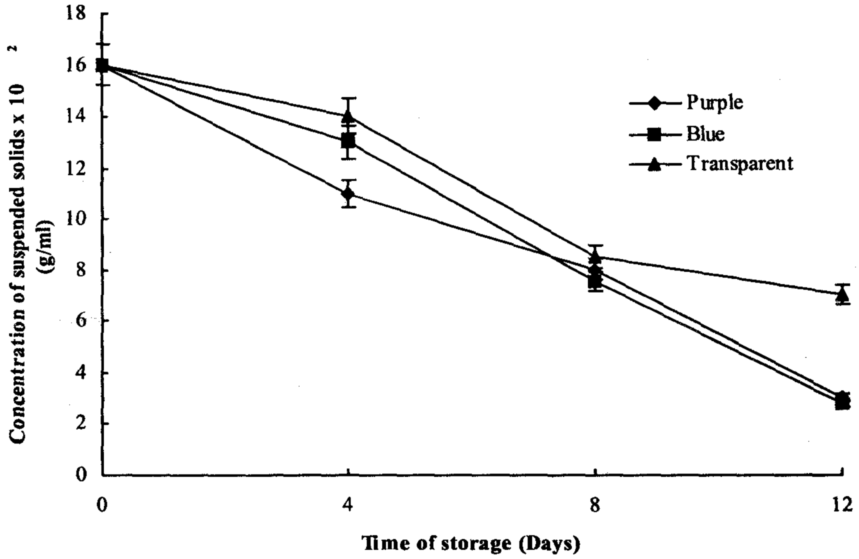

Figure 2. Change in mean suspended solid content of the water during storage.

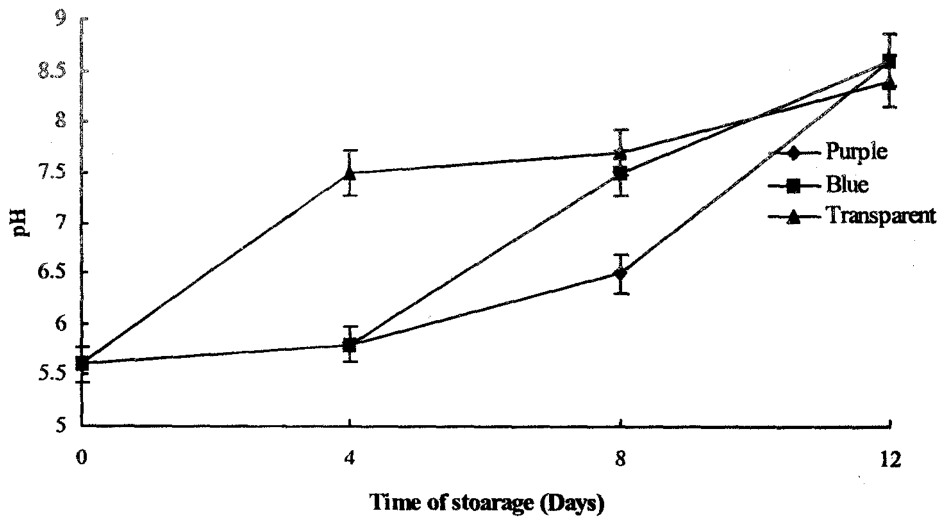

Figure 1. Change in mean pH of water during storage.

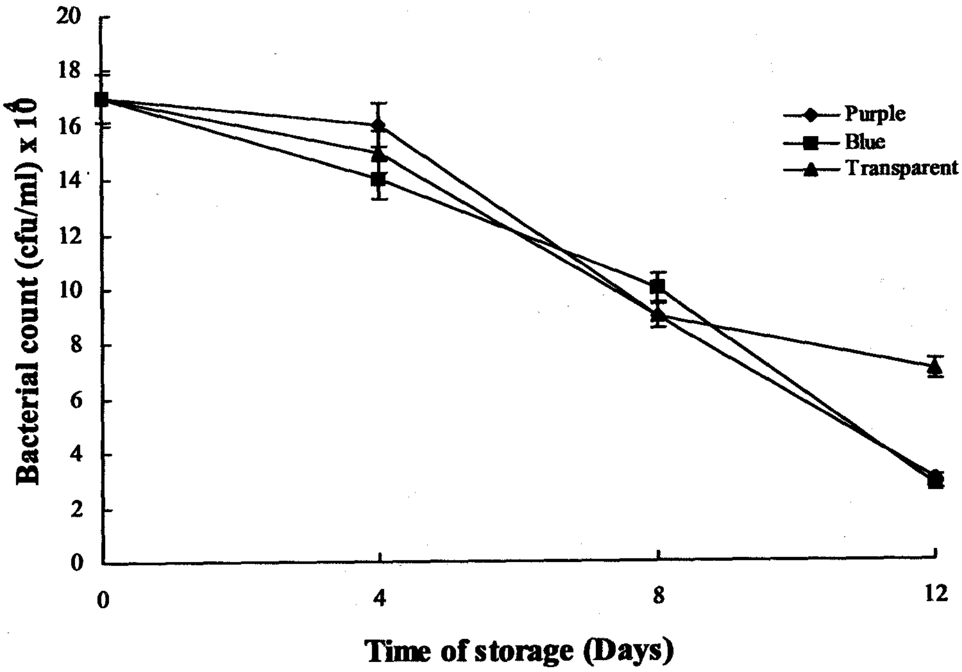

Figure 3. Variation in mean total bacterial count during storage

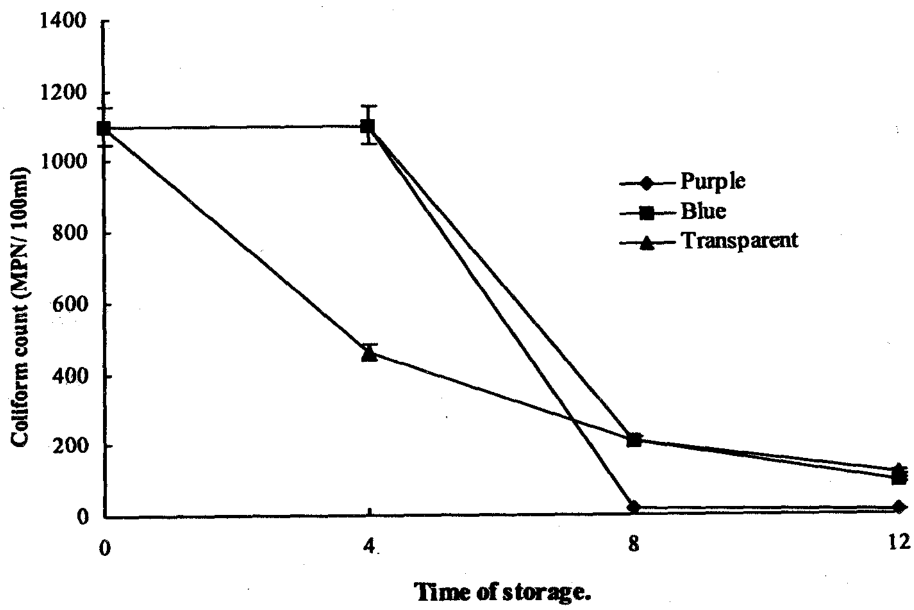

Figure 4. Variation in mean total coliform count during storage.

Table: Microbial succession in borehole water during storage

Isolate	Purple Bucket				Blue Bucket				Transparent Bucket			
Days	0	4	8	12	0	4	8	12	0	4	8	12
Acinectobacter spp	+	+	+	-	+	+	+	-	+	+	-	-
Micrococcus luteus	+	-	-	-	+	-	-	-	+	-	-	-
Serratia marcescens	+	+	-	-	+	+	-	-	-	-	-	-
Klebsiella pneumoniae	+	+	+	-	+	+	+	-	-	+	-	-
Bacillus cereus	+	+	-	-	+	+	-	-	-	-	-	-
Enterobacter aerogenes	+	+	+	-	+	+	+	-	-	+	+	-
Pseudomonas aeruginosa	+	+	+	+	+	+	+	+	+	+	+	+
Staphylococcus aureus	+	-	-	-	+	-	-	-	-	-	-	-
Escherichia coli	+	+	+	+	+	+	+	+	+	+	+	+
Proteus vulgaris	+	+	+	+	+	+	+	+	+	+	+	+
Shigella dysenteriae	+	+	+	-	+	+	+	-	+	+	-	-

DISCUSSION

The pH of the samples fell within the range of pH of water, which favours survival of bacteria. The importance of pH in the survival of microorganisms has been identified [13]. The observed increased in pH during storage could be due to activities of the resident flora and or their death, which result in the release of inorganic substance such as ammonia; this has been highlighted [5]. The observed progressive reduction in suspended solid content is consistent with the submissions of some researchers [14]. This is attributed to gravitational pull, which will cause the suspended materials to settle out with time.

The population of total bacteria and total coliform progressively dropped suggesting death of the resident bacteria during the storage period. Death of bacteria could occur due to depletion of nutrients. The decline in bacterial population could also result from sedimentation of suspended material in the water, which would include suspended bacterial cells. Sedimentation has earlier been identified as one of the ways by which storage act in reducing the bacterial content of water [8].

Eight of the eleven bacterial species isolated were not encountered after the storage period. *Pseudomonas aeruginosa, Klebsiella pneumoniae, Staphylococcus aureus, Shigella dysenteriae, Bacillus cereus, Enterobacter aerogenes,* and *Escherichia coli,* which were isolated, are well established as either pathogens or opportunistic pathogens. In addition, the presence of *Escherichia coli* is a well established index of faecal contamination. The presence of these organisms is a further confirmation of the report [5] that the water from the borehole fell short of the standard required of untreated drinking water as stipulated by the World Health Organization (WHO). Among the seven potential pathogens, only *Escherichia coli* and *Pseudomonas aeruginosa* survived to the twelfth day of storage.

Results obtained buttress the opinion that storage is valuable as a preliminary accessory stage of treatment but it cannot be relied on as a sole measure of purification [7]. A difference was observed in the rates of reduction of the suspended solids, total bacterial and total coliform counts among the different coloured buckets. The reason for this is not yet known, however, the colour of the bucket is considered an important factor. To verify this, a collaborative study is being planned with colleagues in the Department of Physics of this institution to monitor the changes in the light or optical properties of the colours.

CONCLUSION

Generally, storage was found to be desirable as it brought about improvement in the quality of the water sample, reducing the types and number of bacteria in the water. It is therefore suggested that water drawn from the borehole should be stored for about a week if it is to be consumed.

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