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Analysis of Bacteriological and Physico-Chemical Quality of Potable Water of Bedesa Town, Wolaita Zone, Southern Ethiopia

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Abstract
This study was conducted in Bedesa town, Wolaita zone, southern Ethiopia to assess the bacteriological and physico-chemical quality of potable water of the town. For this study, 195 households were selected by using systematic random sampling technique. Both primary and secondary data sources were used in this study. For primary data collection, household surveys, key informant interview, focus group discussion and field survey were used as tools to collect the necessary information. For secondary data collection, document review was used to collect valuable information. Water quality sampling point of the town was prepared using Arc GIS 9.2 software. The data from the respondents were analyzed using descriptive statistical techniques and explanation building. Accordingly, one way ANOVA was employed to see the statistical significances of the variables at 5% significant level. The laboratory result revealed that the average values for all selected physico-chemical water quality parameters such as pH, EC, turbidity, TDS, total hardness, iron, phosphate, NH_3, fluoride, free chlorine residue and chloride were found within the acceptable limits of WHO and Ethiopian water quality standards. But, the mean value of temperature for source, reservoir, pipeline and household container were beyond the recommended WHO value (<15℃); the laboratory result of bacteriological water quality for all sampling sites were in agreement to the WHO and Ethiopian standard of potable water quality. The major strategies for maintaining water quality in the study area are protecting the existing water source from pollution and carrying out integrated watershed management activities.
Keywords: Bacteriological quality, physico-chemical quality, potable water: Bedesa.

1. INTRODUCTION

Water is a natural resource of fundamental importance. It supports all forms of life and creates jobs and wealth in the water sector, tourism, recreation and fisheries (Ntengwe, 2005). Without water life as it exists on our planet is impossible (Asthana and Asthana, 2001).

Inadequate access to clean drinking water directly or indirectly affects health. According to WHO, more than 80% of diseases in the world are attributed due to unsafe drinking water or to inadequate sanitation practices (WHO, 2003a). Global statistics estimate that currently the world is not on track to meet the MDG sanitation target, and 2.5 billion people still lack access to improved sanitation, including 1.2 billion who have no facilities at all particularly in Sub-Saharan Africa and Southern Asia (WHO/UNICEF, 2006).

Eventhough there is abudant water resource in the country, many Ethiopian people have suffered from a lack of access to safe drinking water and basic sanitation for many years. The majority of drinking water sources in Ethiopia are still rivers, streams, hand-dug wells, and intermittent springs none of which are protected from flooding or livestock, wildlife, and human contamination. As a consequence of poor sanitation practices and consumption of contaminated water, over 100 out of 1000 live births die within the first five years of age (WHO, 2008).

The main health problems in Bedesa town are results of poor access of potable water, poor hygiene and poor sanitation practices. In these cases, supplying safe drinking water is of critical importance. Consequently, this study was conducted in Bedesa town, Wolaita zone, Southern Ethiopia in order to assess the bacteriological and physico-chemical quality of potable water of the town.

2. MATERIALS AND METHODS

Description of the Study Area

Bedesa town is found in Damot Woyde Woreda of Wolaita Zone, Southern Nations, Nationalities and Peoples' Regional State. It is the capital of the Damot Woyde Woreda. The town is about 160 kms far from the SNNPRS capital, Hawassa, and about 376 kms south from the capital of Ethiopia, Addis Ababa. Bedesa is geographically located approximately in latitudes of 6°51′30″ and 6°54′0″N, and longitudes of 37°54′30″ and 37°57′0″ E. The altitude of the Damot Woyde Woreda where the study area located ranges from 1001 to 2500 m.a.s.l.

Data Sources and Collection Methods

For this study, combination of both primary and secondary data sources was used. The primary data were gathered through questionnaires and field survey. The secondary data were gathered from the published and unpublished documents.

Sampling Technique and Sample Size

In this study, both probability and non-probability sampling techniques were employed to draw the sample households. Accordingly, the sample households were selected using systematic random sampling technique. Hence, the sample size (n) of this study was 195.

Water Quality Sampling

To examine the physico-chemical quality of drinking water, representative samples were taken in triplicate from the current source of the town's water supply, the existing service reservoir, the pipeline, and end users (household containers). Therefore, one sample from the source, one sample from the reservoir, two from pipeline and two samples from household containers with a total of six triplicate samples were taken and analyzed.

For bacteriological water quality test, the samples were taken in triplicate from the above mentioned sources for total coliform and faecal coliform tests. Hence, one sample from the source, one sample from the reservoir, two from pipeline and two representative samples from end users (household containers) with a total of six triplicate samples were taken and analyzed.

Analysis of Physico-chemical Parameters

Turbidity of collected water samples were measured by turbidity meter 2100A instrument in which international standard samples with different turbidity ranges were observed from the reading instrument. EC and pH were measured by EC meter (JENWAY4200) and pH meter (JENWAY 430) respectively. EC meter was calibrated by using 0.01N KCl and pH meter was calibrated by buffer standards of pH of 4 and 7. Total dissolved solids (TDS) were determined by using conductive meter. Determination of total hardness, nitrate, fluoride, iron, chloride, dissolved ammonia and phosphate were carried out by hardicol test method by using palintest photometer 5000 instrument. A colorimetric method can be used to determine free chlorine in water at concentrations of 0.1–10 mg/liter.

Analysis of Bacteriological Parameters

With regard to bacteriological parameters, samples were analyzed in the laboratory using membrane filtration (MF) method for water quality to determine the degree of contamination (WHO, 2002). All samples were analyzed for the presence of indicator bacteria, TC and FC. One hundred milliliter of water sample for each test was filtered through a sterile cellulose membrane with a pore size of 0.45μm to retain the indicator bacteria.

Data Analysis

In this study, the Statistical Package for the Social Science (SPSS) was used to analyze the data obtained from the household and field survey. Moreover, ANOVA was used to determine the significant differences in the mean values of the water quality parameters at various sampling sites.

3. RESULTS AND DISCUSSION

Water Quality Analysis

Physico-Chemical Quality Analysis

In order to analyze physico-chemical quality of water, a total of thirteen parameters were selected and analyzed. These physico-chemical parameters included temperature, turbidity, PH, EC, TDS, phosphate, nitrate, iron, total hardness, ammonia, free chlorine residual, chloride and fluoride.

Temperature and pH

The laboratory result indicated that, the mean values of temperature for the source, reservoir, pipe water and household container were 25.87^oC, 25^oC, 26^oC and 25^oC respectively. According to WHO, the recommended temperature value for drinking water is less than 15^oC. Therefore, the mean values of temperature for the source, reservoir, pipe water and household container were not within the limit of WHO standard value. There was no such a great variation in the mean values of water temperature in all sampling sites as they have similar atmospheric temperature. As a result, the differences in the mean temperature of the sampling sites were not significant at $p < 0.05$ significant level. The Previous study by Momba *et al.*, (2002) have shown that temperatures greater than 15°C have been associated with bio-film formation in drinking water distribution systems. Another study in Canadian cities, Japan Gulch water treatment plant also indicated that the warm temperature in the distribution systems favor the growth of coliforms. When water temperature increases, disinfectant demand and microbial activity will also increase so that palatability of water quality decreases (WHO, 2004b and 2004c). The finding of this study was not similar with the studies conducted by Momba *et al.*, 2002, CRD, 2005, WHO, 2004b and 2004c. Although the mean temperature values of the study area were beyond the recommended limit of WHO, Total Coli and Faecal Coli were not available in the distribution systems.

The result of laboratory analysis revealed that the mean values of pH for the source, reservoir, pipe water and household container were 6.87, 6.77, 6.65 and 7.07 respectively. This finding was in agreement to the WHO standard pH value of potable water which is 6.5 to 8.5. The highest pH value was recorded at end user while lowest was recorded at pipeline.

Turbidity, TDS and EC

The highest turbidity value was recorded at the source while the lowest was recorded at the end user. As the particulate matter floats on the surface of the source water, its turbidity value gets higher than all sampling sites. At the end user level, the value of turbidity of water becomes less as the particulate matter settles down in the household water storage container. The mean turbidity values for the source, reservoir and the pipe water and household container were 2.01NTU, 1.06NTU, 1.12NTU and 0.95NTU respectively. The recommended turbidity value for drinking water is <5 NTU (WHO, 2004a; WHO, 2004b).

The laboratory test also revealed that the average TDS value (mg/l) and EC value (μS/cm) for the source, reservoir, pipe water and household container were below the WHO and Ethiopian standard value for drinking water. The average TDS values for the source, the reservoir, the pipe water and the household container were 146, 131, 136.84 and 134.17 respectively. The water is more turbid when it has high TDS content. The correlation result for the association between turbidity and total dissolved solids revealed that there was a strong positive relationship between turbidity and TDS with the correlation value of 0.751.

Chloride and Free Chlorine Residual

In areas where there is little risk of a waterborne outbreak, residual free chlorine of 0.2 to 0.5 mg/l at all points in the supply is recommended (Dagnew et al., 2007). In this study, the concentration of residual free chlorine in all water samples were below the recommended limit of WHO (0.2-0.5 mg/l), which indicates the inefficiency of disinfection in the distribution system.

Iron, Fluoride and Dissolved Ammonia

The laboratory test result showed that the mean values for iron, fluoride and dissolved ammonia were within the acceptable limits of WHO and Ethiopian standards for potable water quality. The one way analysis of variance (ANOVA) test showed the significant differences in mean values of iron, fluoride and dissolved ammonia among the different sampling sites at $p < 0.05$ significant levels.

Total Hardness

The mean total hardness as $CaCO_3$ for the source, reservoir, the pipeline and the household container were 124.67mg/l, 128mg/l, 124.17mg/l and 127.84mg/l respectively. The one way analysis of variance (ANOVA) test showed the significant differences in mean values of total hardness among the various sampling sites at $p < 0.05$ significant levels.

Bacteriological Quality Analysis

The total coliforms and faecal coliform test were selected and carried out to measure bacteriological quality of drinking water in Bedesa town.

Table 3.1 Results of Bacteriological quality analysis of potable water

Sampling point	**Bacteriological Parameters**		**WHO standard**	**Ethiopian standard**
	Total coliform (CFU/100ml)	**Faecal coliform (CFU/100ml)**		
Source	0	0	0	0
Reservoir	0	0	0	0
Pipeline1	0	0	0	0
Pipeline2	0	0	0	0
HH Container1	0	0	0	0
HH Container2	0	0	0	0

As it is indicated in Table 3.1 above, the mean values for total coliform and faecal coliform for all sampling points were within the limits of WHO and Ethiopian water quality standards (0CFU/100ml). The reason for bacterial un-contamination of water at all sampling sites was due to the quality of the source water even if poor sanitation condition was observed around some public taps during the survey. Besides, the high temperature of water beyond the WHO standard did not cause the growth of bacteria in the water.

4. CONCLUSION AND RECOMMENDATION

Conclusion

The result of water quality test revealed that average values for all selected physico-chemical water quality parameters such as pH, EC, turbidity, TDS, total hardness, iron, phosphate, NH_3, fluoride, free chlorine residue and chloride were found within the acceptable limits of WHO and Ethiopian water quality standards. But, the mean values of temperature for source, reservoir, pipeline and household container were beyond the recommended WHO value (<15℃). The one way analysis of variance (ANOVA) test indicated that there were significant differences for mean values of all physico-chemical parameters of water among various sampling points at $p<0.05$ significant level with the exception of temperature. In general, the findings of this study revealed that Bedesa town was provided with clean potable water.

Recommendation

Based on the findings, the following recommendations are made:

- ❖ To maintain the quality of potable water, the existing water source should be protected from pollution;
- ❖ Furthermore, the integrated watershed management activities should be carried out to protect the quality of water at the source.

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