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Bacteriological and Physico-chemical Quality of Deep Well Water Source in Jimma, Southwest Ethiopia”

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Abstract

Increase in development has brought about continuous scarcity of water resources in many parts of the world. The sustainability and quality of ground water is vulnerable to overexploitation and contamination due to poor management. This study was carried out to evaluate the bacteriological and physicochemical quality of deep well water at Kito-Furidsa Institute of Technology, Jimma Town to assess its suitability for drinking and other uses. Fecal coliform and total coliform tested positive for the tap water sample. All the physicochemical water quality parameters complied with World Health Organization regulatory standards. The water sample at the outlet of the well tested negative for fecal and total coliform which assures the safety for drinking and other purpose based on the World Health Organization standard. The sanitary survey of the stations illustrates that there was low risk of contamination. Hygienic practice should be improved so as to prevent or reduce contamination of water with microbial flora and undesirable chemicals.

Keywords: Coliforms; Deep well; Drinking water; Sanitary survey; Water quality

Introduction

Water is one of the most important elements for each way of life. It is vital to keep life on earth. It is also essential for the composition and renewal of cells. However, human beings continue to contaminate water sources causing water-related diseases [1]. Drinking water quality which refers to the chemical, physical and biological characteristics of water and waterborne diseases treatments is critical for public health [2]. It is the measure of the state of water in relation to the requirements of or more biotic spices and / or any need or human purpose [3]. The dependence of groundwater is increasing in most of the dry and semi-arid regions of the world as a result of vagaries of the rainy season and shortage of source water [4]. A comprehensive study on urban water supply systems in developing countries revealed that almost list 60 percent of the populations are still reliant on the underground source of drinking water specifically in outside of the city areas and distant villages [5]. About 1.1 billion people in the world have not had water source or system which is uncontaminated [6,7]. Waterborne diseases transmissions have been a concern for years [8]. Bacteria, viruses and parasites that are born from the water estimated to produce about four billion cases of diarrhea every year worldwide. Around the world, it is estimated that more than two million people, almost all newborns and children under five die due to water borne illness every year [7,9]. The microbiological quality of drinking water is a concern to consumers, water suppliers, regulators and public health authorities. The potential of drinking water to transmit microbial pathogens to great number of people causing subsequent illness is well documented in many countries at all levels of economic development [8].

The importance of improved water supply in the process of disease prevention and health promotion has long been identified. It is also described as one of the essential components of primary health care in the Alma-Ata Declaration [10]. The activities of international drinking water supply and sanitation decade signifies role that safe water supply could potentially play towards reaching the goal of health for all [9]. Access to drinking water and sanitation in Ethiopia is the lowest in the world. Almost 50 million people do not have access to clean water, while 56 million have no access to sanitation, according to the Ethiopian water sector report of 2008. Water-related diseases and sanitation such as cholera, fever, yellow hepatitis, diarrhea and typhoid takes the lives of hundreds of people in Ethiopia every year [1,11]. The water coverage of Ethiopia is about 53% as reported by Ethiopian Ministry of Water Resource [1]. This study can give valuable information about the current states of the well water source for those who are responsible to have regular monitoring and maintenances of the water system and for the users in having proper use and hygienic practice.

Moreover, it can serve as base line data for researcher for further investigation.

Methods and Materials

Samples and sampling method

Using appropriate data collection techniques, the data was collected from Kito-Furidisa deep well water source. One grab sample was taken from station 1 (deep well) and two independent grab samples were taken from station 2 (tap water) in two separate days at 6:30 local time, which was pick hour of water usage and analyzed separately. The sampling stations were critically described using observational checklist during sanitary survey of the area. After sterilization the samples were collected in glass bottle and transported to the laboratory for the bacteriological quality analysis of the well water source, also the sample were not exposed to light and transported in an insulated container filled with ice to protect those indicators for bacteriological analysis from distraction and the analysis was performed within 6 hours of sample collection. For physico-chemical parameters sample collection the sampling bottles were washed with non-phosphate detergent, rinsed thoroughly with running water and rinsed with distilled water. Because of the inherent instability of certain variables like nitrate and ammonia-nitrogen they were preserved with 2 mL of concentrated H2SO4 and stored at 40C [12]. Finally, after sample collection the samples were packed and transported to laboratory for sample analysis by using standard laboratory methods and procedures.

Pre-test

Prior to the actual study a pre-test for field and laboratory instruments were conducted giving emphasis on observation of certain instruments for proper functioning and to ensure the validity of instruments and results were monitored by performing appropriate calibration of instrument using blank during volume trick analysis to minimize possible errors from impurities.

Sample analysis and interpretation

After conducting a pilot study to check the precession of the instruments the collected water samples were analyzed in the laboratory using standard methods and procedures. pH and temperature of the samples was determined by using portable standard pH meter and thermometer respectively. The Chloride concentration of the water samples were detected by Argentometric Titration [13]. The Fluoride content was determined by Alizarine Photometric Method. Ammonia and Nitrate were measured by Direct Nesslerization and Phenoldisulphonic Acid Method as nitrate nitrogen respectively and the total hardness of the water samples were determined by EDTA Titrimetric Method [12]. For bacteriological analysis (i.e. fecal coliform and total coliform) the collected samples were analyzed by Most Probable Number (MPN) method. After sample incubation for required time it was possible to isolate and determine the fecal coliforms from non-fecal coliforms due to their incubation tolerance at a temperature of 44oC for 24-hour incubation time. Sanitary survey was carried out based on physical inspection, of the well water system and how the system is operated and maintained, using standard sanitary survey checklist.

Results and Discussion

Physicochemical analysis

Higher value of chloride 53.3 mg/L, nitrate 2.37 mg/L and ammonia 0.11 mg/L and lower values of hardness 20.4 mg/L and pH 7.64 were recorded at tap water sample station 2 (Table 1). The pH value of the water samples from station 1 and station 2 were 7.94 and 7.61 respectively. The pH values of the two stations were within WHO optimum limits 6.5 the minimum and 8.5 the maximum value. The temperature value of 16.62oC was recorded at station 2 and 14.2oC at station 1. Higher value of temperature at station 2 was mainly due to the exposure of water pipeline to the sun after leaving station 1.

Table 1: Laboratory Results for the Physico-chemical Quality Analysis of the Water Samples at Outlet of the Well (Station 1) and Tap Water Sample (Station 2).

Parameters (mg/l)	Station 1	Station 2		
		1st Day Sample	2nd Day Sample	Average
Chloride	51.3	53.3	54.1	53.7
Fluoride	0.63	0.58	0.56	0.57
Nitrate	2.46	2.5	2.56	2.53
Ammonia	0.09	0.11	0.13	0.12
Hardness	22.5	20.9	19.9	20.4
pH	7.94	7.69	7.53	7.61
Temperature (°C)	14.2	16.8	16.5	16.65

The Chloride concentration in the water samples were 51.3 mg/L at station 1 and 53.6 mg/L at station 2. These values are below the WHO quality standard for drinking water of 250 mg/L. The Fluoride consecration of the samples was 0.63 mg/L at station1 and 0.57 mg/L at station 2. The permissible limit for fluoride concentration ranges from 1-1.5 mg/L [14]. Fluoride has a significant mitigating effect against dental caries if the concentration is approximately 1 mg/L. However, long term exposure or consumption of higher concentration of 4 mg/l or more can cause dental fluorosis and in extreme cases even skeletal fluorosis [15]. Nitrate concentrations in the samples were 2.46 for station 1 water sample and 2.53 mg/L for station 2 water sample. High concentrations more than 45 mg/L of NO_3- may give rise to potential health risks such as methemoglobinemia or blue-baby syndrome particularly in pregnant women [16]. Total Hardness of the water sample from station 2 was 20.4 mg/L and 22.5 mg/L for station 1 water sample. These values are within the range of 0-60 mg/l which is soft water as described by United States Geological survey and World Health Organization. Ammonia concentrations of the

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water samples were 0.09 mg/L and 0.12 mg/L. The minimum value was for the sample from station 1 and the maximum was from station 2 water sample. The concentration of ammonia in the samples are below the WHO recommended standard of 0.5 mg/L. According to World Health Organization (WHO), the level found in ground water is typically below 0.2 mg/L.

Microbiological analyses of collected samples

Through the microbial analysis of station 1 abstracted water sample did not revealed the presence of total coliform and fecal coliform. The bacteriological analysis of station 2, based on MPN count in 100 mL sample, were 6 CFU for total coliform and 3 CFU for fecal coliform. This result revealed that the sample from station 2 did not meet WHO standard of zero fecal coliform and less than 5 CFU per 100 mL total coliform for safe drinking water, but station 1 was within standard. The total and fecal coliform count of station 2 was higher than station 1. This was basically due to the break of the continuity of the main distribution line which results in cross contamination as observed during sanitary survey (Table 2).

Table 2: Total Coliform and Fecal Coliform Count of Outlet of the Well (Station 1) and Tap Water Sample (Station 2).

Coliform count (CFU/100 mL)							
Total Coliform				Fecal Coliform			
Station 1	Station 2			Station 1	Station 2		
	1st Day Sample	2nd Day Sample	Average		1st Day Sample	2nd Day Sample	Average
0	5	7	6	0	3	3	3

Increased level of fecal and total coliform indicates the lack of water treatment and poor management of water harvesting system. Since contamination after collection, during transportation and storage is increasingly being recognized as an issue of public health importance it may require treatment such as boiling or treatment with hypochlorite solution since that will kill most microbial parasites before drinking [17,18]. Ground water is a relatively safe source of potable water compared with other unprotected water sources e.g. rivers, springs, rainwater [19]. Samples taken from station 1 in this study contain coliform count below standard by MPN technique. However, the sample from station 2 was identified to have a little higher than the standard.

The on-site inspection (sanitary survey) of the water source, facilities, equipment's, operation and maintenances of station 1 revealed that the station was in good condition with a score of 35 which is lower than 45 that recommended by WHO. The physical on-site measurements were noted the distance between the proposed stations and potential source of contamination. Also, during this evaluation station 2 was considered to be at risk of contamination with leakage through the break of the distribution line when compared with station 1 based on WHO standard. Sanitary survey is meant to identify problems which may affect the quality of the water.

Conclusion and Recommendation

The study has shown that generally physiochemical parameters of groundwater from selected well were found to be acceptable according to the guidelines for drinking water provided by the World Health Organization for drinking and domestic activities with the exception of pH which was low (out of recommended range) for all boreholes and hand-dug wells. The microbial quality of water at the point of usage were unsuitable for human consumption without treatment. Treatment and hygienic practice should be improved so as to prevent or reduce contamination. Replacement of damaged pipelines and lining of sewer drains is necessary to prevent the leakage of sewage in pipes and seepage through unlined channels and prevent the mixing of sewage with ground water. Government must be determined to increase regular monitoring and enforcement of drinking water quality.

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