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BACTERIOLOGICAL AND PHYSICO CHEMICAL QUALITY OF DRINKING WATER FROM HAND DUG-WELL IN ADIGRAT TOWN, NORTHERN ETHIOPIA

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ABSTRACT

Lack of potable water has become a critical and urgent problem in many developing countries including Ethiopia. A study was conducted to assess the bacteriological and physico-chemical quality of water from hand-dug wells of Adigrat town. Four water samples were collected from four main hand-dug wells within the town between February and May 2014 and analyzed for bacteriological and physico - chemical characteristics. Macconkey and plate count agars were used for development of enterobacteriaceae and aerobic mesophilic bacteria, respectively. Water analysis revealed the presence of two types of pathogenic bacteria including enterobacteriaceae and aerobic mesophilic bacteria. The total aerobic mesophilic bacterial count of the samples analyzed was $4.3x10^4$ CFU/ml and the mean count was $1.075x10^4$ CFU/ml. The total count of Enterobacteriaceae was (156000 CFU/ml) and the mean count of Enterobacteriaceae was 3.9×10^4. Temperature and pH levels were above WHO acceptable levels for drinking water in almost samples. Almost all samples tested did not meet the WHO bacteriological standards for drinking water. The presence of enterobacteriaceae and aerobic mesophilic bacteria should particularly raise serious public health concerns over the quality of the town's hand-wells water. Therefore, intervention measures including creating awareness and educating residents on hand-dung well construction, care, boiling of water and improving sanitation should be urgently instituted.

KEY WORDS: Adigrat town, bacteriological, hand dug-well, physicochemical, water quality, Ethiopia.

1. INTRODUCTION

Quality drinking water is essential for life.[1] The quality of drinking water has a powerful impact on public health and therefore effective monitoring and comprehensive assessment of public drinking water supply systems are crucial to protect the wellbeing of the public and to allow implementation of a preventive approach to manage drinking water quality.[2] Contaminants such as bacteria, heavy metals, nitrates and salt have found their way into water supplies as a result of inadequate treatment and disposal of human and agricultural waste, industrial discharges and over-use of limited water resources. Even if no sources of anthropogenic contamination exist, there is potential for natural levels of metals and other chemicals to be harmful to human health.[3]

The provision of potable drinking water for rural and urban areas is necessary to prevent the dangers of water diseases and public health prevention. Potable water has to comply with certain physical, chemical and microbiological standards which should not contain microorganisms and chemicals at harmful levels. [4, 5] Water borne diseases are the most dangerous ones in terms of public health, because they can easily spread.[6]

Water born diseases are caused by pathogenic microorganisms that most commonly are transmitted in contaminated water. According to WHO, water born disease account for 4.1% of the total daily global burden of disease and cause about 1.8 million human deaths annually. The WHO estimates that 88% of the total burden is attributable to unsafe water supply, sanitation and hygiene.[7]

The majority of the populations in developing countries including Ethiopia, is not adequately supplied with potable water and is thus compelled to use water from alternative water sources like hand dug and shallow wells, rivers, ponds and streams that render the water unsafe for domestic and drinking purposes due to high possibilities of contamination and risks of water borne diseases are therefore a major public health concern in these countries.[6,8]

Most of the Ethiopian population (approximately 63%) relied on alternative sources of water such as ponds, lakes, rivers and open dug wells and according to the study conducted in 2004 to assess the water-supply coverage of the country, Tigray region uses 8.9 % hand dug well

as water source.[9] Polluted water is potentially dangerous to health because of possible out breaks of dysentery or cholera, epidemics and other water born disease because these alternative water sources like hand dung wells provide cheap and low technology solution to the challenge of rural urban water supply and their construction also vulnerable for introduction of agricultural and domestic wastes due to lack of afford an opportunity for community participation during all phases of the water supply process.[10] Similar to the people of Ethiopia, the community of Adigrat draws their water sources from the alternative water sources for domestic and drinking purposes and this may causes them vulnerable to the water borne diseases. Therefore, since not study was conducted on the bacteriological and physic chemical characteristics of hand dug wells of the town, the need to assess the quality of water from these alternative sources has become imperative because they have a direct effect on the health of individuals. Thus this study was conducted to assess the bacteriological and physico chemical quality of water from hand-dug wells of Adigrat town, Northern Ethiopia implication to ensure public health.

2. MATERIALS AND METHODS

2.1. STUDY AREA

The study was conducted in eastern zone of Tigray, Northern part of Ethiopia at Adigrat town. Adigrat town is located in Tigray regional state of Ethiopia, which is about 921 km far from Addis Ababa and 115 km from Mekelle city, the capital city of Tigray regional state. It is located at altitudinal ranges from 2000 - 3000 meter above sea level and geographically it located 014^{o}16’34’’ N latitude and 039^{o}27’51’’E longitude with total population 57,588 according to 2007 census. It has different agro-ecological areas namely sub moist dry, sub moist cool and sub dega. The annual rain fall ranges from 400-600mm and the minimum and maximum temperature ranges from 6-21.8^{0}c. Its maximum rain fall occurs from June up to September. Potable water or pipe water is the main problem of this town and the residents use different alternative water sources like hand dug wells for their domestic and drinking purpose.

2.2. SAMPLE COLLECTION

Water samples were collected from February to May, 2014. Samples were collected from four (4) residential hand dug wells on the same day during the study period using sterilized plastic bottles. 900ml of water sample from each well was collected and approximately

100ml of each container was remaining empty. Water samples collected from each well were immediately transported to the laboratory for bacteriological and physicochemical analysis.

2.2.1. BACTERIOLOGICAL ANALYSIS

Bacteriological analysis was conducted by the use of Macconkey agar and plate count agar. The total of two numbers of Coliform bacteria present in four wells was determined.

2.2.1.1. MACCONKEY AGAR PREPARATION

8.81gram of Macconkey agar was suspended in 120ml of distilled water. The mixture was mixed well and dissolved by heating with frequent agitation.[11] The solution was also boiled for one minute and complete solution was formed. It was sterilized in autoclave at 121 ^{o}c for 15 minutes. It was cooled to 45 ^{o}c and after mixed well, it was dispensed in to the plate. The plate was allowed to solidify and placed them upside down to avoid excessive moisture on the surface of the medium. The prepared medium was stored at 14 ^{o}c. The violet red color was observed.

2.2.1.2. PLATE COUNT AGAR PREPARATION

By similar procedure with Macconkey agar, 3.76 gram of Plate count agar was suspended in 120ml of distilled water. The mixture was mixed well and dissolved by heating with frequent agitation. The solution was also boiled for one minute and complete solution was formed. It was sterilized in autoclave at 121 ^{o}c for 15 minutes. It was cooled to 45 ^{o}c and after mixed well, it was dispensed in to the plate. The plate was allowed to solidify and placed them upside down to avoid excessive moisture on the surface of the medium. The prepared medium was stored at 14 ^{o}c yellow color was observed. The plate was incubated at 35 ^{o}c for 48 hours. After that, colonies were counted by using plate count and results were recorded. The results were compared with the standard chart to determine the probability of the sample. The colonies showed color change was selected for further identification. The pure cultures of these selected colonies were track plate on nutrient agar and final gram testing and morphology was observed using microscope and results were recorded.

2.2.2. PHYSICO-CHEMICAL ANALYSIS

Physico-chemical characteristics of water samples such as color, odor, temperature and PH level were also conducted. Thermometer was kept in the water until a constant reading was attained for two minutes and measurement was recorded in Celsius. The test was repeated three times and average result was recorded. Change in temperature was recorded and PH

was measured by using PH meter. The test was repeated three times and average result was recorded. The water samples were also analyzed physically by their appearance either clear or having contaminant.

3. RESULTS

3.1. BACTERIOLOGICAL QUALITY OF HAND-DUG WELLS WATER

The results of the bacteriological analysis of the water samples of the selected wells are shown in Table 1 and 2. In three wells two types of pathogenic bacteria namely, enterobacteriaceae and aerobic mesophilic bacteria were identified. The total aerobic mesophilic bacterial count of the samples analyzed was $4.3x10^4$ CFU/ml and the mean count was $1.075x10^4$ CFU/ml. The first well count is much higher in the range of 8×10^4 CFU per 90 ml and the lowest count is in range of 0 CFU per 90ml for the fourth well. The total count of Enterobacteriaceae was (156000 CFU/ml) and the mean count of Enterobacteriaceae was 3.9×10^4. The coliform counted from the samples: 8×10^4 CFU (80%) of S1a, $2x10^4$ CFU (20%) of S1b, $6 x10^4$ CFU(92%) of S2a, $5 x10^3$ CFU (8%)of S2b , 1.6×10^4(47%) of S3a ,$1.8 x10^4$ (53%) of S3b 0% of S4a and 0% of S4b (Table 1). The bacterial load however varied highly between the four sample sites.

Table-1 Bacteriological analysis of hand dug wells

Solid samples	Types of bacteria	No of colony(CFU/ml)	Percent (%)
S1a	Enterobacteriaceae	8×10^4 Mca	80
S1b	aerobic mesophilic bacterial	2×10^4Pca	20
S2a	Enterobacteriaceae	6×10^4 Mca	92
S2b	aerobic mesophilic bacterial	5×10^3 Pca	8
S3a	Enterobacteriaceae	1.6×10^4 Mca	47
S3b	aerobic mesophilic bacterial	1.8×10^4 Pca	53
S4a	No bacteria	No colony	0
S4b	No bacteria	No colony	0

S = sample

Analysis of the laboratory result demonstrated that among the total of eight Medias three of them (75%) (S1, S2, S3) of the sample had both Enterobacteriaceae and aerobic mesophilic bacteria. The fourth sample (S4a and S4b) (25%) did not show any growth of indicator bacteria.

Table-2.Colony morphology of the positive isolates on different media

Isolate number		Colony morphology	
		McConkey Agar	Plate count agar
S1	Enterobacteriaceae	Violet-red,road,opaque,0.5mm	×
	aerobic mesophilic bacteria	×	Yellow, Transparent,
S2	Enterobacteriaceae	Violet-red,round,opaque,0.5mm	×
	aerobic mesophilic bacteria	×	Yellow, Transparent
S3	Enterobacteriaceae	Violet-red,round,opaque,0.5mm	×
	aerobic mesophilic bacteria	×	Yellow, Transparent
S4	Enterobacteriaceae	Violet-red,round,opaque,0.5mm	×
	aerobic mesophilic bacteria	×	Yellow, Transparent

Table-3. Degree of total coli form bacteriological water pollution

Sample and no of colony found(cfu/100ml)	Remark
0	Save water
1-10	Contaminated(reasonable quality)
11-100	Contaminated
101-100	Dangerous

Negative sample in liquid media (25%) are free from coliform bacteria (Table 4). Positive samples in liquid media (75%) had Enterobacteriaceae and aerobic mesophilic bacteria as shown (Table 5).

Table-4. Bacteriological analysis of wells water for negative gas production in Adigrat town.

Negative liquid	Presence gas production	No of negative plate	Percent
S4a	no	4	50
S4b	no	4	50
Total			100

Table-5. Bacteriological analysis of wells water for positive gas production

Positive Liquid samples	Presence of gas production	No of positive sample	percent
S1a	+	4	16.7
S1b	+	4	16.7
S2a	+	4	16.7
S2b	+	4	16.7
S3a	+	4	16.7
S3b	+	4	16.7
Total			100.00

S = sample + = positive

3.2. PHYSICOCHEMICAL ANALYSIS OF HAND-DUG WELL WATER

The results of the physiochemical analysis of the water samples are shown in Table 7. Three of the water samples were posses color while one is colorless and the two water samples also have unpleasant odor. The pH values of the samples ranged from 6.51 to 7.58. This indicates that the water was polluted with substance which alter the properties of water to acidic condition such as organic chemicals or inorganic chemicals or microorganism which has ability to produce toxic substances.

Table-6. Physical appearance of hand-dug wells water

Organoleptic Property		Description
color	S1	greenish-chlorophyll
	S2	Brown
	S3	grey
	S4	Colorless
Odor	S1	greenish-chlorophyll-like odor
	S2	Unpleasant odor
	S3	Odorless
	S4	Odorless

Table-7. Temperature and PH of wells water, Adigrat town

sample	Temperature	PH
S1	24.90	7.58
S2	24.40	6.71
S3	25.00	6.51
S4	24.90	6.70
Average	24.80	6.78

4. DISCUSSION

Coliforms are the indicators to assess the domestic pollution level in water samples. The quality of drinking water is determined by both its physical and biological characteristics. In this study, bacteriological analysis revealed that two pathogenic bacteria were identified from the selected study hand dug wells. When the isolated coliforms were inoculated into MacConkey agar and plate count agar, violet-red and yellow coloration developed, respectively, indicate the presence of gram negative coliform bacteria. These differences may rise because of different system of well- water supply, difference in maintenance of the well, difference in sanitation system and environmental factors. The finding of this study is in consistent with the study conducted in Jimma town by Divekulu and Delelegn.[12] However, the number of colonies counted in this study was less than colonies counted with the study also conducted in Jimma town.[13]

In this study the content of both enterobacteriaceae and aerobic mesophilic bacteria from kebelle 01. This kebele also harbors the highest concentrations of septic tanks that serve the various business premises and residences. These facilities are also the oldest in town and the conditions found in Kebelle 01 are particularly conducive to facilitating fecal contamination of ground water. This could account for the presence of pathogenic bacteria in hand dug wells. The presence of these pathogenic microorganisms predisposes the residents to diseases such as typhoid, cholera and dysentery. Water from kebelle 01 can thus be considered as the most unsuitable for human consumption within Adigrat town.

The physico chemical analysis of the study revealed presence of colorful, unpleasant odor and high PH level in water from the hand dug wells. The water quality of hand dug wells in Adigrat town is therefore poor in terms of one or several physical and chemical parameters investigated. Water intended for drinking should not contain harmful microbial organisms and high amount of physico-chemical characteristic. In almost all the wells, relatively high temperatures were observed with a maximum of 25°C. Physical parameters, such as pH and temperature have a major influence on bacterial population growth.[14, 15]

Overall the findings of this study suggest that hand dug wells, the most reliable source of water for domestic use in Adigrat town are both bacteriologically and physico chemically contaminated and are not suitable for human use without further processing. Many studies also demonstrate to the generally poor quality of water from similar water sources in the tropics [16. 17, 18, 19] attributed to pollution from widespread and indiscriminate human and animal defecation and general poor sanitation. Mostly in developing countries the hand dug wells studied not met the chemical and /or bacteriological standards for drinking water.[6]

Several factors could possibly contribute to this condition such as the well-toilet orientation, age of the well, topography and overall sanitation could therefore also play a role in determining bacterial contamination of the wells. In this study it was observed that most wells were not properly secured thus exposing them to contamination from human, animal wastes as well as surface runoff. Public health interventions to improve the water quality including boiling, chlorination and use of ceramic filter technology as well as improving the overall sanitation within the residential areas should be instituted. Improving sanitation has been shown to have greater impacts as it leads to improvement of the quality of the water at the source.[20] Further interventions should also include providing technical advice on proper

well construction including installation of pumps, well citing, monitoring and decommissioning unsanitary wells.

5. CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUSION

The present study was identified two pathogenic bacterias namely, enterobacteriaceae and aerobic mesophilic bacteria and other physico chemical characteristic of the hand dug of Adigrat town. The results of this study strongly suggest that the bacteriological and physico-chemical of hand dug wells in Adigrat town are poor and do not meet the WHO guidelines for drinking water quality for various parameters. This poses serious public health concerns to unsuspecting water users. To safeguard the health of the town's residents, intervention measures including creating awareness and educating residents on hand dug well construction and care, boiling of water and improving general sanitation should be urgently instituted. Further studies should aim at identifying specific sources of pollution, monitoring seasonal changes in bacterial incidences and correlating this to outbreaks of waterborne diseases in the town.

5.2. RECOMMENDATIONS

To obtain data that can form the basis of a comprehensive public health intervention programme, there is need to incorporate not only biological and chemical data as presented in this study but also socio-economic information including sources and methods of treatment of domestic water, methods of human waste disposal, the perceptions of possible sources of water contamination in the area as well as data on age, methods of hand dug well construction and maintenance.

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