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ASSESSMENT OF DRINKING WATER QUALITY IN DIFFERENT WATER SOURCES AND ITS IMPACT ON DOWNSTREAM COMMUNITY HEALTH AROUND WOLDIA TOWN, ETHIOPIA

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ABSTRACT

Water is one of the most vital natural resources known on the earth. The quality of drinking water is degrading by various sources of contaminants. The analysis of Bacteriological and physio-chemical quality from hand dug and open stream/rivers around Woldia town was conducted from March, 2018 to September, 2018. Sixty water samples were drown from a total of ten hand dug wells located around town and analysed for total coliforms, fecal coliforms and E.coli using multiple tube fermentation (MTF) method. Physico chemical parameter (temperature and electrical conductivity) by conductivity meter 4200 UK, Turbidity by turbidity meter 2100Q, ammonia, Sulfate and pH determined by photometer, E. coli 11 (18.3%) was detected from both sources of samples and 60 (100%) water samples were analysed had total coliform and also 48 (80%) drinking water samples were analyzed had fecal coliform. There was a statistically significant difference among water sources with respect to TC and TTC ($p < 0.05$) and there was a statistically significant positive and negatively correlation between coliform counts and physicochemical parameter ($p < 0.01$) and ($p < 0.05$). Most water sources didn't satisfy the turbidity values recommended by World Health Organization. Average value of temperature, pH, electrical conductivity, turbidity, Sulphate and ammonia were 22.5±1.11oC, 98±0.38, 40.40±10.67μs/cm,7.3±6.15 NTU, 0.167±0.19mg/l, 3.64±0.84 mg/l, respectively. Water supplies at open hand dug and protected hand dug were contaminated with coliforms. The water sources were heavily contaminated which suggested poor protection and sanitation practice in the water sources are the causes for contamination.

Contribution/Originality: This study contributes to the existing literature on the quality of drinking water in different sources.

1. INTRODUCTION

Water is an essential component for life on Earth, which contains minerals extremely important in human nutrition (Versari *et al.*, 2002). Water is an invaluable resource to man and living things, essential for the sustenance of life (Al Nahyan, 2012). The quality of drinking water is a powerful environmental determinant of health (WHO, 2010). Increasing population and urbanization make it difficult for governments around the world to meet the increasing demand for portable drinking water. Most municipal and industrial wastes contain organic solids, trace heavy metals, salts, bacteria, viruses, other microorganisms and sediment. Drinking water can be polluted by wastes from both natural and anthropogenic sources, causing variations in biological, and chemical and physical parameters (Isikwue *et al.*, 2011).

Wastewater is characterized in terms of its physical, chemical, and biological composition (Tchobanoglous *et al.*, 2003). Several studies have confirmed that water-related diseases not only remain a leading cause of morbidity and mortality worldwide but that the spectrum of diseases is expanding and the incidence of many water-related microbial disease is increasing WHO (2003). Diarrhea remains a major killer in children and it is estimated that 80% of all illness in developing countries is related to water and sanitation; and that 15% of all child deaths under the age of 5 years in developing countries results from diarrheal diseases (WHO, 2004).

Well water can be polluted by wastes from both natural and anthropogenic sources, causing variations in biological, and chemical and physical parameters (Isikwue *et al.*, 2011). Contamination join well water supplies by direct injection through wells, by percolation of liquid from soluble solid at surface, by broken sewer lines, seepage from waste lagoons, infiltration of polluted surface streams, irrigation return waters, inter aquifer linkages, leachates from landfills, septic tank effluents, and up welling of salt water in to fresh water aquifers. Ground water is usually high quality and consumed without treatment in many developing countries (WHO, 2003). However, recent studies shown that underground water sources and aquifers in urban area and their surrounding contains facial coliforms (Tamiru *et al.*, 2005) and it is reported that 30% of illness in developing countries is related to water and sanitation.

Most Amara Region towns have no well treated sufficient drinking water. Most peoples were found in and around Woldia Town also facing by poor water supply. The purpose of this study was to assess the quality of different drinking water sources (rivers, ground water, and tap water). The paper focus on bacteriological and physicochemical quality analysis drinking water supplies from hand dug with the sanitary inspection of the hand dug.

2. MATERIALS AND METHODS

2.1. Study Site Description and Location

The study was conducted around Woldia Town from March, 2018 to September, 2018. Woldia Twon is located in Amhara region, North Wollo, Ethiopia. It is located at 521 km far apart from Addis Ababa Ethiopia. Geographically it is located between latitude and longitude of 11°50′N39°36′E/11.833°N39.600°E, respectively and the elevation 2112 meters above sea level.

2.2. Study Design Ad Sample Collection Procedures

A cross sectional prospective study design was applied. Water samples were collected from hand dug drinking water and open stream or spring water. The samples were collected based on WHO sample collection for drinking water analysis (WHO, 1997). TTC and TC were analyzed for detect bacteriological quality of water and physio-chemical parameter (turbidity, pH, temperature, electric conductivity, SO_4^{2}, and NH_3) were measured in situ by following standard method. A total of 60 water Samples were collected from six protected hand dug and three open stream/spring water. A 250ml of water samples were collected for both parameters. The sample was collected using a sterilized glass bottles from each source and transport in an ice box in to the laboratory for bacteriological analysis.

2.3. Bacteriological Analysis Water Samples

The multiple tube fermentation (MTF) technique for coliform and total coliform was used for the water analysis. The procedure, which involved the use of three dilutions (10, 1, and 0.1 ml) of each sample, was adapted from APHA (1998).

Enumeration of total coliforms: The tubes was gently homogenized in shaker to distribute the sample uniformly throughout the medium then incubated at 37°C for 48 hours. After 48 hours of incubation, the culture tubes were observed for the presence of acid production (color change from reddish purple to yellow) or gas formation (displacement of medium from inverted Durham tube). All positive BGLB broth tubes were record. The number of coliforms of positive BGLB broth tubes were estimated from most probable number (MPN/100ml) tables provided in the standardized procedure (APHA, 1998).

2.4. Analysis of Physico -Chemical Parameters Water

The concentrations of major ions; such as Sulphates (SO_4^{2-}), Ammonia (NH_3^-) and PH were determined by photometric methods using Palintest Photometer 7100 (Wagtech, Thatcham. Berkshire, UK). Temperature and Conductivity were measured by conductivity meter 4200 UK. Turbidity was measured by a HACH turbidity meter.

Sanitary assessment on different drinking water sources: All the ground water pollution sources at source were observed by using sanitary inspection forms prepared on WHO guide line for drinking water quality (WHO, 1997). Semi structured questioners was prepared during sanitary assessment.

2.5. Data Analysis

The recorded data were subjected to analysis of variance (ANOVA) to assess the bacteriological and physico chemical quality analysis of drinking water from hand dug that was tested. Generally, the mean bacterial counts in water samples were expressed as MPN/100 respectively. All the statistical analyses were computed using SPSS software version 20. Significance of differences was considered at p value less than 0.05.

3. RESULTS AND DISCUSSION

3.1. Bacteriological Parameters

The results for the bacteriological analysis of water samples taken from the two sources (open stream water and protected tap water) in and around Woldia Town were showed significance difference in total coliform. Regarding to TC, all protected dug well and open stream drinking water samples were analyzed and didn't met with WHO recommended limits Table 1.

Table-1. Comparison of total coliform analysis of two source of water samples around Woldia Town.

Recommended level of parameters Total coliform	Protected hand dug well (n=30)	Open stream water (n=30)	P= value
count/100ml	2 (7.7%)	6 (20%)	
>100	24 (79%)	23 (75.7%)	0.004
10-100	4 (13.3%)	1 (4.3%)	
1.01-9.99	-	-	
Total	30 (100%)	30 (100%)	

Source: Authors laboratory analysis result, 2018.

From a total of 60 samples analysed 12 (20%) had TTC 0MPN/100ml met both WHO and Ethiopian national guide line value (zero TTC count/ml). But 21 (35%) had TTC from1.01-9.99 and 27 (45%) had TTC 10-100MPN/100ml didn't met both WHO and Ethiopian national guide line value (zero TTC count/ml). Analysis of variance on the data obtained showed that there was significant difference ($P \leq 0.05$) in both total coliform (P=0.003) Table 1 and faecal coliform (P=0.026) bacteria counts in the water samples using the MPN technique as shown in Table 2. Bacterial indicators can predict the probable presence of pathogen in water (Payment and Locas, 2011). This study agreed to the other works (Mengesha *et al.*, 2004; Shittu *et al.*, 2008; Tsega *et al.*, 2013). A study conduct on drinking water sources in North Gondar by Shittu *et al.* (2008) showed 50% of protected dug well had all kinds of indicator bacteria and 28.6% water samples had facal coliform.

Table-2. Comparison of fecal coliform analysis of two source of water samples rural area around Woldia Town, April-June, 2015 (n=30).

Recommended level of parameters	Protected hand dug well	Open stream water	P= value
Thermo tolerant coliforms count/100ml			
>100	-	-	
10-100	10 (33.3%)	17 (56.7%)	
1.01-9.99	12 (40%)	9 (30%)	0.026
0.01-1.01	-	-	
0	8 (26.7%)	4 (13.3%)	
Total	30 (100%)	30 (100%)	

Source: Authors laboratory analysis result, 2018.

According to sanitary survey, the hand dug wells are surrounded by different agricultural activities, had poor water drainage systems, exposed by animals contamination which might be increase the risk for contamination of drinking water. Therefore, the possible contamination route water sources (wells) were agricultural activities, livestock grazing, human handling and sewage leakage. This is similar with the report of Shittu *et al.* (2008).

3.2. Physico-Chemical Parameters

The rise in temperature from the 10 to 16 °C of WHO recommendation to the current 21.46±1.45 could favor faster growth rate of any aerobic mesophilic microbes by shortening their lag-phase. The turbidity of water depends on the quantity of solid matter present in the suspended state. It is a measure of light-emitting properties of water and the test is used to indicate the quality of waste discharge with respect to colloidal matter and leads to its acceptance or rejection for human consumption (WHO, 2000; Tsega *et al.*, 2013). The result presented in Table 3.

Table-3. Mean physico-chemical analysis of two sources of water samples around Woldia Town.

Physico-chemical	Protected hand dug	Open stream	WHO	ET
PH	7.20±0.24	6.8±0.37	6.5-8.5	6.5-8.5
Temperature (°C)	22.33±1.06	22.67±1.15	-	-
Turbidity (NTU)	9.14±8.30	5.44±0.98	5	7
Conductivity (μs/cm)	38.80±8.88	42.01±12.14	250	-
Ammonia (mg/l)	0.10±0.13	0.22±0.23	0.5	1.5
Sulphate (mg/l)	3.57±0.95	3.71±0.71	250	483

Source: Authors laboratory analysis result, 2018.

All protected dug Wells and 23 (76.7%) of open stream water sample met national and WHO guidelines. However, seven (23.3%) of open dug wells had pH values below the recommended national and WHO limits Table 4.

Table-4. Comparison of nutrient levels of the two water source with WHO recommended value.

Recommended level of parameters	Protected hand dug well	Open stream	P= value
Ammonia (mg/l)			
>0.5	2 (6.7%)	7 (23.3%)	0.018
0.1-0.5	28 (93.3%)	23 (76.7%)	
0	-	-	
Total	30 (100%)	30 (100%)	
Sulphate (mg/l)			
>250	-	-	
1-250	30 (100%)	30 (100%)	
0	-	-	
Total	30 (100%)	30 (100%)	

Source: Authors laboratory analysis result, 2018.

The sulphate ions ($SO4^{-2}$) occur naturally in most water supplies and hence are also present in well waters. The average salphate recorded was 3.64 ±0.84 and ranged between 2-5.30mg/l. From 60 protected and open stream water samples had sulphate below the level of WHO and Ethiopian recommended concentration limits value 250 and 483mg/l, respectively (WHO, 2000; Tsega *et al*., 2013).

3.3. Assessment of Downstream Community Health and Sanitary Inspections

In this study, chance of contamination of drinking water with feces showed statistically significant association with isolation of *E. coli* (P=0.048, 4.39), 21 (42.8)% the hand dug well had a chance of contaminated by human activities, showed statistically significant association with isolation of *E. coli* (P=0.042,5.45). 20 (40.8) % hand dug wells water had a chance contaminated by agricultural activities and showed statistically significant association with isolation of *E. coli* (P=0.006, 9.01) as shown in Table 5.

Table-5. Association between isolation rates of *E.coli* with sanitation checklist of the open stream around Woldia Town.

Sanitation checklist	Positive No. (%)	Negative No. (%)	Total No. (%)	χ2 (p-value)
Agricultural activities (fertilizers and pesticide).				
Yes	10 (90.9)	20 (40.8)	30 (30)	9.01 (0.006)*
No	1 (9.1)	29 (59.2)	30 (30)	
Are there any human activities around the well field area?				
Yes	9 (81.8)	21 (42.8)	30 (30)	5.45 (0.042)*
No	2 (18.2)	28 (57.2)	30 (30)	
Contamination with feces				
Yes	9 (81.8)	23 (47)	32 (42)	4.39 (0.048)*
No	2 (18.2)	26 (53)	28 (18)	
Animal contact.				
Yes	10 (90.9)	34 (69.4)	44 (44)	2.12 (0.26)
No	1 (9.1)	15 (30.6)	16 (16)	
Does split water collect in the apron area?				
Yes	6 (54.5)	23 (47)	29 (29)	0.20 (0.74)
No	5 (45.5)	26 (48.9)	31 (31)	

a= no statistics are computed because the variables are constant *= statistically significant difference.

The study conducted by Dagnew *et al*. (2007) reported that 52.9% of inspected boreholes in Ethiopia had a risk frequency regarding the presence of latrine. The study conducted in Hawassa by Wubalem (2010) which revealed that the general possible routs of contamination of raw water sources were human settlement, sewage leakage and livestock grazing. The study by Bayable (2011) showed that 7 (34% BHS) a chance of contaminated by agricultural activities and 17 (47% BHS) had a chance of contamination by human activities around the well filed.

4. CONCLUSIONS AND RECOMMENDATIONS

The overall bacterial count from water sources investigated that there is contamination. High total coliform and thermotolerant counts and medium risk scores found in the water sources suggest poor source water protection and poor sanitation practices. The physico-chemical test results of samples from all Hand dug were within the permissible limit of national and international guidelines, except turbidity. The contamination of these water sources with enteric organisms can be explained in part by absence of fencing of hand dug that could prevent the entrance of animals, livestock grazing nearby water sources, people's open area defecation, drawing of water with agricultural activities nearby water sources. Priority should be given to create awareness in the community of measures to improve hygiene, such as to develop a habit of using latrines, which is indispensable for improved water quality. Defecation of people around water points should be corrected. Awareness to be created about the present situation of these hand dug, to inform the people on the necessity for further treatment of this water before they can be used for drinking purposes.

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REFERENCES

Al Nahyan, S.M.B.Z., 2012. Keynote address. Abu Dhabi, UAE: World Future Energy Summit 2012.

APHA, 1998. Standard methods for the examination of water and waste water. Washington. DC: American Public Health Association Inc.

Bayable, A., 2011. Bacteriological and physicochemical quality of well water in and around Addis Ababa city, Ethiopia. M.Sc Thesis, Haramya University, Ethiopia.

Dagnew, T., D. Assefa, G. Woldemariam, F. Solomon and O. Schmoll, 2007. Rapid assessment of drinking-water quality in the federal Republic of Ethiopia. Federal Democratic republic of Ethiopia, Ministry of Health. Environmental health Department. Country Report. Addis Ababa. pp: 19-67.

Isikwue, M., D. Iorver and S. Onoja, 2011. Effect of depth on microbial pollution of shallow wells in Makurdi Metropoilis, Benue State, Nigeria. British Journal of Environment and Climate Change, 1(3): 66-73.Available at: https://doi.org/10.9734/bjecc/2011/354.

Mengesha, A., W. Mamo and G. Baye, 2004. Survey of bacteriological quality of drinking water in North Gondar. Ethiopian Journal of Health Development 18(2): 113-135.Available at: https://doi.org/10.4314/ejhd.v18i2.9946.

Payment, P. and A. Locas, 2011. Pathogens in water: Value and limits of correlation with microbial indicators. Groundwater, 49(1): 4-11.Available at: https://doi.org/10.1111/j.1745-6584.2010.00710.x.

Shittu, O., J. Olaitan and T. Amusa, 2008. Physico-chemical and bacteriological analyses of water used for drinking and swimming purposes in Abeokuta, Nigeria. African Journal of Biomedical Research, 11(3): 285-290.Available at: https://doi.org/10.4314/ajbr.v11i3.50739.

Tamiru, A., L. Dagnachew, A. Tenalem, T. Yirga, W. Solomon and M. Nuru, 2005. Hydrogeology, water quality and the degree of groundwater vulnerability to pollution in Addis Ababa, Ethiopia. Addis Ababa, Ethiopia: Addis Ababa University Printing Press.

Tchobanoglous, G., F.L. Burton and H.D. Stensel, 2003. Waste water engineering treatment and reuse. 4th Edn., Mc Graw-Hill.Companies Incorporation. pp: 1231-127.

Tsega, N., S. Sahile, M. Kibret and B. Abera, 2013. Bacteriological and physico-chemical quality of drinking water sources in a rural community of Ethiopia. African Health Sciences, 13(4): 1156-1161.Available at: https://doi.org/10.4314/ahs.v13i4.42.

Versari, A., G.P. Parpinello and S. Galassi, 2002. Chemometric survey of Italian bottled mineral waters by means of their labelled physico-chemical and chemical composition. Journal of Food Composition and Analysis, 15(3): 251-264.Available at: https://doi.org/10.1006/jfca.2002.1058.

WHO, 1997. Wrold health organizaion guideline for drinking water quality survillance and control of community supplies. 2nd Edn., Geneva Swtherland: WHO.

WHO, 2000. Global water supply and sanitation assessment report. Geneva: World Health Organization.

WHO, 2003. Water, sanitation and health. Geneva: World Health Organization.

WHO, 2004. World health organization guidelines for drinking water quality. 3rd Edn., Geneva, Swtherland: WHO.

WHO, 2010. Guideline for drinking water quality. 3rd Edn., Geneva, Switzerland: World Health Organization.

Wubalem, D., 2010. Bacteriological quality of drinking water at sources of households at Hawassa City, South Nations, Nationalites of people regional states (SNNPRS) Ethiopia. M.Sc Thesis.Hawassa University, Hawassa.