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Fecal Coliform Bactria Extent and Distribution Assessment in Lake Hawassa Watershed

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Abstract

Usually, the life of human beings is determined by how much they get adequate and safe water. Despite its importance, however, water may have adverse effect if the quality is low. Contaminated water mostly leads to exposure of bacterial pathogens such as Salmonella, Shigella, and Vibrio that can cause several types of infections and diseases to those who utilize it. In order to keep the public safety and avoid health risks from pathogens carried by water, gastrointestinal pathogens for instance, there are different bacteriological tests fundamental indicating the presence of specific bacteria thereby assessing the hygienic quality. Hence, this study was initiated with the aim of determining the extent and distribution these water quality indicators exist in Lake Hawassa Watershed, thereby assess the level of risk on public health and ecosystem of the watershed. In order to assess fecal coliform bacteria the present study were considered two major sites; surface and tap water. The presences of fecal coliform bacteria in the collected samples were analyzed in the laboratory by implementing membrane filter technique. All samples were found to be contaminated with faecal coliform and the counts were higher than the maximum microbial contaminant level established by World Health Organization. More than 5 FC/100 ml were recorded from communal borehole water source mostly located in rural parts of the watershed. While samples from public tap water from Hawassa city shows less than 4 FC/100 ml compared to boreholes. Similarly sample analysis from river indicated that most of the samples contained FCB. The maximum FCB was recorded in the upper part of the watershed at Bussa and Shenkora River where the rural population density is much higher. Whereas, the minimum FCB is recorded at Tikur Wuha, which is the only perennial river recharging lake Hawassa. On average, the number of FCB from the sampled rivers was 4.6 per sample whereas 3.3 from tap water. As compared to the tap water, the number of FCB obtained from the sampled rivers was high but not significantly different. Hence, an indication of improper and low water treatment practices and/or lack of well protected water supply mechanisms therefore, a need for an immediate action.

Key words: Water quality; Fecal Coliform; Spatial distribution; temporal distribution

1. Background and Justification

Water is one of the basic required elements to sustain life. Usually, the life of the human being is determined by how much they get adequate and safe water. However, water may have also adverse effect if the sanitation quality is low. Contaminated water leads to expose to bacterial pathogens such as Salmonella, Shigella, and Vibrio that can cause several types of illness and diseases in humans, including gastroenteritis and bacillary dysentery, typhoid fever, and cholera (MWR, 2008). Salmonella and Shigella are two of the most common etiologic agents of bacterial diarrhoea. Sensitive and specific laboratory methods for the isolation, identification, and serotyping of Salmonella and Shigella are key to monitoring and controlling programmes. The ideal diagnostic test for these organisms should be rapid, inexpensive, easily reproducible, sensitive, and specific. Currently however, no single method meets all these criteria (Mikoleit, 2010). As a consequence, coliforms, detected in higher concentrations than pathogenic bacteria, are used as an index of the potential presence of entero-pathogens in water environments. The use of the coliform group, and more specifically *E. coli*, as an indicator of microbiological water quality dates from their first isolation from feces at the end of the 19th century (Berg, 1978).

Fecal indicator bacteria are used to assess the microbiological quality of water. Although these bacteria are not typically disease causing, they are associated with fecal contamination and the possible presence of waterborne pathogens. The density of indicator bacteria is a measure of water safety for body-contact recreation or for consumption (Hijnenet al., 2000). Bacteriological tests for specific indicator bacteria are used to assess the sanitary quality of water and sediments and the potential public health risk from gastrointestinal pathogens carried by water.

Globally, waterborne diseases kill more than 5 million people annually. The bacterial pathogens originate from human and animal feces responsible for most of these deaths (Hunter *et al*., 2002). Fecal material from warm-blooded animals may contain a variety of intestinal microorganisms (viruses, bacteria, and protozoa) that are pathogenic to humans. Consumption of inadequately treated water leads to those water borne diseases. Simple water treatment procedures such as chlorination inactivate the majority of these pathogens (Romney, 2003). However, it must also be noted that certain of these pathogens, such as the protozoan parasites Cryptosporidium and Giardia, are very resistant to chlorine (Carpenter *et al*., 1999; Korich *et al*., 1990 as cited form Romney Hyland *et al*., 2003).

Recent reports of WHO, suggest 80% of all human illnesses in developing world are caused primarily by bacteriological contamination. In Ethiopia, the bacteriological contamination of drinking water has been reported to be one of the most serious problems. The most comprehensive picture of drinking water quality in the country are the results of a national statistically representative survey of piped water supply, boreholes, protected dug wells and protected springs carried out by the WHO and UNICEF in 2004-2005. It shows that 72% of samples complied with the values for coliform bacteria in the Ethiopian drinking water standard ES 261:2001 and the WHO guidelines for drinking water (MWR, 2008). Therefore, the main aim of the study was to identify to what extent and distribution these water quality indicators exist, and to assess the level of risk on people health and ecosystem of the watershed.

2. Methodology

Study area description

The study was conducted in Lake Hawassa Watershed in the central rift valley of Ethiopia. Geographically the area lies between 6^{O} 49'N to 7^{O}15'N latitude and 38^{O}17'E to 38^{O} 44'E longitude, 275 km south of Addis Ababa (figure 1). The agro-climatic zone of the watershed varies from dry wina dega (the west part of the watershed including Hawassa city) to most wina dega (east part of the watershed). The area has a bimodal rainfall pattern form march to April and from June to September, with a total rainfall ranging between 860 mm and 167 mm. On average 80% of the total annual precipitation occurs between June and September. Average maximum and minimum temperature at Hawassa station is 20 ^{O}C and 11 ^{O}C, respectively. It is very hard to get population data based on watershed level since the available data account only regional or local administrative zone or woredas. However, according to Ethiopia central statically agency (SCSA), 2013 projection the total population of the watershed reaches more than 700,000 without accounting nearby Ormia Regional Stat Wordas by the year 2017. It is also known that connected to Hawassa city development the population of watershed expected to increase rapidly compared to other major city of the Ethiopia.

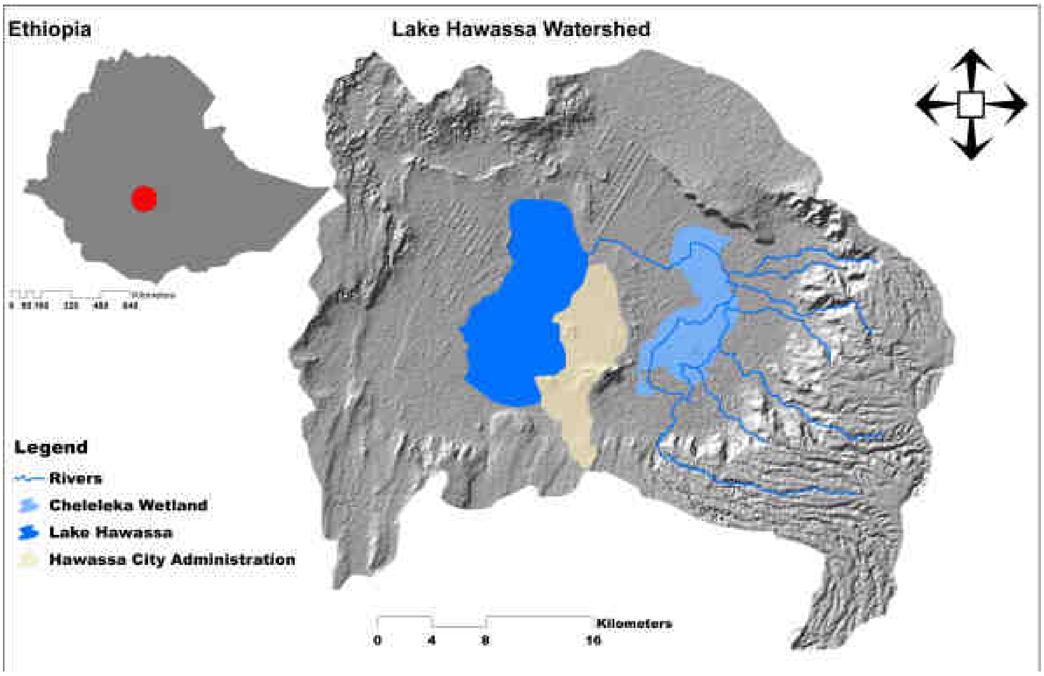

Figure 2: Map of study area

Data Collection Approach

The present study was considered two major study sites; surface and tap waters. Then the watershed was classified in to smaller sub-watersheds (sub-catchments) with the help of GIS. Then From the outlet points of each sub-watershed, water samples were collected at an approximately 30cm depth below the surface of the water. Similarly, the area was searched for tap-water sources and samples were collected for each identified sources. All the samples were collected using sterile 250ml bottles, placed on icebox, which helped the immediate and safe delivery of the samples to the laboratory for fecal coliform cultivation and enumeration.

Data Analysis Approach

Membrane filter technique

In this technique 100ml of the collected water sample was filtered off with 0.45µm pore size (nitrocellulose acetate or polycarbonate, are 150 µm thick, and have 0.45 µm diameter pores) filter paper by using vacuum filtration system. The filter paper was then placed on to the prepared M-Endo MF broth medium plates, which were incubated for 24 hours. The numbers of colonies were then counted using the colony counter as indicated in (Taras *et al*., 1998). When the water sample was filtered, bacteria (larger than 0.45 µm in size) in the sample were trapped on the surface of the filter. The filter was then carefully removed, placed in a sterile petri plate on a pad saturated with a liquid medium, and incubated for 24 hours at 35°C. By counting the colonies one can directly determine the number of bacteria in the water sample that was filtered.

Media preparation

In order to enumerate the fecal coliform filtered off by membrane filter technique, Endo broth media was prepared according to the company's instructions. The media comprised di-potassium hydrogen phosphate 3.5 g/l; lactose, 10 g/l; peptone, 10 g/l; and sodium sulfite, 2.5 g/l. The media was autoclaved at 121^{O}C for 15 minutes. A sterile absorbent pad aseptically placed on the plate and 2ml of the autoclaved media was added on the absorbent pad. Then after, the filtered membrane filter was placed on the Endo-broth media. E-broth plates which were incubated for 24 hours and the number of colonies were counted using the colony counter proposed by (Taras *et al*., 1998). The red colonies were then identified as the total coliform bacteria whereas the blue ones as fecal coliform bacteria.

3. Result and Discussion

Fecal coliform bacteria in drinking water

The result of the present study confirmed that all tap/drinking water samples were contaminated with fecal coliform bacteria (Fig 1.). The maximum and minimum fecal coliform bacteria were recorded as 8 FC/100 ml and 1 FC/100 ml, respectively. Both the highest and lowest values were obtained from nearest to the lake Hawassa. While samples from public tap water from Hawassa city shows less than 4 FC/100 ml compared to boreholes (figure 2). From sixteen samples, only one meets the minimum standard, which is seated by World Health Organization (WHO). Usually, drinking water is recommended to be free from any bacterial population. However, one per 100 ml may be acceptable (WHO, 2003). In this respect, almost 14 of the samples exceed the limits.

A total of 16 samples, 100 % revealed growth of coliform (Fig. 2). The detection of coliforms in large numbers implies that the contaminated water may be responsible for increasing number of water borne diseases in the city. The present study supports that the quality of drinking water in Ethiopia is not up to the WHO standard.

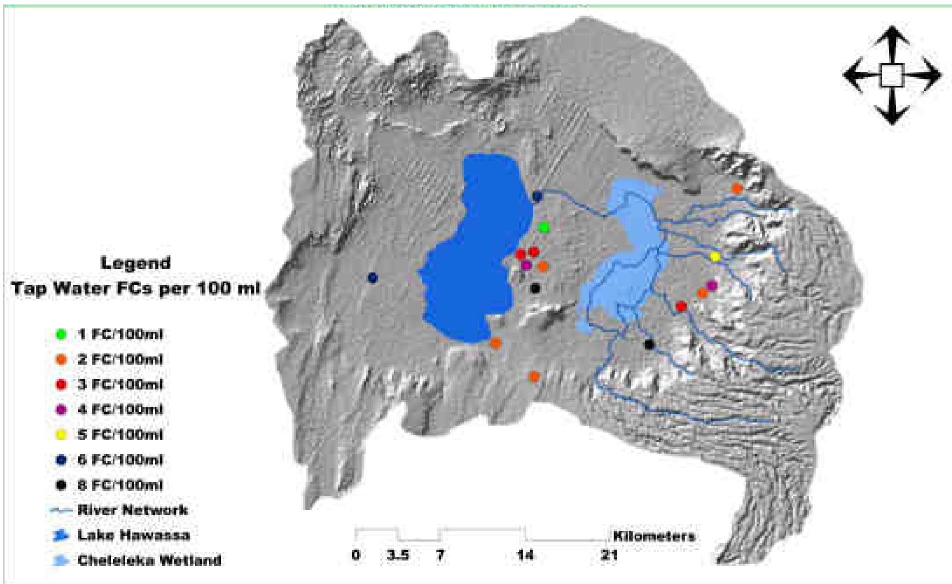

Figure 2 Tap Water Fecal Coliform Bacteria

Results from various investigations provide evidence that most of the drinking water supplies are fecally contaminated. This makes the water unsuitable for drinking. The presence of fecal coliform (*E. coli*, *Vibrio*, *Klebsiella*, *Enterobacter*) species and other bacteria not only make the water unsuitable for human consumption, but also poses serious health concerns (WHO, 2011). According to Ethiopian Ministry of health (Moh), 2005 report, in the country more than 250,000 children die every year from sanitation and hygiene related diseases. Although, most of the people living in the watershed have accesses to drinking water, the biological quality of water is classified as poor because of presence of FCB. The present study also supports the above reports in regards that the quality of drinking water in many parts of the study area is not acceptable. The high faecal coliform count in the consumers' tap and distribution line might be due contamination of water from the sewerage from where the damaged distribution line passes. Drinking water quality in both, urban and rural areas of the study area is not being managed properly.

A similar drinking water quality assessment study in Ethiopia which is carried out by WHO and UNICEF showed that 70% of the water samples from piped water supply, boreholes, protected dug wells complied with the values for coliform bacteria in the Ethiopian drinking water standard ES 261:2001 and the WHO guidelines for drinking water (MWR, 2008).

Fecal Coliform bacteria in surface water

Sixty samples from fifteen sample points were taken from the rivers and all the samples were collected one per week for a month. Since almost all perennial and intermittent rivers are exist in the upper catchment (tikur wuha sub- catchment) of the study area many of the samples were taken in this region.

The study revealed that (Table 1) most of the samples contained fecal coliform bacteria. The maximum FCB was recorded in the upper part of the watershed at Bussa and Shenkora river where the rural population density is much higher. Whereas, the minimum FCB was recorded at Tikur Wuha, which is the only perennial river recharging lake Hawassa. It was expected that bacterial populations were much higher in this particular place since the cumulative flow of the upper catchment water enter Lake Hawassa through this point. However, due to the acidic nature of the water as result of toxic substance released from textile factory the bacterial population in this point is recorded low. Although the number of FCB at TIkur wuha is low relative to upper catchment of the watershed, the risk level of the rest samples at Hawassa city shows that high since most of the samples confirmed presence of the bacteria and exceed the WHO recommended levels. Similar study has been reported by Brian and Elizabeth, 2000; Fecal-coliform bacteria concentrations in the Chattahoochee River were low downstream from Buford Dam, especially nearest the dam, because of dilution from water released from near the bottom of Lake Sidney Lanier.

Table 1. Counted surface water fecal coliform bacteria per 100ml from the selected sampling points

Sample points	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
1st round	3	6	6	6	14	19	6	7	2	0	2	2	4	1	0
2nd round	6	2	6	4	3	1	4	3	0	0	5	5	2	1	0
3rd round	2	1	0	11	2	3	0	4	1	2	0	3	8	1	0
4th round	9	3	5	3	5	5	1	3	8	7	4	2	2	3	1

Note: S- sampling points

Comparison of surface and tap water

Results of the number of faecal coliform bacteria obtained from surface water and tap are presented in (Table 1 and fig 2). On average, the number of FCB from the sampled rivers was 4.6 per sample whereas 3.3 from tap water. Accordingly, it was found that the number of faecal coliform bacteria obtained from surface water (3.642) was higher than the tap water (3.611). However, there was no significant difference between the two sample sites (Table 2). More than 5 FC /100 ml are record from communal borehole water source mostly located in rural parts of the watershed (figure 2). These results correlate with another study by Shar et al (2008) in which all the samples of tap water (100%) were found to be contaminated with coliforms. This study also revealed that more contamination was found in consumer taps, followed by the distribution lines and reservoirs. Therefore these samples were all unsatisfactory for human consumption. These samples may have cross contamination with sewerage pipelines and also the level of biological treatment is very low.

Table 2. Distribution of FCB between surface and tap water

Distribution of coliforms	**Fecal coliform Bacteria**	
	Surface water(Rivers)	**Tap water**
FCB	3.642[a]	3.611[a]

* The mean difference is not significant at the 0.05 level.

Accordingly, it was found that the number of faecal coliform bacteria from surface water was not significantly different from the tap water at 5% confidence level.

Spatial and Temporal distribution of FCB

In ordered to assess the spatial and temporal distribution of FCB, first the watershed was classified in to sub catchments by considering the sample points as an outlet. Since the samples were taken during rainy season, it was assumed that the samples represent the whole catchment. The result obtained from laboratory was then imported in to GIS and used to map the spatial distribution of FCB for each sub catchments.

Water borne bacterial concentrations are highly variable over time and space. Temporal variability is due to relative rates of bacterial growth/die-off and to episodic re-suspension and redistribution of nutrients due to rainfall events, while spatial variability is due to stream bed heterogeneity. Accordingly, it was found that on average 6.5 CF/ 100 ml/ month maximum from upper middle of the watershed and 0.25 CF/ 100 ml/month in lower catchment. Figure 3 clearly show how much risk level is serious in rural and rural city of the catchment.

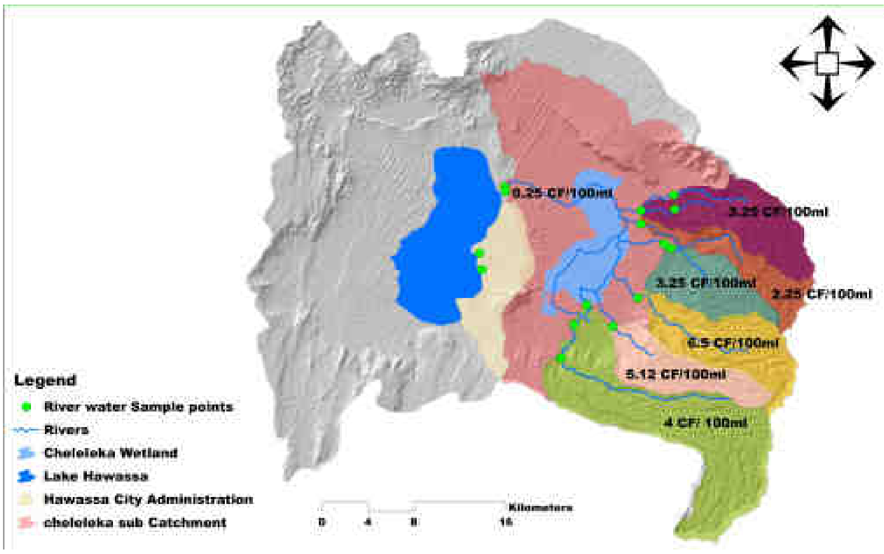

Figure 3 Spatial Distribution of fecal coliform bacteria

Seasonal dynamics in fecal coliform concentrations in water have been documented by several authors. Goyal et al. (1977) observed higher numbers of FC in canal sediments in winter than in summer, and attributed these differences to lower die-off rates in winter months. On the other hand, Crabill et al. (1999) encountered differences of 3 orders of magnitude between sediment FC concentrations in summer versus winter. The frequent flushing of sediments during the winter melt has been suggested as a possible cause of the decrease of the sediment FC population in winter (Crabill, 1999). Buckley et al. (1998) observed more than a twofold difference between E. coli sediment concentrations in wet and dry periods for a subtropical rainforest creek.

4. Conclusion and Recommendation

The microbiological drinking water quality in Lake Hawassa watershed is below WHO standards. The study indicated that most of the sampled tap water is contaminated with fecal coliform bacteria. The presence of fecal coliform in all sampled rivers and the tap water with no significant difference means that the level of treatment taken for each tap water is low or the water supply systems are no well-functioning and needs to take necessary measure.

The spatial and temporal distribution of fecal coliform bacteria is much higher in the upper part of the watershed (Wosha, Worka and Bussa) where highly populated and rural population lives. This implies, either the sanitation and hygiene awareness of people less or waste management system of the area have some kind of problem and hence need to identify source of the coliform and take remedial measure.

This research assesses only fecal coliform bacteria, which is the main indicator of water quality. However, also other bacteria types can help to measure the quality of water such as Escherichia coli, fecal streptococci, and enterococci. Determining these bacteria helps to identify weather the contamination is from human or animal wastes. Therefore, it is recommended to identify those bacteria and gets more information so the health of the environment and the people could be improved.

In not much different perspective, since there is a higher possibility for much of the FCB to come from the human wastes, creating awareness about waste management and its benefits should be given a due attention.

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5. References

Abdul H., Sidra S and Usman AM (2010). Bacteriological analysis of drinking water from 100 families of lahore by membrane filtration technique and chromagar. Journal of Biomedica, Lahore 26:152-156.

Adejuwon JO, Adelakun MA (2012). Physiochemical and bacteriological analysis of surface water in Ewekoro Local Government Area of OgunState, Nigeria: Case study of Lala, Yobo and Agodo Rivers. Int. J. water Res. and Environ. Engr., 4(3): 66-72

Ajayi AO, Akonai KA (2005). Distribution pattern of enteric organisms in the Lagos Lagoon. Afr. J. Biomed. Res., 8(3): 163-168.

Berg, G. (1978). The indicator system. In Indictors of Viruses in Water and Food (ed.G.Berg), pp. 1–13, Ann Arbor Science Publishers, Ann Arbor, MI.

Cruickshank R (editor). Bacteriology of Water, Milk, Ice-Cream, Shell-Fish, Other foods, Air.In: Medical Microbiology. 1965; 11th edition: 961-76.

Franceska D. Wilde(edt), (2008). National Field Manual for the Collection of Water-Quality Data.U.S. Geological Survey TWRI Book 9.

Hijnen W.A.M., Veenendaal D.,. Van der Speld W.M.H, Visser A., Hoogenboezem W. and Van der Kooij D. (2000).Enumeration of faecal indicator bacteria in large water volumes using on site membrane filtration to assess water treatment efficiency.Water Research,34:73-86.

Mikoleit ML (2010). Isolation of Salmonella and Shigella from Faecal Specimens. Centers for Disease Control and Prevention Atlanta, GA; USA, 1-15.

Okonko IO, Adejoye OD, Ogunnusi TA, Fajobi EA, Shittu OB (2008). Microbiological and physicochemical analysis of different water samples used for domestic purposes in Abeokuta and Ojota, Lagos State, Nigeria. Afr. J. Biotechnol., 7(3): 617-621.

Romney Hyland, James Byrne, Brent Selinger, Thomas Graham, James Thomas, Ivan Townshend and Victor Gannon, (2003). Spatial and Temporal Distribution of Fecal Indicator Bacteria within the Oldman River Basin of Southern Alberta, Canada, Volume 38, No. 1, 15–32.

South Carolina Department of Health and Environmental Control. (2010). Watershed Water Quality Assessment: Salkehatchie River Basin. Technical Report No.03F-10.Bureau of Water, Columbia, S.C.

WHO, (2011). Guideline for drinking water quality 4th ed. Geneva 27, Switzerland, ISBN 978 92 4 1548151.