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The Practices and Challenges of Cleaning and Disinfecting Water Storage Tanks in the City of Addis

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Abstract

Water storage tanks, which are not cleaned and disinfected regularly, undergo a complex interaction with the environment and bring deterioration on the quality of water and thereby health-related problems. This study assessed the practices and challenges of cleaning and disinfecting of household water storage tanks in Yeka and Bole sub-cities of Addis Ababa. Structured and semi-structured interviews, questionnaire and field observation were conducted to collect data on a range of variables such as the number of years the water storage tank is used, the practice of cleaning water tank, the awareness of the society towards cleaning and disinfecting water storage tanks, the frequency of cleaning and disinfection, and how they treat water for consumption, etc. Questionnaire was distributed to a total of 197 respondents, of which 190 of them (96.4% response rate) responded and were included in the analysis. For water quality assessment, 12 water samples were taken direct from household's reservoir tanks. The collected data were analyzed using descriptive statistics, and laboratory analysis. The results of the study indicated that households give little attention to water storage tanks cleaning and disinfecting. Unavailability of professional water storage tank cleaners, inaccessibility of the location of the water storage tanks, lack of awareness of household's on the sanitary condition of their tanks and lack of modern tank cleaning and disinfecting equipment and products, are some of the challenges that hindered household's water storage tank management. The results of laboratory analysis on water samples taken indicated that a significant level of water-borne pathogens exist in the water storage tanks that deteriorate the quality of water for consumption, which makes it unsafe for use. Thus, using water from water storage tanks for consumption purpose has a severe impact on household's health. Regular monitoring and examination of water storage tanks for the presence of photogenic organisms, chemicals and physical parameters should be made. Furthermore, to maintain the health status of the dwellers of the city, awareness on the safety-level of household's stored water should be created.

Keywords: Water storage tanks, water-borne pathogens, health risk, water tanks management, Addis Ababa, Ethiopia
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1. Introduction

1.1 Background of the Study

Having safe drinking water and basic sanitation is a human need and right for every man, woman and child. People need clean water and sanitation to maintain their health and dignity. Having better water and sanitation is essential in breaking the cycle of poverty since it improves people's health, strength to work, and ability to go to school.

Yet, 884 million people around the world live without improved drinking water and 2.5 billion people still lack access to improved sanitation, including 1.2 billion who do not have a simple latrine at all (WHO/UNICEF, 2008). Many of these people are among those hardest to reach: families living in remote rural areas and urban slums, families displaced by war and famine, and families living in the poverty-disease trap, for which improved sanitation and drinking water could offer a way out.

Water is an essential resource for life and used by everyone, every day. Not only do all people need drinking water to survive, but water plays an important role in almost every aspect of our lives – from recreation to manufacturing computers to performing medical procedures. When water becomes contaminated by parasites, however, it can cause a variety of illnesses (CDC 24/7). Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. Provision of water and sanitation also plays an essential role in protecting human health during crisis and disease outbreaks. Most water-borne diseases cause diarrheal illness. Other water-borne diseases can cause malnutrition, skin infections, and organ damage. Pneumonia and diarrheal diseases are the two biggest killers of children under 5 years old, accounting for 18% and 15% of all deaths respectively in 2008 (Angeliki, 2011).

Worldwide, diarrhoea claims the life of 2 million children each year, of which 22% deaths occur in sub-Saharan African countries. The burden of diarrheal morbidity prevails largely in the developing world where water quality and sanitation and the general living conditions remain poor. For example, in Africa, a child below the age of five years experiences five episodes of diarrhoea per year, and 800,000 children die of diarrhoea and dehydration each year. The World Health Organization (WHO) report in 2004 rated Ethiopia as the 4th among the 15 countries with the highest child deaths due to diarrhoea, which was estimated to be 86,000 children. The annual report published in 2008 by the Federal Ministry of

Health of Ethiopia showed that diarrhoea is the 4th leading cause of morbidity at the national level (Merga and Alemayehu, 2015).

Stored water quality deterioration is a big issue in many countries water supply system, which may be a result of many interconnected physical, chemical, and biological factors. It may or may not be at the source only rather it may happen in a storage tanks. Moreover, it is also very difficult to identify strictly the cause as well as a place of pollution. Because of this by assessing the quality of water at its storage based on physical, chemical, bacteriological parameters different reports showed the problem of significant level of water pollution both at source of distribution systems and storage tanks. The World Health Organization (WHO, 2008) estimates that 88% of diarrheal disease is caused by unsafe water, inadequate sanitation and poor hygiene. As a result, more than 4,500 children die every day from diarrhoea and other diseases. The report from UNICEF (2010) shows that, about 672 million people will continue using unimproved drinking water sources in 2015. The WHO (2000) revealed that 75% of all diseases in developing countries arise from polluted drinking water. The lack of access to water also limits sanitation and hygiene practices in many households because of the priority given for drinking and cooking purposes.

Water quality concerns are often the most important component for measuring access to improved water sources. According to world health organization acceptable quality shows the safety of drinking water is in terms of its physical, chemical and bacteriological parameters (WHO, 2004). User communities' perceptions of quality also carry great weight in their drinking water safety (Doria, 2010). Depending on their perception on taste, odour and appearance (Sheat, 1992; Doria, 2010), this can lead to having different opinions about the aesthetic values of water quality. Consumer perceptions and aesthetic criteria need to be considered when assessing drinking water supplies even though they may not adversely affect human health (WHO, 2004). There are several reasons to clean and disinfect water storage tanks regularly including: to kill or prevent the survival of waterborne pathogens (bacteria, viruses, and other microorganisms) that can cause gastrointestinal and other diseases; to prevent the accumulation of scale and slime (biofilm), which can be sources of contaminants and can also harbour pathogens; and to control the accumulation of sediments and algal growth, which degrade the taste and odour of potable water (Jonick el al 2012).

Countries adopt rules according to their condition to clean and disinfect water storage tank regularly. For example in October, 2014 the USEPA (United state Environmental Protection Agency) developed a rule for cleaning water storage

tanks and towers and inspecting it to remove the sediment from water storage tanks and towers. Sediment enters the tank one particle at a time and eventually accumulates enough for bacteria, protozoa and even viruses to use it as a habitat, grow and become a serious health problem. If proper inspections are not done to determine sediment levels, corrective action is seldom, if ever, taken. Therefore, potable water storage facilities should be inspected inside and out every year, and a cleaning program to assure all drinking water tanks and towers are cleaned every 3 to 5 years to improve the water quality for millions of Americans (Perrin, 2014).

The state of Texas requires all potable water storage tanks to be inspected at least once a year. TCEQ (Texas Commission on Environmental Quality) rules state: Each of the system's ground, elevated, and pressure tanks shall be inspected annually by water system personnel or a contracted inspection service (Allen et.al 2014). Furthermore, in the Emirate of Abu Dhabi the Code of Practice for the Inspection and Cleaning of Customer Water Storage Tanks (CP/T03/100,09 March 2014) is issued by the Bureau in support of the Water Supply Regulations and Water Quality Regulations and has been developed to put in place water tank cleaning and inspection requirements and guidance to ensure that water quality and wholesomeness supplied and subsequently received by customers is protected and maintained beyond the distribution network and to the customer's taps. The Code details the regulatory requirements for building owners or managers and for water storage tank cleaning and inspection companies. The Code also provides good practice guidance to building owners and managers; water tank cleaning companies; and water tank inspection and sampling companies on methods for the safe and effective cleaning, disinfection and/ or sampling and testing of the most common types of water storage tanks (Emirate of Abu Dhabi, 2014).

1.2 Statement of the Problem

Ethiopia has made remarkable progress in water and sanitation over the last two decades. According to WHO/UNICEF (2014), the country has improved water supply by 57% (97% in urban areas and 42% in rural areas), thus achieving the Millennium Development Goal (MDG). Although the sanitation target has not yet been achieved, there has been tremendous progress during the past decade in improving sanitation. As a consequence, governmental & nongovernmental organizations made efforts to construct improved sources to provide access to safe and potable drinking water. Nevertheless there is always a regular breakdown of electric engine that is used to pump water (Addis Ababa Water and Sewerage Authority 2008 E.C official report). Hence the majority of residents do not have access to safe pipe water and they are obliged to store water. Accordingly, the

unavailability of tanker cleaners and awareness of water borne diseases to resident put people at serious consequence to health and hygiene risk. Bole sub-city Health Office (2003) indicated that among the top ten diseases registered in the area, waterborne disease take the highest rank and among all typhoid, cholera, helminthiasis and diarrhoea were the most rapidly occurring waterborne diseases. On the other hand, the Addis Ababa water and sewerage Authority claims that the quality of the water being distributed to the population is monitored and generally safe for drinking (Alemayehu et al., 2005).

Thus, un-cleaned water storage tanks and infected stored water are probably the cause of water quality deterioration and use of infected stored water may have a chance to cause waterborne diseases. Removing the sediment and keeping water tank clean is the best way to maintain health water system. The study done by Schafer and Mihelcic (2012) investigated how the materials used to construct large household water storage tanks and how user maintenance influenced the physical, chemical, and microbial quality of the stored water and also frequent storage tank cleaning (three or more times per year) can reduce the likelihood of contamination of the stored water. Additionally study by Bushman and kroon (1998) point out protecting water storage tanks from corrosion through the application of cathodic protection devices is an accepted practice (Bushman and Kroon, 1998).

Several studies were done regarding to household water storage tank in different countries and different researchers for example; the study done by Evison and Sunna (2001), found that water temperature inside the tank and tank age were the parameters for bacterial growth. The study undertaken by Tokajian and Hashwa (2003), in rural Bolivia, found that the stored water deteriorated significantly microbiologically after 7 days. Other study done by Omisca (2016), in Malawi found that fecal coliform levels increased in household storage containers after only 1 hour of storage. In addition Robert et al., (2001), in rural Honduras, chlorinated water in storage containers contamination was only eliminated for the first 4 hours after collection. After 6 hours of storage, there was considerable microbiological growth. Moreover Trevett et al., (2004) found that source water quality appeared to be a significant factor in determining household water quality and that storage factors. Furthermore, the study overtaken by Schafer (2012) in Tiquipaya, Bolivia found that storage tank material and infrequent or lack of storage tank cleaning can affect drinking water quality. Also storage tank material affects water quality most likely because of different water temperatures inside the tanks.

However, in Ethiopia specifically in Addis Ababa an integrated study has not been done on the bacteriological quality of stored water in tanks and as well as on the hygiene and sanitation practices of the consumers. Therefore, to fill the gap in information on the quality of stored water in tanks and to assess the hygiene and sanitation practices of the community in the city of Addis Ababa this study is initiated.

1.3 Objectives

1.3.1 General Objective of the Study

The main objective of the study was to assess the practices and challenges of cleaning and disinfecting drinking water storage tanks in the city of Addis Ababa.

1.3.2 Specific Objectives

The specific objectives of the study were;

- To determine the water quality status of drinking water stored in tanks and explain its associated risks;
- To assess the public practice and opinion of drinking water from storage tanks;
- To assess the practices of cleaning and disinfecting water storage tanks;
- To assess the challenges of cleaning water storage tanks.

1.4 Research Question

This study planned to answer the following research questions;

- What is the health effect of using infected tanker water?
- How frequent the water storage tanker cleaning?
- How is the awareness of the society regarding cleaning and disinfecting there water storage tanker?
- What are the major challenges on cleaning and disinfecting water storage tanker?
- What are the practices of cleaning and disinfecting water storage tanker?

1.5 Significance of the Study

The information from the study about the condition of water tank quality and contamination can be used by the government to take necessary initiatives for immediate prevention. Government organizations (Ministry of Health and Water and Sewerage Authority) can benefit from the research finding to adopt preventive health measures. Regulatory bodies (Ministry of Water resource and or water resources development bureau) can use the results of this study in regulating and

planning activities related to water quality. And Addis Ababa society can aware about the condition of their water storage tanker and can take necessary treatment action to improve health effects.

1.6 Scope and Limitation of the Study

1.6.1 Scope of the Study

The study focused on the strategy of conventional and properly managed drinking household water treatment and safe water storage practices in Addis Ababa, particularly in the Bole and Yeka sub cities. The emphasis was to identify the practices and challenges of cleaning and disinfecting drinking water storage tank and assessing its sanitation situation.

There is a growing body of evidence that distribution systems can cause a decrease in the quality of water, which can lead to illness in consumers in developed countries (e.g. Craun and Calderon, 2001), emerging countries (e.g. Mermin et al., 1999; Basualdo et al., 2000; Egorov et al., 2002) and developing countries (e.g. Agard et al., 2002; Lee and Schwab, 2005). As stated above, there are several reasons to contaminate drinking water, even though this study confines (limited) itself only to the issues of drinking water storage tanker accessibility and inadequate basic sanitation practice.

1.6.2 Limitation of the study

Contextually, it was restricted to the study of only two sub-cities water storage tank cleaning and disinfecting practice and challenge of Addis Ababa City, and thus finding was extrapolated to other sub-cities. And also unidentified number of product of water storage tank in the city was another constraint to select sample size. This study was not immune from limitations. Even due to high professional cost to laboratory test this present limited in bacteriology and physicochemical parameters, scope and sample size.

1.7 Organization of the Thesis

This thesis has five main chapters. The first chapter deals with the introductory aspect of the paper whilst chapter two deals with the review of related literature relevant to the objective of the study by referring standard journals, reference books and conference proceedings. Chapter three presents the data collection methodology used in the study whereas chapter four dedicates data discuss results and discussion of finding, and finally, chapter five presents the conclusion and recommendations of the study.

2. Research Methodology

The purpose of this chapter was to provide an overview of the research methodology adopted by the study. It included the data types and source, study area, population, sample and sampling designs, data collection instruments, and methods of data analysis.

2.1 Research Approach and Design

This study adopted both quantitative and qualitative approach. In making inference the researcher used a combination of both descriptive design and laboratory analysis. Descriptive study design, as the name implies, is used when the researcher wants to describe specific characteristics as it occurs in the environment. Descriptive research involves three main categories: observation, case studies, and surveys (Clause, 2016). In this study, this design helped to examine the sanitary condition of the study area, and to assess attitude and practice of water storage tanker management of residents of Addis Ababa. The sanitary conditions of the study area were assessed using questionnaire. The experimental method using laboratory analysis is the only method of research that can help to check and objectively test evidence collected through observation and questionnaire. This study used laboratory/experimental approach to assess the physicochemical and bacteriological quality of drinking water stored in water storage tank.

2.2 Population and Sampling

According to the CSA (2007), Addis Ababa has a total population of 3,384,569, with an annual growth rate of 3.8%. This number has been increased from the originally published 2,738,248 figure and appears to be still largely underestimated. The city is administratively organized in ten sub-cities in which Bole and Yeka sub city are among them consisting of 14 and 13 Woredas respectively. Bole and Yeka sub-cities are inhabited by 173,000 and 42,000 people respectively. In analysing the practice and challenges of cleaning and disinfecting water storage tanks in the city of Addis Ababa specifically at Bole sub city Woreda 10 from new area and Yeka sub city Woreda 8 from old resident area, focus has been given to households which are using water storage tanks at their resident. Since there is no full data about number of water tanks users in Addis Ababa, to conduct the study first the researcher selects sub-cities, and then selected two Woredas purposively for the reasons that these sub-cities dominantly use water storage tanks.

The total household population of the two Woreda is 215,000. If, on average, one household has 5 family members, the expected permanent resident in two Woredas

are 43,000 households. Among them at Bole sub-city of Woreda 10 more than 18,000 and at Yeka sub-city of Woreda 8 around 3, 400 households are living in Condominium houses with no water storage tanks. Among the rest of 21, 600 households, 6,600 households are living in common private buildings at Bole sub-city of Woreda 10. Yet, again among the rest of 15,000 households 40% of them are fairly expected to use a water storage tank, which means 6,000 households (Source: Personal communication with Woreda 8 and 10 Vital statistics office, 2016).

Sampling is the act, process, or technique of selecting a suitable sample, or a representative part of a population for the purpose of determining parameters or characteristics of the whole population (Webster, 1985). The research applied a simplified formula provided by Yamane (1967) to determine the minimum required sample size at 95% confidence level, degree of variability= 0.5 and level of precision (e) = ±7% to calculate sample sizes.

$$n = \frac{N}{1+ N(e)^2}.$$

Where n is sample size, N is the total number of study population 6,000

Where e is the level of precision 7%

Using the total population of 6,000 and level of precision of 7%, the sample size is calculated as follows.

$$n = \frac{6,000}{1+ 6,000(0.07)^2}.$$

$$n = \frac{6,000}{1+6,000*.0049}. = 197$$

Since people attitude and practice are different, the total numbers of sample household were used to fill the questionnaires. By using proportion a total of 110 household units from Bole Woreda 10 and total of 80 household sampling points from Yeka Woreda 8 were used. In Yeka after sorting house number in ascending order, the first house was selected by lottery method and the next was elect purposely. In Bole the first sampling point selected seven resident associations randomly and elected 10 residents among each association cooperatively, (each resident association was holding 24 households). These works were done at Saturday and Sunday to meet Household head or the person who played the main role in the decision making process of a family. On the other hand, the participant of interviews and field observation were selected purposively. The selection

criterion included knowledge and the use of water tank for a long time, in addition water sample to test physicochemical and bacteriological quality of drinking water at storage tank to Addis Ababa City Administration Health Research and Laboratory Service was elected by all type of tanks.

2.3 Data Sources and Data Collection Instrument

Primary data were collected to attain the research objectives regarding the practices and challenges of cleaning and disinfecting drinking water storage tanks from residents of Bole and Yeka sub cities by using questionnaire survey and interview checklists. In addition, field observations were made. Secondary data were collected from different government offices and respective sub-cities. Primary data were collected through survey/questionnaires, interviews, observation and laboratory test.

Survey/Questionnaire: This has been used to collect information from Addis Ababa residents at study site. For this purpose structured questionnaires were developed and administrated that obtains quantitative data on issues regarding the practice and challenges of cleaning and disinfecting water storage tanker based on the selected indicators.

Interviews: Household head means the person who plays the main role in the decision-making process in a family. He/she were selected to answer the questions, and in absence of the household head, the second important adult member of the family was selected.

Field Observation and Sanitary Survey: It refers to field observation and water storage tank survey through observation using checklists. A checklist having number of questions were prepared for assessing the sanitary services, handling system of water storage tank, placement of drinking tank water and other basic environmental condition on the study area.

Water sample: 12 tank water samples were collected and analyzed for different parameters at Addis Ababa City Administration Health Research and Laboratory Service laboratory.

2.4 Data Analysis Technique

The methods that the researcher used to analyze all gathered data concerning each study parameters and environmental conditions from checklist and observation results were frequencies, means, Percent, maximum and minimum values. The results are presented in tables and figures to describe of some important variables and laboratory test results. Tank water analyses have been compared against

standards set by WHO (2004) and Federal Democratic Republic of Ethiopia, Ministry of Water Resource (MoWR, 2002). The analysis was done using IBM SPSS Version 20 Statistics software.

3. Results and Discussion

3.1 Introduction

This chapter presents the main findings of the study on sanitary inspection of the residents' water storage tanks. The results presented in this chapter sought to achieve the objective of the study, which was to determine the quality of drinking water stored in tanks, explained its associated risks and assess the public practice, opinion and challenges of cleaning water storage tanks in the study area. This chapter, accordingly, presents the descriptive findings of the study and gave a brief overview of the constraints confronting societies in cleaning and disinfecting their drinking water stored tanks. The results of the data analysis using descriptive statistics were used to describe the frequency of water storage tanks cleaning and the challenges faced while the laboratory test was employed to present the status of water storage tanks in terms of its quality, standard and to draw implications to associated health risks.

3.2 Demographic Characteristics of the Society

Age of Respondents: The ages of the respondents ranged from 22 to 55 years with mean of 39.8 years. The mean age of respondents did not have a major difference in the distribution of the sampled respondents. Age has very little influence on the decision to participate. This was attributable to the fact that all groups belong to the same population and the variable in question did not lend itself to change based on participation or otherwise.

Family Size: The average household size for the respondent was found between minimum 4 and maximum 9 with mean of 5.88. This result suggested that the frequency of water consumption was an important factor to shorten or lengthen water storage time period at the household level.

Level of Education: The average level of education for the respondent was between 41.6%, 34.2%, and 24.2% for Diploma, 1st Degree, and Master's Degree respectively (Table 4.1). This result was important, suggesting that education is the means to have better attitude to sanitation and better opinion about water quality deterioration and its associated risks as well as storage handling practice, meaning that this variable influences those participating in drinking water storage and handling processes in the study area.

Table: 4.1 Demographic Variables of the Participant

Variable definition	Variables	Frequency	Percent
Gender	Male	120	63.2
	Female	70	36.8
	Total	190	100.0
Family size	4	34	17.9
	5	71	37.4
	6	28	14.7
	7	16	8.4
	8	22	11.6
	9	19	10.0
	Total	190	100.0
Educational level	Diploma	79	41.6
	College degree	65	34.2
	Master	46	24.2
	Total	190	100.0

3.3 Practices and Challenges of Water Storage Tank Management

The study areas mainly receive their water directly from AAWSA (Addis Ababa Water and Sewerage Authority) tap network system and using three types of water storage tanks such as metal (steel), fiberglass and plastic (plotline) for their household reservoir. This discussion played attention only to those three types of water storage tanks. Its schematic representation is presented in Figure 4.1 Even though detailed survey was undertaken from the household reservoirs up to the end uses. In or this study, rough observation of inlet or external part of tanks was also made. Potential sources of pollutants such as corrosion, unsecure cap, poor inspection, weeds and vegetation around the exterior of base of the tanks, grow of algae, sediment etc exist in and outside the drinking water storage tanks. As such, the under listed activities were planned to be discussed by this study.

Management of drinking water storage tanks primarily involves maintaining stored water quality, and minimizing the risk of contamination and deterioration of quality during storage. But this activity was not given attention like the above mentioned ones.

3.3.1 Main Source of Drinking Water

Regarding the communities' source of drinking water, in the study areas, the following results were gained. 72.1% of them got it from tap water, 8.4% from tanks and 19.5% from bottled water. 72% of those who were using direct tap water, they were not using the water for drinking but they used it for some other purposes like washing dishes, brushing teeth, bathing etc., and it was highly probable that this might have contaminated water borne diseases.

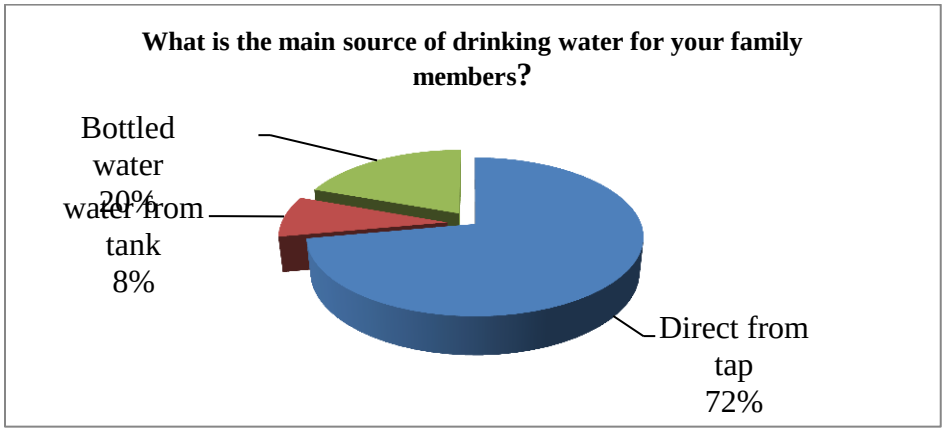


Figure: 4. 1 Main Source of Drinking Water for Family Members in Two Sub Cities

From the total household assessment, the main source of drinking water in the study area was AAWSA tap water. Even though daily labourers who are working in cobblestone and farmers living in Bole sub city Woreda 10 were using water provided through truck, this was excluded from the study because it didn't match with the objective of the study. According to the informal discussion with the community, for most of the people in Bole Sub-City Woreda 10, the existing municipal water supply service in the area was not bad. However Woreda 10 is an expansion area of the Sub city with changing life style of the society almost all the new buildings were with water storage tanks and the water system for household use was not direct from the tap but rather it was from the storage tank, As a result, people were forced to use stored (tank) water in their day-to-day consumption. Also due to the big size of their water storage tanks and small size of family members, most of the residents were storing water for more than 8 days. Water age was managed by normal turnover of a tank's stored water and daily water level fluctuations,

The American Water Work Association AWWA, (2012) report recommends that water in storage tanks be turned over about every 2.5 days to minimize water age and maximize water quality. This turnover rate translates to a 40 Percent daily turnover in tank volume. If water storage tanks are not turned over every 2.5 days, the operating range should be increased. Laboratory study discovered factors such as long retention times of 4 to 7 days, increase microbial re-growth in commonly used 1000 L fiberglass, polyethylene and cast iron household storage tanks (Evison and Sunna, 2001)

On the other hand, in the Yeka Sub city Woreda 08, the existing municipal water supply service was very bad because there was no continuous supply of tap water. Sometimes they did not have access to water supply for weeks and they were obliged to make minimum usage of their household water for a week. In addition, in this area, residents were experiencing year's long use of water storage tanks, According to the field observation of this study, most of the old metal or steel tanks were being replaced by fibre glass and plastic tanks. Although there were several metal tanks in the study areas, these were much likely to rust and possibly to contaminate household water.

3.3.2 Assessment of the Society Awareness

As shown in Figure 4.2 of the questionnaire distributed about 51.6% of the communities do not expect that their tank water would be contaminated. This was due to their inadequate knowledge about their stored water quality deterioration and absence of appropriate education from water and health sectors.

Even though all of them have good understanding of waterborne diseases, they did not expect that it occured in big cities like Addis Ababa because tap water was treated by AAWSA and it was not infected. This might rather be a problem in rural areas. Due to this, the habit of cleaning and disinfecting water storage tanks was very low. In other words the Sub-city water sector and health office did not try to undertake any activity to advance consumer's knowledge of water storage tank cleaning and stored water quality deterioration, and the practice that must be taken to minimize hazards related to usage of poor stored water quality.

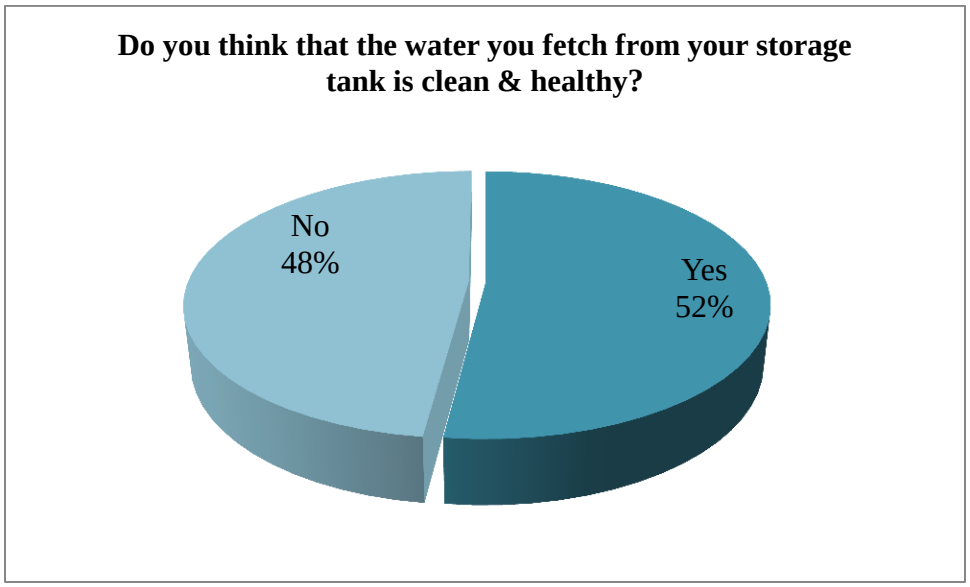


Figure: 4. 2 Expectations of the Society Regarding Tank Water

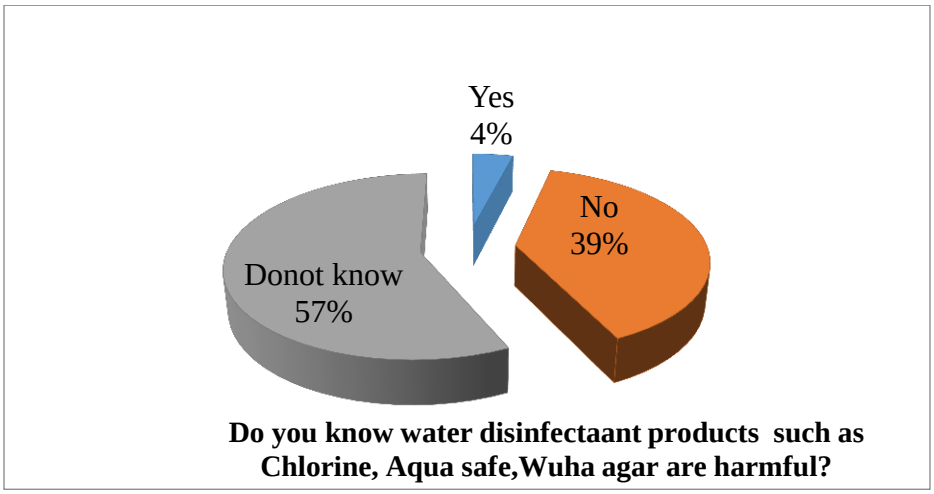
Society awareness of the condition of their water storage tanks, stored water sanitary conditions, and factors that cause water quality deterioration within the storage tanks was poor, Therefore, this project considered use of water disinfectant products and their management by the community, as well as the cleaning and disinfecting trend, and the drinking water storage tanks assessed.

In the study areas water for drinking was stored in a separate tank from water intended for cooking, washing hand, bathing, brushing teeth, etc. As gathered from questioner results, about 73.7% of the respondents were storing separately and 26.3% were not storing there drinking water in separate tanks. This resulted in further quality deterioration of water as proved by the study undertaken by Getnet (2008), in Bahir Dar to the effect that water stored inside the household had often a worse bacteriological quality than water from the source.

Moreover, various studies detected that stored water has contained more contamination than tap or piped water (Brick et al., 2004; Molbak et al., 1989; Sandyford et al., 1989). There is an increasing need to understand the impact of household drinking water collection, storage and management practices on water quality and preventing ineffective interventions and wastes of resources.

Also 51.6% of the respondents believed that water in the storage tanks was clean and healthy. The remaining 48.4% believed that their tank water was not clean and healthy. Those people were still using tanker water directly for all purpose including drinking. Among them, 75.8% still never used any disinfectant to make their water safe to drink, only 24.2% of the respondents were using chlorine or any other water disinfectant products and they even did not know the side effects of disinfectants. According to Rook (1994) discovery of THMs in drinking water led to research on other chemicals formed when chlorine is added to water, and to the health effects of these chemicals. This indicates the need for the establishment of stricter standards for disinfecting bi-products and precautionary principles, which advocates the avoidance of chemicals. According to the American Water Work Association, (1999), DBPs have been linked to bladder and rectum cancer, and may also have reproductive and developmental effects. Chloroform affects liver and kidney function in humans in both acute and long-term exposures.

Figure: 4. 3 Knowledge of the Society about Water Storage Tanks Disinfectants



Source: survey questioner response

3.3.3 Water Borne Diseases

It's obvious that regarding the water borne diseases depending on their academic background almost 100% of the respondents are aware of water borne diseases such as typhoid, cholera and diarrhoea but 36.8% are not aware of dysentery. In the study areas about 12.1% of them had suffered from typhoid, diarrhoea, or cholera one year before. Fortunately and as indicated on table 4.2, only 8.4% faced water born disease in recent years, According to O'Reilly et al., (2006) Point-of-use water treatment and safe water storage has proved to have to reduced diarrhoea risks by 25-85 %, depending on the population, setting, and other factors. This indicates that improved water storage handling practice in the study areas must have made a difference in the society health.

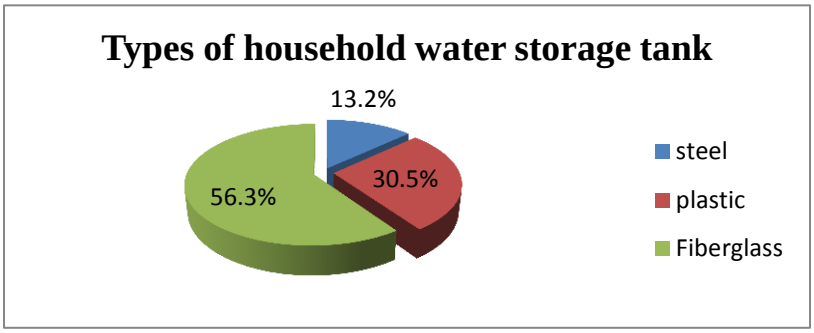
Table: 4. 1 Expectation and Frequency of Water Borne Diseases in The Study Area

Items	Responses	Frequency	Percent
Do you think your storage tank water is clean and healthy?	Yes	98	51.6
	No	92	48.4
	Total	190	100.0
Did you face water borne diseases in recent years in your home?	Yes	16	8.4
	No	174	91.6
	Total	190	100.0
What Frequency	No	174	91.6
	Once a year	8	4.2
	Three times a year	1	.5
	Twice a year	7	3.7
	Total	190	100.0

3.3.4 Household Water Treatment Practice

As observed from the results of questioner distributed in the study areas, all the community (100%) are storing their household water on ground or lifted on towers or top of roofs. And 30.5% are plastic, 56.3% fiberglass and 13.2% steel type tanks. Around 61.1% do not use any other source of supply except direct tap and tank water but, 38.9% are using bottled water, Jar or direct tap water. This indicates that most of the society water supply depends on household storage tank.

Figure: 4. 4 Types of Household Water Storage Tanks and Their Representation



Source; Survey questioner response

Accordingly, the age of water storage tanks in the areas still ranges between 4 - 20 years and the society rates regarding existing municipal water supply service in the study area were 6.8%, 22.6%, 40.5%,and 30.0% as Very good, Good, Bad and Very bad respectively. The result shows that due to the irregularity of supply more than 70% of the society rated bad. From the informal interview with residents, sometimes they could not get water for two week's even after two week's dirty water came through the system, which made possible for cloudy or dirty water enter in the reservoir tank because 92.6% of the tank pumped by a pipe network directly connected to the municipal system even the remaining 7.4% using a hose directly connected to an outside tap which was likely to become the reason for dirty water storage, a habitat for growing microorganisms where stored water turned into cloudy and dirty with bad taste and foul smell. According to Suffet et al., (1999), conditions at reservoirs, the type of disinfectant used, and decaying vegetation in the influent water are the reasons given for these taste and odour problems.

Additionally, by following their tap water physical properties like colour and taste, the residents of the study areas announced that their tap water was not pure and attractive to the government authorities. But branch of the water sector and the Woreda Health Office were not timely responded. In addition tap water quality reports were not communicated to the community to create awareness. These kinds

of problems were not actively addressed by the water sector and the people were forced to store and use this water which likely to have for growing bacteria. As stated by Payment et al, (1997), Colour in drinking water may be due to the presence of coloured organic matter, e.g. humic substances, metals such as iron or manganese, or highly coloured industrial wastes. Changes in colour from that normally seen can provide warning of possible quality changes or maintenance issues and should be investigated. That may reflect degradation of the source water, corrosion problems in distribution and storage systems (Payment et al., 1997).

From the checklist results about 98% of the household water storage tanks were lifted up on the roof and long tower which was exposed to direct sun light and difficult either to clean or maintain. According to the study by LeChevallier et al, (1996), coliform bacteria occurred more frequently and in higher concentrations at water temperatures greater than 15°C. Results from that study indicate that for a temperature increase from 5°C to greater than 20°C, there was an 18-fold increase of coliform occurrence in free-chlorinated systems (LeChevallier et al., 1996). These results also uncovered tank from direct sun light, environmental pollution and dusts can result in bad smell, dirty and rusts on the tank inlet and outlet fixtures.

In other words, in some places, water storage tanks are placed near different trees which were getting in touch with solid and liquid birds and small animals wastes in the nearby place and gate. Some tank Caps were also open or not secure, which has a probability to drink and even to die in for birds and small animals like rat.

Furthermore, the resident's drinking water pipe was not lined in a safe and sound manner or it was not away from any potential source of pollution like kitchen and toilet. According to the study by Tizita and Wondwosen (2009) drinking water pipe must be placed at a distance of 20-50 meter away from any potential source of contaminant or pollutant.

Table: 4. 2 Assessment Results of Characteristics of Water Stored in Tanks

Variables	Responses	Frequency	Percent
What is the smell of your water?	No smell	115	60.5
	Foul smell	75	39.5
	Total	190	100.0
What is the taste of your water?	No test	113	59.5
	Bad test	77	40.5
	Total	190	100.0
What is the colour of your water?	Clear	103	54.2
	Cloudy	55	28.9
	Dirty	32	16.8
	Total	190	100.0

Source: Survey questioner response (2017)

The data collected from the study areas regarding the household water treatment practice in the society was very poor. According to the results 43.7% of the society water tanks water for day to day use remained not treated. But 38.4% and17.9% were using some household water treatment measures like filtering and boiling for drinking purpose only. Currently, while collecting this data from the sample areas, no one treated or cleaned her/his water storage tank for the past months.

According to the interview with residents of the study areas because of the need for high shortage of water most of them were obliged to store water for weeks. As indicated in the table below, only 13.7% of the residents stored for a day, 13.2% stored for a week and 50.5% of the society stored their drinking water depending on the frequency of their consumption. Results of the interview shows that frequency of the consumption varies from time to time depending on events and occasions at home, holiday seasons and long day-offs were when per capital consumption of water by the community become high. Therefore, it could be stored for a days or a week. Also 22.6% were not sure as to how long they should store, whether for a week or weeks and as soon as possible, they use their tap water when it was available and they were saving tank water for the shortage periods. This is opposing with (Newfoundland and Labrador, 2011) "maximum tank water retention time ranging from 1-5 days or a set required percentage turnover per day".

Figure: 4. 5 Algae Formed in Un-Cleaned Drinking Water Storage Tanks

Additionally, almost all the residents of the study areas were using their tank water for bathing, washing, dishes, cooking; brushing teeth etc. Even if they were not drinking it, it was possible with in many other ways the intake of untreated tank water could expose them to water borne diseases.

In other word more than half (61.1%) of the community in the study areas did not use home treatment mechanisms. This made them to be infected with water borne diseases like amoeba and cholera. Those who had good understanding of water quality deterioration were using some household water treatment measures, like boiling and freezing before use, use of water disinfection tablets. Those who were financially better off use water purifier pitcher filter and water dispenser. Even if these options were good they had limited treatment by their nature. Brick et al, (2004) research found that according participants of studies report, having either boiled or filtered water, microbiological testing has indicated that contaminants were still present. Solar disinfection (SODIS) is by far the cheapest method of decontaminating water, and also one of the safest (EPA, 1996).

Table: 4. 3 Household Water Treatment

Variables	Responses	Frequency	Percent
How long you store your drinking water?	For a day	26	13.7
	For a week	25	13.2
	It depends	96	50.5
	Don't know	43	22.6
	Total	190	100.0
For what purposes do you use the water stored in tanks?	For all except drinking	190	100.0
Is your tanker water treated for all uses	No	34	17.9
	Treat for drinking only	107	56.3
	Never treated	49	25.8
	Total	190	100.0
Do you currently treat the water stored in tanks using chorine or any other disinfectant?	No	190	100.0
What methods do you use to treat your water tanks before use?	Boiling	34	17.9
	Filtering	73	38.4%
	No treatment	83	43.7%
	Total	190	100.0

3.3.5 Challenges of Water Storage Tank Cleaning and Disinfecting

Response to the questioners and the interview indicates that 72.1%, 10.5%, 14.7% and 2.6% were white, black, grey, and blue respectively and that the minimum capacity of the tanker was from500- 3,000 litres. 44 % of the communities gave attention and 146 % never had their water tanks visited unless there was any type of maintenance needed.

Even those who had good understanding of stored water quality deterioration in their tanks, checking was not done due to problem of availability of professional cleaners, accessibility of the tank location, lack of cleaning materials, As a result, awareness of the society on the sanitation conditions of their tanks were the main challenges in the study areas regarding cleaning and disinfecting their water storage tanks.

Figure: 4. 6 Common Ways of Placing House Hold Water Storage Tanks.

As gathered from checklist results, 92% of household water storage tanks were lifted on challenging inaccessible roof of buildings and long towers, which was making it difficult to clean and to repair. The rest tanks, about 8% were lifted on flat roof tops, which made them 100% exposed to direct sunlight. That may cause water quality deterioration and chemical reaction on the material of tanks. Evison and Sunna, (2001) study also discovered that water temperature inside the tanks and the tank age were the most important parameters for bacterial growth.

As regards to the age of water storage tanks in Yeka, it was between 6 and 20 years and at Bole it was between 4- 10 years even though 97.4% of the community never cleaned their tanks. 2.6% of the community water storage tanks were cleaned by broom and detergents by family members or plumbers last year. This unprofessional cleaning method may lead to contamination rather than disinfection. In addition, due to the fact that their storage tanks were directly connected to a pipe network of municipal water system. Access to pumped running water was 2-7 days a week when the supply was low and water pressure increased during night. Due to lack of continuity, water supply tanks should not be fully mixed with active water. This was opposing maximum tank water retention time ranging from 1-5 days or the set required percentage turnover per day (Newfoundland and Labrador, 2011).

In other words, the survey results indicate that 59.5 % of the residents had water tanks that hold 2,000 litres or above and the household family members had an average 5.8 which was consuming 2000 litres may have a probably for more than 4 days. In contrary a laboratory study by Evison and Sunna, (2001) indicate that factors such as long retention times of 4 to 7 days, low or no chlorine residual and temperatures above 15°C have been shown to increase microbial re-growth in commonly used 1000 L fiberglass, polyethylene and cast iron household storage tanks.

Table: 4. 4 Challenges of Cleaning Water Storage Tanks

Variables	Responses	Frequency	Percent
What is the capacity of your water storage tanks?	500liters	16	8.4
	1,000 litres	61	32.1
	2,000 litres	88	46.3
	3,000liters	19	10.0
	Others	6	3.2
Do you give attention for cleaning?	Yes	5	2.6%
	No	185	97.4
Who is the main responsible person for cleaning?	Plumber OR Sanitary	26	13.7
	Father	14	7.4
	Child	4	2.1
	Laborer	40	21.1
	Never cleaned	106	55.8
Do you have/use water tank cleaning equipment?	Not Availability	35	18.4
	Don't know	135	71.1
	Low availability	20	10.5
Do you use water disinfectant products?	Available	74	38.9
	Not Available	36	18.9
	Don't know	43	22.6
	Low available	37	19.5
Do water tank cleaning professionals available?	No	190	100.0
What are the challenges of clean water storage tanks?	Lack of material Lack of professionals Accessibility of tank Lack of awareness	162	85.3
	All except tank location	28	14.7
	Total	190	100.0

Source: Own survey (2017)

The results of survey in the study areas indicate that only a small proportion of tanks were inspected even not on a regular basis and that no cleaning standards exist at this time. Although cleaning and disinfection were recommended as a

measure to prevent water quality deterioration, the other challenges in the study areas included lack of appropriate cleaning equipment. The most commonly used methods in the United States include: flushing, pressure washing, and sediment removal by divers or robotic equipment. But in Addis Ababa City there are no structured or trained professional cleaners who are responsible on a regular basis for cleaning. On the other hand, in some European countries regular drinking water tank cleaning is an integral part of water quality management. In addition, results of the survey indicate that the most common challenges for cleaning and disinfecting drinking water storage tanks include lack of awareness. As stated by Martel et al. (2002), the common challenges of tank inspection have thus far received very limited attention.

3.3.6 Physico-Chemical Water Quality Analysis of Stored Water in Tanks

To reach at acceptable and finalized conclusion about stored water quality, it was important to start from storage tank and then pull out up to the point of use. The results of this study on water quality at Water Reservoir and Consumers end use tap for all selected parameters were presented hereunder:

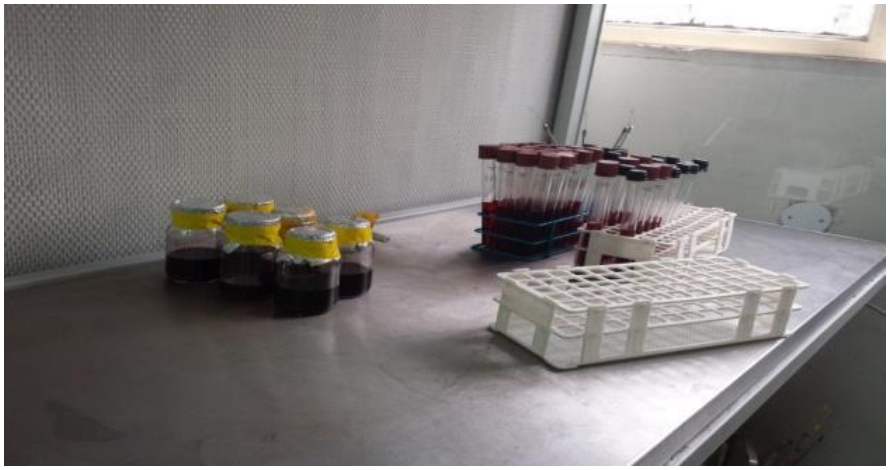


Figure: 4. 7 Tanker Water Samples for Bacteriological and Physico-Chemical Water Quality Test

Table: 4. 5. Measured Physico-Chemical Analysis of Stored Water in Tank

No	Type of storage tank	Test parameters	Results from:		Acceptable Standards	
			Bole Sub-city	Yeka Sub-city	WHO (Max)	Ethiopia (Max)
1	Steel	PH	7.89	6.99	6.5-8	6.5-8.5
		TDS	112 mg/l	112mg/l		1000 Max
		Turbidity	0 NTU	0 NTU	<5	<5
		Ammonia	0 mg/l	0 mg/l		1.5 mg/
		Nitrite(NO_3)	5.28 mg/l	4.4mg/l	0.5 mg/l	0.5 mg/l
		Residual chlorine (CL_2)	0 mg/l	0.6 mg/l	0.2-0.5 mg/l	0.1-0.5 mg/l
2	Fiber glass	PH	7.76	7.46	6.5-8	6.5-8.5
		TDS	220 mg/l	246 mg/l		1000 Max
		Turbidity	0 NTU	19 NTU	<5	<5
		Ammonia	0 mg/l	0 mg/l		1.5 mg/
		Nitrite(NO_3)	3.96 mg/l	5.28 mg/l	0.5 mg/l	0.5 mg/l
		Residual chlorine (CL_2)	0.5 mg/l	0 mg/l	0.2-0.5 mg/l	0.1-0.5 mg/l
3	Plastic	PH	8.33	7.33	6.5-8	6.5-8.5
		TDS	96 mg/l	154 mg/l		1000 Max
		Turbidity	0 NTU	0 NTU	<5	<5
		Ammonia	0 mg/l	0 mg/l		1.5 mg/
		Nitrite (NO_3)	3.52 mg/l	6.16 mg/l	0.5 mg/l	0.5 mg/l
		Residual chlorine (CL_2)	0 mg/l	0 mg/l	0.2-0.5 mg/l	0.1-0.5 mg/l

Source: Own survey data analyzed by Addis Ababa City Administration Health Research and Laboratory service (2017).

PH: The PH of water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems (WHO, 2008). Because of this, AAWSA has undertaken an activity to adjust the raw water that has acidic character to neutral. Through PH adjustment by neutralizing with soda ash, which increases the sodium content of this PH value of treated water at different tank was found to be between 6.99, and 8.33. This was in the range of WHO guidelines and Ethiopian standards. It solves the problem of higher and lower pH values. Lower PH water is likely to be corrosive and basic and higher PH value is strongly acidic in pure water and the concentration of PH ions (value) is in equilibrium (Gaur, 2008).

Household stored water samples tested in Yeka and Bole Woreda 18 and 10 had a PH value in a range of 6.99-8.33. This shows that only a small portion of households used water complies with the standards of drinking water with regard to PH. For drinking purposes PH value within this range is preferable and recommended because it does not have consequences on the effectiveness of other parameters.

Having less a PH value may be due to mix up of hydrogenous waste to water along the storage tank or distribution system in the presence of leaky pipes. Water with a low pH can be acidic, naturally soft and corrosive. Acidic water can leach metals from pipes and fixtures, such as copper, lead and zinc. It can also damage metal tanks and cause aesthetic problems, such as a metallic or sour taste, laundry staining or blue-green stains in sinks and drains.

Having greater PH value may be due to reaction of water with Carbonous wastes in the presence of leaky pipes. Drinking water with higher levels of PH does not pose a health risk. However, it will have bitter taste that may reduce the aesthetic acceptability of the water. Conversely, increase in PH chlorine vapour pressure reduces due to the dominant chlorine species and the disinfection process may be the hypochlorite ion (Brain, 2006). Also it may tend to facilitate the solubilization of ammonia. These results in formation of chloramines there are not so effective against viruses, protozoan cysts, and bacterial spores. Increase in PH value may result in formation of scale which reduces the carrying capacity of pipes and provides shelter for biofilm growth.

Turbidity: Turbidity of water is one of the important physical parameters that affect not only the quality of water, but also other chemical and bacteriological parameters and efficiency of treatment (WHO, 2006). Due to this, through the process of stored water in study areas, screening or Pre-sedimentation, Coagulation, Flocculation and Sedimentation, the turbidity of tanker water was improved and reclined. Accordingly, household samples tested in the YEKA Woreda 08 had a turbidity value of 19 NTU. These were critically above WHO and Ethiopian standard (≥5NTU) (WHO & ES, 1993,

1998 and 2001). Since turbidity is the measure of cloudiness of water, it mainly indicates growth of pathogen along the storage tank that pathogens may contaminate the water and entrance of any objectionable matter towards the storage system (Olson, 2004). The turbidity records of the present study (1.16-8 NTU) was slightly higher than the lowest limit and the highest limit of 0.3-7.6 NTU from Debrezeit town tap water samples(Desta,2009), it was also lower than the lowest limit and higher than the highest limit of 1.6-4.4 NTU from Bahir Dar town (Getnet, 2008) tap water samples, respectively.

Typical sources of turbidity within the storage tank maybe waste discharges and Algae or aquatic weeds and products of their breakdown along the distribution network. Excessive turbidity, or cloudiness, in drinking water is aesthetically unpleasant, and may also represent a health concern. Turbidity can provide food and shelter for pathogens. If not removed, turbidity can promote regrowth of pathogens in the tank, leading to waterborne disease outbreaks. As a result of this, water used by the community was not aesthetically pure.

Free residual chlorine: To overcome any contamination that might enter into the water distribution system, to inhibit biofilm formation and to stabilize water quality within the distribution system, free chlorine residual must be maintained. For this reason, WHO and ES allow a free chlorine residual of 0.5-1mg/L. On account of this, water stored in different tanks in study areas 80% were 0 mg/l which is far from accepted limit and only 20 % were 0.5 and 0.6 of free chlorine residual starting from 0.7 up to 1mg/L that obey the standard and this amount of free chlorine was assumed to be not sufficient for the whole disinfection process along the water storage tanks and require an excessive disinfectant. This may be the result of any of the following conditions:

The age of the water in the storage tank since it was treated, microbial re-growth within the storage tank and distribution system, reaction with tank corrosion, by-products and cross-connection of other contamination that consumes the disinfectant.

The higher PH value, highly turbid water, contact time of disinfection agent with water and number and type of microorganisms will play vital role in reducing the efficiency of chlorine along the storage tank. From the study, it can be concluded that only small amount of household storage tanks got the appropriate proportion of disinfectant.

Ammonia: Main water source of the study area were direct from municipal tap water. AAWSA water is collected from different land uses with consequences of the water containing slightly higher ammonia concentration that possibly will not be recommended for drinking purposes and from the health point of view. So to lower this

concentration ion exchange method was done by AAWSA. As a result, concentration of Ammonia was nil at storage tank, which complies with the recommended value of WHO and ES.

Nitrate: The detection of nitrate is an important water quality indicator that shows organic matter pollution due to microbial activity and accumulation of Ammonia (Desta, 2009). Even though Ammonia concentration was nil during the analysis, nitrate concentration in different storage tank was 3.52 mg/l, 3.96 mg/l, 4.4 mg/l, 5.28 mg/l, 5.28 mg/l, and 6.16 mg/l. The total samples had Nitrate concentration of greater than 0.5Mg/l, which was greater than standard. Nitrate which is the final stage of oxidation of Ammonia Nitrate concentration may be due to the presence of Ammonia caused by interconnection of drinking water with storage tank material. Since Nitrate does not evaporate the way chlorine does boiling, freezing, or letting, water stand does not reduce the nitrate level. So, there is no simple way to remove nitrate from water at home because home water treatment options are generally limited. High levels of nitrate in drinking water are a health concern primarily because of the potential for the nitrate to be converted into nitrite. That interferes with the ability of blood to carry oxygen. It does this by converting blood haemoglobin into methemoglobin. Unlike hemoglobin, methemoglobin does not function as an oxygen carrier to the tissue. The resulting condition is known as methemoglobinemia and causes severe oxygen deficiency and can lead to death. It is characterized by shortness of breath and blueness of skin. As a result, it is often called the blue baby syndrome.

3.3.7 Bacteriological Water Quality of Household Water Tank.

The usefulness of water for human use is determined by its quality. Quality is a major determinant for the health of ecosystems. Proper monitoring and assessment of the quality of surface, ground, tap and household tank water is essential for efficient water quality management, which in turn can ensure human welfare and environmental sustainability. The direct merit of microbiological examination was to take immediate action such as disinfecting reservoir water, replacing leaking tank and feting's, if the sample examination proves pathogenic contamination. In order to evaluate the bacteriological quality of household tank water stored in the study areas, the presence of two indicator bacteria, Total coliforms (TC) and fecal coliforms (FC) was tested from household water storage tanks (reservoirs). According to AAWSA official report, (2016), due to the well efficient disinfection process and proper management of treatment plant treated water from Addis Ababa water treatment plant were wholesome. Bacteriological water quality proves that water at source is free from both TC and FC. Thus quality of drinking water at source is within WHO, 1993 and ES, 1998, 2001,

which was 0 CFU/100 ml. This shows that there was no coliform and the water was safe and palatable.

Apart from water source and reservoirs, it is most important to analyze water quality that reaches to household storage tank. This determines the health status of the population. Accordingly, for this study to assess bacteriological quality of drinking water at household tank level, the following water quality parameters were done.

Total Coliform: total coliforms were used as indicator bacteria to assess the level of bacteriological contamination of the water supplies. Total of water samples were analyzed for thermo tolerant coliforms and the result indicates that majority taps water were not contaminated to a significant extent. With the help of laboratory analysis household reservoir water samples in Yeka Sub city Woreda 8 indicate the presence of total coliform. Even if the presence of total coliform is not an index of fecal pollution or of health risk, it provides basic information on treatment efficiency and water quality.

Fecal Coliform: household samples tested at the same tank in Yeka Sub city Woreda 8 study area show the existence of thermo-tolerant (fecal) coliform. There is the presence of Fecal or thermo tolerant coliform that grows at 44-44.50c and ferment lactose to produce acid and gas. In drinking water, the presence of fecal coliform should not be ignored as there is the basic assumption that pathogens would not be present in drinking water. This result shows the presence of fecal coliform. Since they are indicators of possible presence of waterborne pathogens, one can expect waterborne diseases in the study area. This was proved by the results of the questioner and the report from the Sub-city Health Center, which shows their people were rapidly exposed to waterborne diseases. Among the ten top diseases in the study areas, diarrhoea was caused by ingestion of contaminated water or food or poor sanitation.

High counts of total coliforms and thermo tolerant coliforms at the household drinking water indicate that the water has been fecally contaminated. The presence of coliform in drinking water in the study areas could be attributed to cross-contamination between the municipal water supply and sewer, and reduction in efficiency of chlorine. In this study, the average count of total coliforms and thermo tolerant coliforms were above the recommended value of WHO and Ethiopian Standards. Especially the total coliform and thermo tolerant coliform counts were higher in household water samples. This is in accordance with an intervention study done in Sri Lanka that shows their water from household tap had often a worse bacteriological quality than water from source or reservoir (Dissanayake, Dias, Perera, Iddamalgoda, 2004). Results of this study are also in agreement with studies conducted in South Africa and Zimbabwe which reported that

compliance is significantly higher for water reservoir than from tap water (Gundry, Wright, Conroy, Dupreez, Genthe, 2006).

E-Coli; household water tank samples tested at the same tanks in the Yeka Sub city Woreda 8 show the existence of E-Coli. E-coli is a bacterial species found in the fecal matter of warm blooded animals (humans, other mammals, and birds). Total coliform bacteria are an entire group of bacteria species that are generally similar to and include the species E-Coli. There are certain forms of coliform bacteria that do not live in fecal matter but instead live in water or soil in temperate climates that have not been subjected to faecal pollution (although there is the possibility of regrowth in hot environments (Fujioka et al., 1999).

Table: 4. 6. Summarized microbiological result

Parameters (Tests)	Method reference	Results	Sub Cities	Acceptable Limit
APC at 35°c/48 hrs.	APHA,1995 19th ed.	TNTC efu/ml		-
Coliform	WHO, 1971/2004, Eijkman	>161 MPN/100 ML	Yeka	<1 MPN/100ML
Fecal Coliform	WHO, 1971/2004, Eijkman	>161 MPN/100 ML	Yeka	<1 MPN/100ML
E. Coli	ICMSF, 1988.2nd ed.	Present	Yeka	Absent

Result: Addis Ababa City Administration Health Research and Laboratory Service.

Generally, from bacteriological water quality tests household water tanker samples do not meet the TC standard set by WHO and Ethiopia. Due to this, the samples indicate failed to meet safe water quality with regard to TC and FC criteria of 0 CFU/100ml, respectively (WHO, 1971/2004).

4. Summary, Conclusion and Recommendation

4.1 Summary

Water storage tanks are often the most visible and expensive component of a water distribution system. Although no specific drinking water quality event has ever been linked to a water storage tank in the sub cities, the potential for pathogenic contamination leading to a waterborne disease outbreak was there and has occurred in both sub cities. Tanks have a major influence on the resulting drinking water quality provided to users on the water distribution system. Unfortunately, most of the societies were unaware of how their water storage tank is affecting their drinking water quality. The main drinking water quality issues associated with tanks in the area include formation of algae, loss of chlorine residuals, and taste and odour complaints due to

stagnation. An evaluation of existing water storage tanks in the area was performed as part of this study and provided valuable information on practice and challenges of cleaning of water storage tanks. General recommendation for the result of practice and challenges of cleaning water storage tank and awareness of the society include the following:

- Most of the society water supply depends on household storage tank.
- Because of shortage most of them are obliged to store water for more than weeks.
- Most of the communities do not expect that their tank water would be contaminated.
- No one treated or cleaned her/his water storage tank.
- Stakeholders do not try to undertake any activity to advance consumer's knowledge.
- Majority of the society still never use any disinfectant to make their water safe to drink.
- Generally, household water storage tanks were lifted up on the roof and long tower which were exposed to direct sun light and difficult either to clean or maintain.
- Household water treatment practice in the society was very poor.
- Tank checking was not done due to problem of availability of professional cleaners, accessibility of the tank location, lack of cleaning materials, lack of awareness of the society
- Generally, Tanker water samples for bacteriological and Physico-chemical water quality tests household water tanker water samples did not meet the standard set by WHO and Ethiopia.

4.2 Conclusion

All the result from this study is put together in the following conclusion. In the study area most of the people do not expect deterioration in quality status of drinking water at their storage tank. This indicates that the level of knowledge on cleaning and disinfecting water storage tank management has been significantly low. Due to this, the people have no habit in using home water treatment methods. Even though small portion of the community uses home water treatment mechanisms like boiling, filtering and water tabs. Due to lack of information on selection of treatment alternatives based on status of drinking water quality on basic parameters, an antagonist and synergist effect were noticed. Moreover, poor sanitation and lack of attention to clean and

disinfect household's water storage tank were the main factors for the contamination of water during storage at home.

Those drinking water storage tanks not cleaned and disinfected have potential hazard to contaminate the stored water by solid and liquid waste due to poor management of house hold water storage tank by the community the physicochemical and bacteriological test results of samples from different storage tanks were not within the permissible standard limits of WHO and Ethiopia (1971, 2004). Thus, from this study water in different type of storage tank was grossly contaminated with Nitrate turbidity and lack of residual Chlorine. This result in an increase in Turbidity which reduces performance of disinfection process then leads to continued existence of water associated diseases causing organisms. And also there was an increase in bacterial indicator in the steel type water storage tank. The level of contamination was higher in Yeka area than the new area bole Woreda 10 due to tank age and water retention time.

Consequently, the result from health impact assessment of drinking water on the study area shows that use of water stored in tanks for consumption purpose has a severe impact on the community's health. Poor attention, low water treatment practice, and poor tanks cleaning and disinfecting practice and way of placing storage tanks, exposure of drinking water tanks and pipes to direct sunlight and presence of leakage due to torn pipes resulted in cross contamination of stored water with dirty stuff. This had contributed greatly to the high level of bacterial contamination of water in the storage tanks.

On the other hand, the regulatory body of Ethiopian standards Authority doesn't have any standard regarding to the inspection and control of water storage tank's quality and water stored in it. Added to this, the Ethiopian Ministry of Health and the National Public Health Institute laboratory Center has not given attention to household's water storage tank and its impact on water quality. In addition AAWSA and the sub-city water supply sector was not actively participating in drinking water storage management and in tank water quality supervision and monitoring.

4.3 Recommendations

- The idea of this project is to create safe and clean water storage tank system as well as healthy and productive society by showing the requirements related to water storage tank management at household level.
- The society should use modern water tank cleaning and disinfecting mechanisms mainly harmless water tabs and appropriate cleaning and disinfecting materials. Since the people have low level of awareness about the quality of water stored in tanks, the practice of cleaning and disinfecting them is

also very low. Therefore, the stakeholders involved in water sectors should take the responsibility of creating the awareness level of the society and provide the necessary support for its cleaning and disinfecting so that the society will have access to safe drinking water.

- It is also important to adopt appropriate Code of practice for the inspection and cleaning of customer water storage tanks by stake holders and assign responsible body as how other countries practices.
- Regular inspection of water storage tank sanitary and hygienic aspects and strict control and appropriate management of the storage tanks for prevention of contamination should be done.
- Unreachable tanks are hinders of awareness, therefore, construction professionals should improve ordinary way of constructing water storage tank placing towers. It should be accessible and shaded from direct sun light. Since temperature between 15 ^{o}C - 60 ^{o}C is suitable for bacteria growth steel, black or blue color tanks must be avoided and use white color.
- Solid and liquid waste around and inside the tank should be managed properly and frequently cleaned and disinfected.
- The present work is limited to few bacteriology and physicochemical parameters and sampling frequency. Therefore, wide and year round sampling and analysis of additional parameters of household water storage tank quality is recommended to be undertaken.

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