Addis Ababa University

Institute of Technology

School of Civil and Environmental Engineering

Investigating the Efficacy of the Indigenous Water Purification Method Using African Spear Plant

Case: Konso Community

2018 GC

Research Paper in Partial Fulfillment for the Masters of Science in Water supply and Environmental Engineering

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By Sokate Aylate Gudeno

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Declaration

I, the undersigned declare that this is my original work and has not been presented for a degree in this or any other university and all sources of materials used for this thesis have been acknowledged.

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Acknowledgment

I acknowledge the almighty God for His care and help. I also extend my gratitude for my advisor, Dr Alemtsehay Gebremeskel Seyum, for her relentless support and follow-up. She was encouraging, hope filling and absolutely supportive.

Next I appreciate the contribution of my family, particularly my husband Aschalew Korra and my children for they understood me and filled the gap created due to my education at home.

Finally, I appreciate for the encouragement and support I got from my friends in the school, especially Mrs Rekik Hibistu, who was by my side in the journey of study at Addis Ababa University and in the research process.

Abstract

Water supply and environmental engineering primary concern should be making potable water available to the community at large. Among the many topics addressed in the discipline, water purification method is of paramount issue to be addressed. Water purification can be undertaken in more sophisticated method and traditional way.

An indigenous method used by Konso community to purify water using African spear plant was investigated in this research. Lab scale study was conducted to assess the efficacy of African spear plant to purify water in terms of water quality parameters such as PH, Turbidity and Bacteria presence.

The study has used triangulation approach, means, qualitative and quantitative approach. The qualitative approach is used for the exploration of the method being used by the society by interviewing significant people in the community and observation of the practice in the society and to know the situation in which the community uses this traditional method. The quantitative method was used for measurement of African Spear plant efficacy in terms of water quality parameters such as PH, Turbidity and Bactria presence.

The study found that, when the water is stirred with a crashed African Spear plant for about 1 minute and kept for about 10-15 minutes, African Spear plant has the capacity to reduce the turbidity of water, capacity to reduce the level of bacteria in the water and reduce the PH of the water but if it is kept for long time in the water, the African Spear plant makes the water media more favorable for bacteria and the color of the water is changed to the color of the plants. Wet African spear plant has much effect than dry plant in purifying water.

Abbreviations and Acronyms

AACAEPAL	Addis Ababa City Administration Environmental Protection Authority Laboratory
AUWQL	Arbaminch University Water Quality Lab
DO	Dissolved Oxygen
EC	Electrical Conductivity
ES ISO	Ethiopia Standard International Standard Organization
ES	Ethiopia Standard
MCL	Maximum Contamination Level
MDG	Millennium Development Goal
NTU	Ne photometric Turbidity Unit
PH	Power of Hydrogen ion scale
TDS	Total Dissolved Solid
UNICEF	United Nation International Children's Emergency Fund
WHO	World Health Organization

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Chapter One

Introduction

1.1. Background Information

Water is a very crucial thing for the existence of life on the earth. It is well said that water is the second most urgent body need after air. The total volume of water on the Earth is about 1.4 billion km^3 and 97 percent of it is found in ocean which is salty water. But, for the sake of human health, salty water is not convenient for human well being.

Water supply and its cleanness is one of the fundamental base for determining development and health of a society (WHO report, 2003). Approximately 1.1 billion people worldwide lack access to safe drinking water (International Journal for Serviced learning in Engineering, 2009). In Ethiopia, 81 million people, according to USAID report, have lowest rates of access to water supply, sanitation, and hygiene even though it has abundant surface and ground water resources in Africa. In 2005, 40 percent of the population had access to safe water according to the government report; however, according to nongovernmental organizations and World Health Organization (WHO), the ground figure was around to 22 percent (USAID, 2007).

The WHO estimated that only 13 percent of the population had access to sanitation. Ethiopia's Millennium Development Goals (MDGs) for improved water and sanitation access are 70 percent and 56 percent respectively (USAID, 2007).

Water need to be purified before it is supplied for use. There may be several reasons to improve the quality of the water. The most important is the removal of organisms like germs and parasites that causes water born, water based and water related diseases. We may also want to remove suspended particles like dirt which make the water look and taste bad and that might be carrying germs which make people ill.

Nowadays there are a number of technologies which are used to treat water. To mention some of the techniques used are physical method of which boiling is the most reliable method when water is boiled vigorously for 1 minute and allowed to cool to room temperature. Other physical methods include exposure to sunlight and ultra violate light.

Chemical purifiers such as tincture of iodine, 2% solution of iodine, can also be used, where we add 5 drops of the iodine to 1 liter of clear water and wait for 30 minutes before we use it. For very cold or cloudy water, add 10 drops to 1 liter of water and wait for several hours before use. Other chemical methods include precipitation using alum, soda, ash, and lime (Hong Kong Special Administrative Region Government, Information Services Department, 2016).

To use most or all of the above mentioned methods to purify water, it would be unaffordable and expensive for communities like Konso, which is the area of this study. Traditionally, Konso community applies different methods to treat raw water and use for their daily activities. As it is known in literature, both surface and sub surface water have impurities and it requires different level of treatment. Physical impurities are treated through physical mechanism such as screening, sedimentation, filtration, etc; whereas chemical impurities can be removed by adding different chemicals.

Konso community has adopted their own traditional methods of water purification. The indigenous traditional water treatment techniques used by the community can serve the community as whole or applied at individual level. To mention some of the traditional techniques, the Konso uses addition of ash to treat raw water, the root of Moringa, fine sand and African Spear plant to purify water. This research is interested in investigating the technique of using African spear plant to purify water.

African spear plant, its scientific name *Sanseveria cylindrical* also called snake plant, rocket, spear Sanseveria or mother –in-law's tongue is fiber plant that Konso people use for production of fiber to make robe from it. In other parts of the world, it is kept as a houseplant. A research done by NASA on selected plants that are used for air purification includes Sanseveria Cylinderica plant. (https://hirts.com/, Sep, 2018)

Figure 1: ***House grown Sanseveria Cylinderica, (Source: Hirt's Gardens, 2018)***

The Konso African Spear plant is a round plant which is used primarily for fiber production and secondarily for water purification. This plant can also grow in worm temperature area in the field. It has fiber and thorn at its end. This plant is the focus of this study to purify water.

Figure 2: Field ***Grown Sanseveria Cylinderica (Source: Plants & Flowers Copyright © 2010-2017)***

Figure.3: ***Sanseveria Cylinderica from study area (source: Researcher Photo, 2018)***

1.1. Description of the Study Area

The Konso (*local pronunciation Xonso)* live in the South West Ethiopia in Southern Nations, Nationalities and People's Region (SNNPR), in Segen Area Peoples' Zone. Gumayede (local pronunciation, *Komayte)* is the administrative seat of the zone. The Zone has five woreda: Ale, Amaro, Burji, Dirashe, and Konso. Except Ale woreda, the rest used to be special woredas before the formation of the Zone in 2011. Karate is the administrative town of Konso woreda and is about 600 and 360 KM from Addis Ababa and Hawassa respectively (Gelebo, M. 2008). According to 2007 Census, there were 267,000 people in Konso Woreda including Ale woreda.

Konso people use water from river, unprotected well and protected spring well. Usually, they dig water well at the base of mountainous area hoping they get water there. The source of water for drinking water is mainly from unprotected well (Garra,K. 2000). The land has water shortage and the community devised different techniques to overcome such challenges. Among them they devised water reservation technique and techniques to purify the water.

1.2. Statement of the Problem

Even if there is enough amount of water in our country, it is not readily available to supply for community without treatment. Naturally available water contains lots of impurities and the impurities have to be removed before supplying water to the community to avoid negative health impact. There are many technologies used to treat raw water and make it safe for drinking and other daily activity. Physical method of purifying water includes boiling and use of ultraviolet light. Chemical methods include addition of chlorine, tincture iodine, soda, ash, and lime. The technologies are too expensive to use locally in developing countries. This research will focus on

assessing how the people of Konso use African Spear plant to treat water at home level. The research also assesses the efficacy of the method. The research question was birthed from the curiosity of the researcher from what she observed in her area where the people utilize crushed African Spear plant to purify dirty water. The concern therefore, has been developed over time since child hood and now when opportunities of research came, it became a topic of study. Based on the above justifications, the research will try to answer the following research questions

i. What is the existing water supply source of Konso woreda?

ii. What is the difference between dry and wet African Spear plant in water purification?

iii. What is the effect of African Spear plant dosage in water purification?

iv. What is the relation between PH and dosage of the Plant in water purification?

v. How do Konso people apply African spear plant to purify water?

vi. What if Konso community use dried African spear plat to purify water?

vii. What is the difference between natural settlement and use of African Spear plant?

viii. How can time factor affect water purification using African spear plant?

ix. What is the effect of African Spear plant in improving water quality?

x. What is the better way of purifying water using African spear plant?

1.3. Objective of the Study

1.3.1. General Objective

This research presents an investigation on the efficacy of the indigenous water purification method using African spear plant among Konso community

1.3.2. Specific Objective

The specific objectives of the thesis are summarized as follow:

i. To assess the existing water supply sources of Konso woreda

ii. To study how Konso people use African Spear plant to purify water

iii. To measure the effect of African Spear plant in improving water quality

iv. To recommend an improved method to purify water using African Spear plant

1.4. Thesis outline

Introduction, description of the study area and objective of the study are presented in chapter one. Literature review about different traditional water purification methods is presented in chapter two. Interview and observation of the practice, preparation of the plant and sample water and laboratory study method are described in chapter three. Results obtained from laboratory study and interviews and discussion of the results are presented in chapter four. Finally, conclusion and recommendation for further study are described in chapter five.

Chapter Two

Literature Review

2.1. Introduction

For water student, “Water is life”, is the common motto which holds truth beyond their field of study. All living things need water to survive on earth. Both plant and animal bodies are made up of water in their cells. The average adult male has approximately 60% of his body weight water and a female adult has in average 50 % of her body weight water *(The American Journal of Clinical Nutrition,* 1980*).*

The planet earth is covered by about 71 % of water surface. Out of the total water coverage on earth, about 96.5 % water is contained in oceans. Water also exists in the air by the form of vapor, in rivers, lacks, in the form of icecaps, glaciers, and also in the ground. Even though 71% of earth is covered by water, about 96% of the total water on earth is saline, which means it is not fit for drinking. Fresh water fit for drinking is found from rain, in the streams, rivers, lacks and ground *(USGS, 2016).*

In most parts of the world, surface water is used to supply drinking water, and to irrigate crops. However, ground water is also of paramount importance to keep rivers and lakes full. It also helps as a source of water supply in places where surface water is scarce.

Out of the total water volume of 1.4 billion Km^3 on earth, 97% is saline. Out of the total fresh water, 68% is locked up in ice and glaciers in the polar areas. Another 30 % of the fresh water is

in the ground. The rest sources of fresh water are rivers which constitute about 300mi^3 that is 1/10,000th of total earth water *(USGS, 2016).*

Table 1: A brief description of earth's water is given in a table below.

Estimate of Global Water Distribution (Percents are rounded, so will not add to 100)				
Water source	**Water volume, in cubic miles**	**Water volume, in cubic Kms**	**% of freshwater**	**% of total water**
Oceans, Seas, & Bays	321,000,000	1,338,000,000	--	96.54
Ice caps, Glaciers, & Permanent Snow	5,773,000	24,064,000	68.7	1.74
Groundwater	5,614,000	23,400,000	--	1.69
Fresh	2,526,000	10,530,000	30.1	0.76
Saline	3,088,000	12,870,000	--	0.93
Soil Moisture	3,959	16,500	0.05	0.001
Ground Ice & Permafrost	71,970	300,000	0.86	0.022
Lakes	42,320	176,400	--	0.013
Fresh	21,830	91,000	0.26	0.007
Saline	20,490	85,400	--	0.006
Atmosphere	3,095	12,900	0.04	0.001
Swamp Water	2,752	11,470	0.03	0.0008
Rivers	509	2,120	0.006	0.0002
Biological Water	269	1,120	0.003	0.0001

Estimate of Global Water Distribution (Percents are rounded, so will not add to 100)				
Water source	**Water volume, in cubic miles**	**Water volume, in cubic Kms**	**% of freshwater**	**% of total water**
Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources (Oxford University Press, New York).				

Fresh water that is found from rain, in river, lakes and in the ground need treatment before consuming as drinking water. To purify water there are many methods devised, both in scientific ways and traditional ways. Depending up on the depth of water, ground water is considered to be free from pathogenic microorganism contamination. Ground water is considered to have better quality than surface water which is exposed to different sorts of contaminating objects. Chemical composition of ground water is related to external activities and soluble constituents of soil in the area.

Water quality can be seen from physical, chemical and biological aspects. All the aspects are important for human health.

2.2. World Health Organization Guidelines

The World Health Organization, WHO, Guideline for Drinking-water Quality (GDWQ) includes the following recommended limits on naturally occurring constituents that may have direct adverse health impact.

Table 2: WHO Guideline for Drinking water Quality

Naturally Occurring Constituents	Organic Species		
Arsenic 10µg/l	Benzene 10µg/l	Carbon tetrachloride 4µg/l	1,2-Dichlorobenzene 1000µg/l
Barium 10µg/l	1,4-Dichlorobenzene 300µg/l	1,2-Dichloroethane 30µg/l	1,2-Dichloroethene 50µg/l
Boron 2400µg/l	Dichloromethane 20µg/l	Di(2-ethylhexyl)phthalate 8 µg/l	1,4-Dioxane 50µg/l
Chromium 50µg/l	Edetic acid 600µg/l	Ethylbenzene 300 µg/l	Hexachlorobutadiene 0.6 µg/l
Fluoride 1500µg/l	Nitrilotriacetic acid 200µg/l	Pentachlorophenol 9µg/l	Styrene 20µg/l
Selenium 40µg/l	Tetrachloroethene 40µg/l	Toluene 700µg/l	Trichloroethene 20µg/l
Uranium 30µg/l	Xylenes 500µg/l		

Source: Guidelines for Drinking-water Quality, 4th Edition; World Health Organization; 2011

The following table 3 provides a comparison of a selection of parameters for concentrations listed by WHO compared with that of the European Union, USA, and Ministry of Environmental Protection of China.

Table 3: Guidelines for Drinking-water Quality, 4th Edition; World Health Organization; compared with USA and Europe Standards, 2011

Parameter	Symbol	WHO	EU	USA	China
Antimony	Sb	Ns	5.0 µg/l	6.0 µg/l	“
Arsenic	As	10µg/l	10 µg/l	10µg/l	50µg/l
Barium	Ba	700µg/l	Ns	2 mg/L	“
Benzene		10µg/l	1.0 µg/l	5 µg/l	“
Boron	B	2.4mg/l	1.0 mg/L	“	“
Cadmium	Cd	3 µg/l	5 µg/l	5 µg/l	5 µg/l
Chromium	Cr	50µg/l	50 µg/l	0.1 mg/L	50 µg/l (Cr6)
Fluoride	F	1.5 mg/l	1.5 mg/l	4 mg/l	1 mg/l
Mercury	Hg	6 µg/l	1 µg/l	2 µg/l	0.05 µg/l
Nitrate	N	50 mg/l	50 mg/l	10 mg/L (as N)	10 mg/L (as N)
Selenium	Se	40 µg/l	10 µg/l	50 µg/l	10 µg/l
Tetrachloroethene and Trichloroethene		40µg/l	10 µg/l	“	“

Source: Guidelines for Drinking-water Quality, 4th Edition; World Health Organization,(2011).

2.3. National Water Quality Standard

Ethiopia has standard for water quality measurement and the values are presented in table 4.

Table 4: Palatable water quality standard for drinking water

Substances or characteristics	Maximum permissible level	Test method
Total hardness (as caco3) mg/l	300	ES 607
Total dissolved solids mg/l	1000	ES 609
Total iron (as Fe) mg/l	0.3	ES ISO 6332
Manganese (as Mn) mg/l	0.5	ES ISO 6333
Ammonia (NH3+NH4+) mg/l	1.5	ES ISO 7150-2
Residual free chlorine mg/l	0.5	ES ISO 7393
Anionic surfactants mg/l	1	ES ISO 7875-1
Magnesium (as Mg) mg/l	50	ES ISO 7980
Calcium (as Ca) mg/l	75	ES ISO 7980
Copper (as Cu) mg/l	2	ES ISO 8288
Sulfate (as So4) mg/l	250	ES ISO 9280
Chloride (as Cl) mg/l	250	ES ISO 9297
Total alkalinity (as Caco3)	200	ES ISO 9963-1
Potassium (as K) ,mg/l	1.5	ES ISO 9964-2
PH value ,units	6.5 to 8.5	ES ISO 10523

Sources: National Drinking Water Quality monitoring and surveillance strategies, 2011

All over the world, rural community adopted simple treatment techniques that mainly aim at filtering out the visible impurities from the water collected from local source. These traditional treatment techniques can remove the impurities which is visible with eyes only. Traditional water purifying methods do not provide the water quality standard under present day situation.

However, it can be considered that the methods used provide water quality that is acceptable to that community. In most of the cases with a simple step of disinfection, they could yield water free from pathogens.

The issue of water adequacy and sanitation is the concern of all disciplines that study water supply and environmental impact of water related issues. According to United Nations report,2005, there is enough water for everyone on the globe; the problem is the mismanagement and misuse of water. Misuse of water includes corruption and lack of investment in human capacity and physical infrastructure that aid in proper water utilization (United Nations report, 2006)

In developed countries, safe drinking water is piped at household level and the quality is also monitored at higher level. The reverse is true in developing countries, where there is a problem of adequacy and safety in terms of sanitation. To overcome such problem people in developing countries look for sources of water that are not protected and treated.

According to *WHO, (2010),* 5.9 billion people, that is 87% of the world population are using water from safer sources. The result however addresses largely the status of developed nations when compared relatively with developing countries. In sub-Saharan countries, the proportion is only 60% who have access to safe water, and about 2.6 billion people don't have access to safe water and improved sanitation.

The inadequacy and lack of sanitation in the rural area of the developing countries like Africa is the most serious challenge that the people face. About 3.4 million people die due to water born diseases, among which the children are the first victims (UN- Habitat, 2003).

The Ethiopian water condition is affected by different factors. Among the many, the country has great geographic diversity which do have direct and indirect link with water availability and sanitation. The topography height ranges from high peaks of 4,550m above sea level to a low depression of 110m below sea level (Ademe and Alemayehu, 2014, 2:2).

In Ethiopia, the highlands usually get relatively stable and more rain falls than the lowlands. This make the lowlands get surface water and the high lands get more rain. The country has high potential for both surface and underground water. This potential made the country to be nick named, the water tower of East Africa (Said, 1993).

2.4. Ethiopian Water Quality Condition

Ethiopia as one of the developing country of the world it has not fully provided access to clean and enough water in both rural and urban areas of the country. The urban areas of the country have a better access to clean water compared to the rural areas of the country. Improving the accessibility of quality water to all citizens is one of the targets of the Millennium Development Goal that the Ethiopia government strives to fulfill. Access to safe water was considered as one strategy to alleviate poverty as recommended in previous researches quoted (Water Aid, 2009).

The Konso community lives in southern region of Ethiopia, under Segen around people Zone. The Konso people as other remote and rural community of the country, they also face problem of access to safe and adequate water. To overcome the issue of cleanliness, they use different traditional and ingenious methods to purify water. They use, ash, moringa tree root and African spear plant which is the focus of this paper (Garra. K, 2000).

2.4.1. Addition of Ash

During the rainy season the water harvested from the top of roof contains some sort of impurities. And this impurity observed with eye which is physical impurities is removed by adding ash. Ash is added to the turbid water and let it for few minutes, and then the ashes collects the suspended dusts present in raw water and settle it down.

2.4.2. Root of Moringa

The root of Moringa can also play an important role in traditional water purification methods. When the root of Moringa added to the dirty water it collects the impurity from the raw water toward itself as a magnet attracts the metals. The seed of moringa is reported to have anti microbial effect in addition to coagulation effect. (Kibreabe, 2004)

2.4.3. African Spear Plant (*Sanseveria Cylinderica*)

African Spear plant, *Sansevieria cylindrica*, is a Sanseveria family plant with striped, elongate, smooth, greenish-gray sub cylindrical leaves. They can grow up to 3 cm diameter and upward can grow up to 2 m above soil. It grows fan-shaped, with its stiff leaves growing from a basal

rosette.The plant is drought resistant and can survive with less water like getting water once every other week during the season of its growth, thus it grows much in dry area. The plant got its name Sanseveria cylinderica from competition in a Dutch national newspaper by Wencesals Bojer, due to it ornamental feature and easy to culture it. (Lemke, Cal (2002-01-25)

Figure 4: Konso Sanseveria Cylinderica, (Source: Researcher, Konso, 2018)

The plant is used for house plant as ornament; scenery in film and television show, for air purification, its fiber is used for rope fiber works. In Africa, including Konso, the leaves are used for fiber production that is used for rope making. In some species, the plant's sap has antiseptic qualities, and the leaves are used for bandages in traditional first aid. (Philip, D; Kaleena, PK; Valivittan, K & Girish Kumar, CP, 2011)

Water purification using round African Spear plant has no literature as to the scope of literature search by this study, but the practice is available among Konso people, and this study will try to explore its use and application, and also its efficacy in water purification.

2.5. Water Quality Analyses

Water quality analysis is done through representative samples of water. According to WHO guideline, 2004, 4th edition, the tests first of all need to be done onsite and then taken to laboratory.

Water quality measurement parameters are grouped in to three types, namely, physical, chemical and biological parameters. All the three parameters are set from human health perspective. The parameters are to show us the fitness of water for drinking and its safety for human health (Gupta, D. & Saharan, J., 2009).

2.5.1. Physical Parameter of Drinking Water Quality

The physical characteristics that are used to measure water quality are its temperature, color, odor, taste, turbidity.

2.5.1.1. Turbidity of Water

Turbidity of water is its cloudiness and muddiness, which indicates physical sign of water impurity. It is an indication that the optical property of water is affected to absorb end scatter light that passes through the water. Turbidity is caused by suspended materials such as clay, silts, fine organic and inorganic materials, soluble colored materials, plants and microorganisms. The turbidity of water determines the acceptability of the water by the consumers, the type of treatment demanded. During disinfection process, lower turbidity is preferred, that is lower than 1 NTU (John C.et al, 2012).

2.5.1.2. Color of Water

Water color is normally colorless, but if water is colored, it means that there are colored substances in the water that affects its appearance. Color of water can be due to plants, or soluble minerals in it. We can compare the color of water to the color of distilled water. Colored water is not acceptable for drinking, both for its aesthetic and health issues. Drinking water has to be colorless (WHO, 2011, 4th Edition).

2.5.1.3. Odor and Taste

Drinking water has to be odorless; if present it indicates the presence of contamination in the water. Drinking water has to be tasteless; if present it indicates that there is something foreign in it and the water is not safe for drinking. The change in odor and taste of water indicates that there is some problem in the source of the water, on the treatment process or distribution process. Dissolved minerals and algae in the water can change the odor and taste of water (Olijira, G., 2005).

2.5.2. Chemical Aspects of Water Quality

2.5.2.1. Residual Chlorine

Chlorine is one of the disinfectants that we use to treat water. Its preference is due to its cheapness, availability and easy measurement both in the field and laboratory. Another reason for its prior usage is as it leaves residues in the water that can help prevent water contamination from source to house hold usage level. The residue is a sustainable disinfection benefit we get from chlorine usage (Taylor & Francis. G, 2007)

2.5.2.2. PH of Drinking Water

PH of drinking water refers to its level of acidity and alkalinity in respect to hydrogen and hydroxide ions in a serious of positive numbers between 0-14. Water with a PH value of 7 is considered to be neutral, the one with PH level below 7 is considered acidic and is toxic and the one with PH Level above 7 is considered basic, and has bitter taste. Normal drinking water has a PH value between 6- 8.5. Measurement of PH should be simultaneous with Chlorination for the effectiveness of Chlorination which is dependent on the PH of the water under treatment (WHO, 2011, 4th edition).

2.5.2.3. Total Dissolved Solids (TDS)

Water may contain chemical impurities such as dissolved salt of magnesium, sodium, chloride, sulphates, fluorides, nitrates, phosphates and other toxic metal like copper, chromium, iron, mercury and manganese. The impurity may come from sources like town and industrial waste water (Benignos, 2012).The presence of dissolved chemicals in the water helps us classify water hard or soft water. Hardness of water is primarily due to the presence of calcium, magnesium, chloride, sulphate, phosphate and the like ions. According to WHO (2012) and national drinking water quality, the maximum permissible water hardness level is 300mg/L (Olijira, G., 2005). Water has the capacity to dissolve a Varity of solid organic and inorganic substances such as different types of salts, such as Potassium, calcium, sodium, bicarbonates chlorides, magnesium, sulphates and the likes. These dissolved substances can change the taste and color of water. The sources for the dissolved solids are from different areas like urban sewage and industrial waste water sewerage system. TDS is used to measure the general quality water, not specific one (Muhammad et al., 2013).

2.5.2.4. Electric Conductivity (EC)

Electrical conductivity of water is its ability to carry electric currency, which is due to concentration of ions, mobility of the water, its temperature. If water conducts electricity in higher rate, it indicates that that water is not clean. Clean water is poor in electric conduction and best insulation. According to WHO standards, EC value of drinking water quality should not exceeded 400 μS/cm and the conductivity of potable waters varies generally from 50 to 1500 μ mhos/cm (WHO, 2011,).

2.5.3. Biological Aspects of Drinking water.

Drinking water need to be safe not only physically and chemically but also biologically. Biologically we test the water for the presence of bacteria, virus and other disease causing micro organisms, specially the presence of Escherichia coli bacteria. It would be too complex to test for all kinds of microorganisms in the drinking water, and in many instances some of the pathogens may not present in the water or in a very small amount. Therefore we use “indicator bacteria” to identify whether the water is polluted with fecal material or not. The indicator bacteria are those bacteria that are excreted in a large amount in the feces of warm blooded animals, whether they are sick or healthy. The presence of the “indicator bacteria” signals the contamination of the water with fecal matter.

The convention for “indicator bacteria” is using the presence of fecal coli form bacteria in the water. Fecal coli form mainly contains Escherichia Coli or E coli, which are the sub group of total coli form group. Fecal coli form present entirely in the feces.

In contrast, other members of the coli form group can be free living bacteria in nature and their presence in the water does not necessarily indicate the contamination of the water with fecal matter.

Escherichia coli are always present in the feces and the majority of them are normal flora in human bodies, though some strains of them can cause diarrhea.

Differentiation of test result can be made between fecal coli form and total coli form by the temperature of the tests. Total coli form can be tested at body temperature, 37^{o} C but the fecal coli forms can be tested at 44^{o}C (WHO, 1993). Pertaining to the sample collection of water for coli form bacteria test, a properly collected and preserved, if possible with sodium thiosulfate, sample need to be obtained. Total time of holding the sample is only 30 hours. The sample need to be kept in refrigerator or in ice, 4 degree Celsius and +/_ 2 degree Celsius. Usually, we test for their presence or absence in the sample. (Http//www. southjersywatertest.com, accessed January 23, 2018)

The standard for Total coli form bacteria as primary standard is Maximum contamination level (MCL) of zero colonies/100 ml water. If the result of the test for coli form bacteria in your water is above the MCL, then water treatment is needed either by boiling or chlorination (WHO, 1993).

2.6. Traditional Water Purification Methods

Traditional water purification methods are many and variety depending on the area and community that use the method. Public health is mainly dependent on the availability and accessibility of safe drinking water. In the developed countries, there are different types of technologies that are used to purify water. The opposite is true in developing countries where water sanitation is major public health concern. Due to unavailability of the technologies used to

purify water, water born and water related problems are many. The technologies that are available in developing countries is either expensive or inappropriate to be used the large proportion of world population that live in developing countries. Because of inappropriateness and expensiveness, many societies devised low cost traditional methods of water purification. The methods can be at community level or at household level. Almost all such tradition techniques are used to remove physically visible impurities such as plant leaves, twigs or other suspended materials (Vigneswaran, S.and Sundaravadivel, M.,1983).

The methods range from simple and old method of purifying water through cloth to modified methods that are adopted at community levels. To list some of the common methods used to purify water in traditional ways: Purifying through sieves or cloth, stones, coarse media filters, gravels, fibers, and plant parts, ,(Vigneswaran, S.and Sundaravadivel, M.,1983).

The methods are also classified in to three categories, namely: Traditional water treatment method, appropriate water treatment methods and House hold water treatment methods.

To mention some of the traditional water treatment methods, the following are common among many**:** Filtration by winnowing sieve, the method widely used in Mali, filtration by using cloth, which is widely used in India, Mali and southern part of Nigeria, Filtration through clay vessels which is commonly used Egypt, clarification using plant material which is used in Tamil Nadu and Kerala, in India, Jempeng stone filter method commonly used in Bali, Indonesia (Thanh N. C.1982).

2.6.1. Filtration through Winnowing Sieve

This method is used in water pollution caused by wind born impurities, like dry leaves, stalks and coarse particles.

This type of filtration is used when the water source is polluted by wind-borne impurities such as dry leaves, stalks, and coarse particles, where the raw water pass through the sieve and the plant and coarse particles left behind. This method is widely used in Bamaka village in Mali.

2.6.2. Filtration through Cloth

Filtration through cloth is a common method used by many countries, like India, Nigeria, Mali and other developing countries, to remove physically observable dust particles, mud, and debris, suspended and visible martial in water. This type of water purification is not effective to purify highly turbid method; rather it is suitable to purify well water.

2.6.3. Filtration through Clay Vessels

This method of water purification is mainly used by Egyptians. They use clay vessels with a suitable pore size to filter highly turbid water

2.6.4. Filtration by using Plant Parts

By using the nuts of locally available plants, people in India filter highly turbid water with fine suspended particles. This method is followed by cloth filtration. Studies have shown that the nuts excrete a coagulant chemical that does result in the purification process.

2.6.5. Filtration Using Plant Seeds

2.6.5.1. P. aculeata

In Tanzania, Singida rural district, the community uses local plants that produce seeds (especially *P. aculeata*) for water purification. According to study conducted by Nancy et al. (2007), the use of the plant seeds have show that the seeds of the p. aculeate have a great

potential of enhancing social, economic and ecological development in semi-arid areas by purifying water.

2.6.5.2. Moringa Olifera Seed

People purify water at household level by using Moringa Olifera seed. One liter of water is treated by 50-150mg Moring seed depending on the level of clearness of the water. The seed cake left after extraction of oil from the seed is also used to purify water. The procedure is as follow: Use the Moringa seed pod well dried on the Moringa tree, collect the seed pod, remove the seed husks, leave the white kernel, crush the seed kernel to powder, mix the powder with small quantity of water in a small cup, pour the mixture through tea strainer or sieve in to another cup, add then the resulting milky juice in to the water you want to purify. Stir the water and the milky juice quickly for 30 second, and then slowly and regularly for 5 minutes. Cover the water and not disturb it at least for an hour. Finally, the clean water on the top can be siphoned or poured in to another material (Trees for life international, 2011).

Study conducted by Kebreabe, A. Ghebremichael (2004), the Moringa Olifera seed has a coagulant protein that helps to filter and treat water. The result of the study by Gheberemichael (2004) showed that the coagulant protein in Moringa Olifera possesses a prosperity of coagulating waste in the water and in addition it has antimicrobial effect. The antimicrobial effect of the seed protein is found to treat bacteria that are even resistant to antibiotics. Therefore, the two properties that are, the coagulation and antimicrobial effect of moringa seed make it suitable to treat waste water.

According to Asrafuzzaman Md.,et al., (2011), there are locally available natural coagulants that are found in *Moringa Olifera, Cicer artienum and Dolichos lablab plants.* According to that research, the coagulants in the seeds of these plants have the capacity to purify turbid water. Moringa Olifera has the capacity to purify turbid water of 100 NTU to 94.1%, *Cicer artienum* reduced the turbidity of 100NTU water to 95.89% and *Dolichos lablab* reduced 100NTU turbid water to the extent of 88.9%.

According to their research, significant improvement of turbidity and total coli form was found by using the locally available natural coagulants. Maximum turbidity reduction was found for highly turbid water and low turbidity reduction was found for low turbid water. Among the experiment plants used with natural coagulation capacity, *cicer artienum* was found to be the most effective with turbidity reduction capacity of about 95. 89%.

Table 5: **Reduction efficiency of turbidity using d/t coagulants in different turbidity ranges.**

Coagulants	Dose used (mg/L)	% of turbidity reduction (High-*turbidity water)	% of turbidity reduction (Medium-*turbidity water)	% of turbidity reduction (Low-*turbidity water)
Moringa Olifera	50	86.9	65.62	56
	60	87.3	66.45	57.2
	70	89.4	67.29	58

	80	90	68.54	58.8
	90	90.8	68.95	59.2
	100	94.1	69.37	60
Cicer arietinum	50	93.78	74.28	62.58
	60	94.63	74.69	64.51
	70	95.15	79.18	66.12
	80	95.26	81.02	70
	90	95.47	81.42	70.96
	100	95.89	81.63	71.29
Dolichos lablab	50	84.5	65.10	49.71
	60	86	65.91	51.42
	70	86.6	66.73	56.28
	80	87.7	67.55	57.14
	90	88.4	67.75	59.42
	100	88.9	68.16	60.85

Source: Hindawi, International Scholarly Research Notices, ISRN Microbiology, 2011

2.7. Appropriate water treatment methods

Based on the available traditional methods used by different communities of the developing countries, some improvements have been made and the techniques are used in many parts of the developing countries (Vigneswaran S., Tam D. M., and Visvanathan C., 1983). These include Horizontal flow courser media filter, upper flow gravel filter and two stage filter.

2.7.1. Horizontal Flow Coarse Media Filter

This method is used to purify highly turbid water by using coarse gravel or crushed stones as filter media. When the turbidity of the water is greater than 50 NTU, this method is the preferred technique to purify water. The method has two aspects, filtration and sedimentation simultaneously. It also helps to remove pathogens although in a limited manner. A study

conducted by Asian institute of Technology, Bangkok, Thailand showed that, the technique can remove 60-70% of turbidity and 80% of coli form (Vigneswaran S. and Visvanathan C. 1995).

2.7.2. Up flow Gravel Filter

This method is when we want to purify water from physically observable suspended material and biological impurities. The application is used on the pressure side of pump, at the bottom of the upper most ponds in case of multi pond system. A protection fabric is laid over the pond liner in same manner of down flow filter. For the purpose of filtration of water from mechanical and biological impurities, the manifold is covered by layer of 3/4 inch to 1-1/2 inch gravel at least as twice as thick as the pipe diameter and the larger gravel is covered with 6 to 12 inch of the pea gravel which is planted with water iris, cattails, and rushes (www.conservation technology.com/pond filter gravel.html, accessed Feb 27, 2018).

2.7.3. Two Stage Filter

The choice of stages of water filters is dependent on what you want to filter. If you want to filter water for drinking, then the main goal is to get the water taste palatable, so you would use the simple method of two stage filter technique (www.aquaticlife.com/blog, 2016).

2.8. Household Water Treatment Methods

2.8.1. Straining

It is the process of poring muddy water or dirty water through a piece of cloth, which is fine, and clean. If used properly, it aids much in purifying water. It is advisable that the cloth be of cotton rather than other types. The cloth should be thin, not so thick. Even though straining alone is not

enough to purify water for drinking, it is a house hold method that aids much for water purification.

2.8.2. Disinfection

Disinfection is the process that aid in removing biological organisms capable of causing diseases in apparently clean water. Commonly used household disinfection methods include:

Boiling water: Boiling is a commonly used traditional method of treating water. If done properly boiling can help much in removing pathogens from water. In places where there is no other alternative, it is better option. Boiling has no residual effect, so improper storage can lead to re-contamination. Boiled water should be stored safely and used within a few days to be called treated water. The temperature of boiling water must be high to treat water; otherwise it can be a means of water treatment. For boiling to be effective, water must be brought to a rolling, bubbling boil.

- ✓ Low elevation one minute rolling, bubbling boil,
- ✓ High elevation three minutes rolling, bubbling boil.

Exposure to sun: Solar exposure of water can help in destroying pathogens in the water. Methods used are exposing water stored in plastic or glass material and put it on sunlight at mid day for extended period, in tropical countries for about five hours. If the water is cloudy, the time period need to be extended up to two days. The goal of disinfection is to remove pathogens; therefore, we may find alteration in taste of water as a side effect in water treatment with disinfectants. Boiling can leave the water tasteless, sun exposure can make the water hot, and other chemical disinfection can make the water taste bad (Field manual for Red Cross/Red Crescent personnel and volunteers, 2008).

2.8.3. Sedimentation

2.8.3.1. Three Pot Method

In a condition of muddy water, putting water in a container for a given time cause the dirt to fall to the bottom of the water. Purification of water through cloth can make this process efficient. Water that is purified through sedimentation does not mean that it is clean, free from pathogens but sedimentation process makes water ready for disinfection. We can use three pot method of sedimentation. We use three pots, first put water in pot 1 and 2. Then we pour water in pot 2 in to pot 3 and then wash pot 2. Then we pour water in pot 1 in to pot 2 then we wash pot 1. Then pour water from the source in to pot 1 by strain it through cloth. You can settle the water for a day, and repeat the process. You need to use water in pot three for it has settled for 2 days. (ibid)

2.8.3.2. Chemical Method

Water can also be segmented using chemicals. The two most commonly used chemicals to purify water are the PUR and Water maker. To use PUR, we use one sack in 10 liter of water. Water marker is available in different forms and we need to follow specific instruction to use it. They are used in emergency conditions and the chemicals remove dirt and disinfect water simultaneously. Both chemicals can be used at household levels (Field manual for Red Cross/Red Crescent personnel and volunteers, 2008

Chapter Three

3. Materials and Method

3.1. Interview and Observation of the Practice

The study has used triangulation method, means combination of qualitative and quantitative method. The Qualitative aspect has dealt with the practice of the community in using African Spear plant to purify water. The qualitative data is gathered by making interviewing with community members with the experience of using African Spear plant. The semi structured interview guide was prepared to collect the interview. The members involved in interview are chosen purposively from the community. The total numbers of informants are 30 persons, (15 female and 15 male). The thesis has also observed the community practicing the purification process using African Spear plant.

3.2. Preparation of the Plant and Sample water

For the quantitative design, the African Spear plant as well as the sample water for test was taken from Konso. The African Spear plant is collected from farm land and the sample water was collected from local pond in Konso located in Dokatu Kebele. The African Spear plant was taken and then crushed and stirred with turbid water and an experiment was done to check the purification efficacy of African Spear plant.

3.3. Laboratory study

The water quality parameters that were tested in this study are Turbidity, PH and bacteriological test. Turbidity was tested with turbidity meter (HACH2100N), PH with PH meter (Janway3505) and bacteriological presence was tested with membrane filtration method

The experiment for turbidity and PH was conducted at Addis Ababa University, Institute of Technology, Environmental Engineering lab and Arbaminch University Water Quality Lab. The bacteriological test was conducted at Addis Ababa City Administration Environmental Protection Authority, Environmental lab and Arbaminch University Water Quality Lab.

Jar test was test was conducted using six (6) liter of artificially turbid water with turbidity of 70NTU and PH of 6.98@18^0C at the time of preparation. The beaker with 1000ml was used and the water volume in the beaker was 500ml. To determine the optimum PH, the PH in each beaker was adjusted by using HCL and NaOH. Another five (5) liter of synthetic turbid sample with turbidity of 156NTU was prepared for second round jar test.

3.3.1. Materials

The study used pen to record the significant informants, recorder to record sound of the practice of the African Spear plant utilization, 1liter of sample water, stone, African Spear plant and Jar to mix African Spear plant with sample water. Apparatus used in Environmental Engineering

laboratory are turbidity meter (HACH2100N) which is shown in figure 6.

Figure 5: ***Turbidity meter and bottles contains standard solution for calibration purpose***.

Another material used is PH meter (Janway3505) which is used to measure PH of water and the chemical used is KCL, buffer solution with PH of 4, 7 and 10.

Figure 6: PH meter

Jar test was test was conducted using six (6) liter of artificially turbid water with turbidity of 70NTU and PH of 6.98@18^{0}C at the time of preparation. The beaker with 1000ml was used and the water volume in the beaker was 500ml

Fig 7: Jar test experiment

3.3.2. Methods

3.3.2.1. Turbidity:

Turbidity of water was tested using turbidity meter (HACH2100N). Five bottles which contains standard solution of 10ml were also used. The first bottle contains a neat solution with turbidity <0.1NTU, the second one is with standard solution of turbidity 20NTU, the standard solution in third, fourth and fifth bottles are 200NTU, 1000NTU, 4000NTU respectively. These solutions are used for calibration purpose. The turbidity was tested before and after treating the water with

African Spear plant. The African Spear plant was crushed and added to the turbid water and the change was recorded for successive 5 hrs.

3.3.2.2. PH of water:

To determine the PH of the sample, KCl solution was used to prevent the dryness of PH meter sensor. The sensor was washed carefully with tap water, rinsed with distilled water thoroughly and then wiped with tissue paper. The model of the instrument used to measure PH was Jenway (3505) PH meter. The PH meter is calibrated by buffer solution with PH of 4, 7 and 10. The PH was also tested before and after treating water with African Spear plant.

3.3.2.3. Total Coliform and Fecal Coliform level of the Water

The sample water collected from Konso was first tested for the presence of Total Coliform and fecal Coliform. The test was performed in the standard laboratory of Addis Ababa City Administration, Environmental protection laboratory. The test was conducted before and after treating the water with African Spear plant. The method used to test total coli form and fecal coli form is membrane filtration. The sample water was delivered to the laboratory first before treating water with African Spear plant and the test for presence of total coli form and fecal Coliform was done. The crushed African Spear plant was then put in the water for twelve hours and then the sample water was again taken to the laboratory for test, and the water was tested for the total Coliform and fecal Coliform in the laboratory. Membrane filtration method has used to conduct biological test. At Arbaminch University water quality laboratory another sample was tested with addition of African Spear plant, stirred for one minute, kept for 15 minutes. The culture media was prepared from membrane lauryl sulphate of 3.65g and 100ml of water. The

capacity of African Spear plant to remove bacteria was tested at the optimum point. The water bicker with turbidity of 24NTU was taken and tested again for the bacterial presence.

3.4. Study Area

The collection of the experimental water, the African Spear plant, the interview of the significant persons and observation of the practice by the community was conducted at Konso woreda, in SNNPR, Segen people Zone. The Laboratory activities were conducted at three places, Addis Ababa University Institute of Technology, Environmental Engineering laboratory, Arbaminch University Water Quality Laboratory and Addis Ababa City Government Environmental Protection Authority, Environmental laboratory.

3.5. Method of Data Analysis

Microsoft excel was used to analyze experiment data. Data collected from interviewing experienced persons in utilizing African Spear plant has also been analyzed by narration

Chapter Four

4. Results and Discussions

4.1. Results

4.1.1. Result Obtained from Interview and Observation

This research tried to study the efficacy of African Spear plant in purifying water. Accordingly, this paper tried to explore qualitatively how the people apply their local method to purify dirty

water using African Spear plant. This aspect was done by interviewing experienced people in using African Spear plant in the community to share their experience and to demonstrate how they do it.

Figure 8: ***Data collected using semi structured interview***

The result of the interview showed that the source of drinking water for people living in urban part of the woreda is groundwater. This water is first collected to tank and treated with chlorine and wuha agar. The part of the community that lives in rural area of the woreda gets drinking water from spring water and unprotected well. But those who keep cattle and work at farm land far from the resident have used water from local pond and rivers. The water collected from the spring water and unprotected water is consumed by the rural community without any treatment.

Those who use water from local pond and river apply African Spear plant to treat water and use for their daily activity. Water purification using African Spear plant is preferred by the community because of its availability, easiness in application and there is no negative side effect from experience. The time taken to treat water collected from local pond and river is about 10 to 15 minutes. The application of African Spear plant is similar in different villages of the community. The experience is used mainly by those who keep cattle and have no access to well or tap water. People who are working in the far fields of the farm also use this method of water purification as they do not have access to tap or well water.

Those who work on farms near to their villages' for long time also utilize this method to purify their turbid water of river water. According to the interview, the African Spear plant is taken from its root in the field, crushes and stirred and put it in turbid water for about 1 minute.

After approximately 10 to 15minuts, the turbid water turn clear and become apparently safe for drinking. The person in need of drinking water can then drink it without any fear of dirtiness. The observation has been made in three occasions when the local experienced people demonstrated their experience. Figure 9 to 12 demonstrate the procedure used by Konso community purify dirty water using African Spear plant.

Figure 9: African Spear Plant, from Field

(Source: Researcher, Konso, 2018)

Figure 10: Raw water collected from source

Figure 11: Crushing the African Spear plant

Figure 12: Raw water is stirred with African Spear plant

Figure 13: ***The stirred water is left to settle***

4.1.2. Experimental Results

The Next step taken was the quantitative design to test the efficacy of the African Spear plant in purifying dirty water. The parameters tested in the experiment were Turbidity, PH, and

Bacteriological presence of total Coliform and fecal Coliform. The first round experiment for turbidity and PH was done at Addis Ababa University, Institute of Technology, at environmental engineering lab. The experiment for total Coliform and fecal coli form was done at Addis Ababa City Administration Environmental Protection Authority laboratory. The experiment was done before and after the application of crushed African Spear plant.

Second round experiment was conducted at Arbaminch University water quality laboratory for the three parameters. The results of the lab experiments are presented below.

4.1.2.1. PH of the Water

PH of the water was tested before the addition of African Spear plant and it was found to be 6.93 at 20.7 ^{0}C. The testes of PH were done after one hour and the result was recorded. Then tests were done in six consecutive series and result are presented in Table 6

Table 6: **The result of PH tests before addition of African Spear Plant**

Time of Test	**PH @ Temperature**	**Standard PH**

Before the test	6.93 at 20.7 ^{0}C	6.5 to 8.5
After 1 Hour	6.93@20.7^{0}C	6.5 to 8.5
After 2 Hours	6.94@20.6^{0}C	6.5 to 8.5
After 3 Hours	6.96@20.1^{0}C	6.5 to 8.5
After 4 Hours	6.96@20.5^{0}C	6.5 to 8.5
After 5 Hours	6.95@20.6^{0}C	6.5 to 8.5
After 6 hours	6.96@20.5^{0}C	6.5 to 8.5

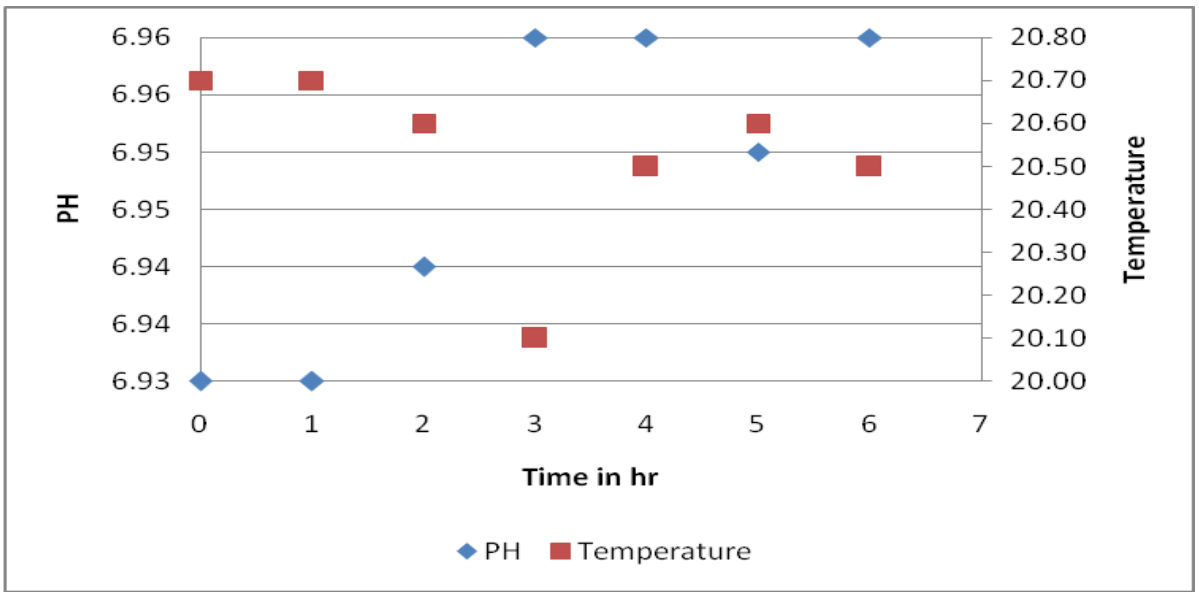

Figure 14: PH and temperature results against time for untreated sample water

The application of African Spear plant was conducted in three different occasions'. First, the water is treated with African Spear plant and settled up to 6hrs and the change is recorded in one hr interval.

The result recorded was found to be different at different times as presented below in Table 7**.**

Table 7: the result of PH Tests after treating water with African Spear Plant

Time of Test	PH @ Temperature	Standard PH
Before the test	6.93 at 20.7 ^{0}C	6.5 to 8.5
After 1 Hour	6.41@22.0^{0}C	6.5 to 8.5
After 2 Hours	6.42@20.6^{0}C	6.5 to 8.5
After 3 Hours	6.29@20.9^{0}C	6.5 to 8.5
After4 Hours	6.22@20.40^{0}C	6.5 to 8.5
After 5 Hours	6.34@20.30^{0}C	6.5 to 8.5
After 6 Hours	6.35@20.2^{0}C	6.5 to 8.5

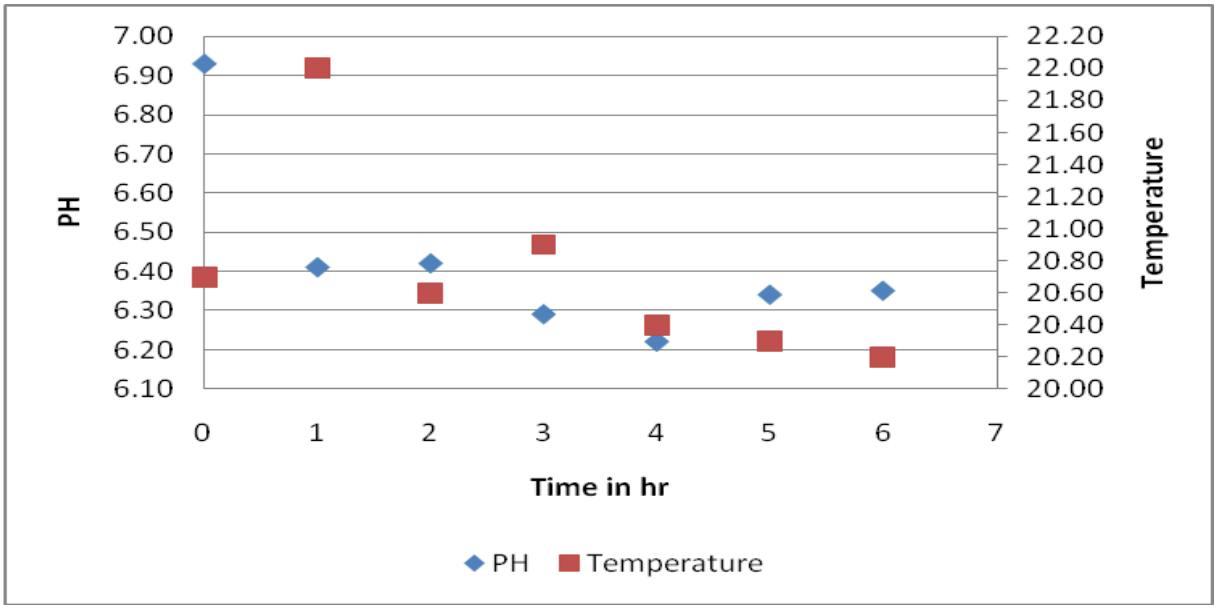

Figure15: PH and temperature results against time for treated sample water

In this entire situation, the PH of the water was in the range of minimum 6.22 and maximum 6.93. The slight fluctuation of the PH might be related to slight variation of Temperature.

Again, for the second time, another water sample of PH 7.11 has tested after treating the water with African Spear plant for 12 hrs and the record is displayed below in Table 8

Table 8: The result of PH after treating water with African Spear plant for 12 hours

Time of Test	**PH @ Temperature**	**Standard PH**
Before the test	7.11@19.9^{0}C	6.5 to 8.5
After 12 Hour	6.27@19.2^{0}C	6.5 to 8.5
After 13 Hours	6.28@19.6^{0}C	6.5 to 8.5
After 14 Hours	6.26@19.1^{0}C	6.5 to 8.5
After 15 Hours	6.36@19.5^{0}C	6.5 to 8.5
After16 Hours	6.25@19.4^{0}C	6.5 to 8.5

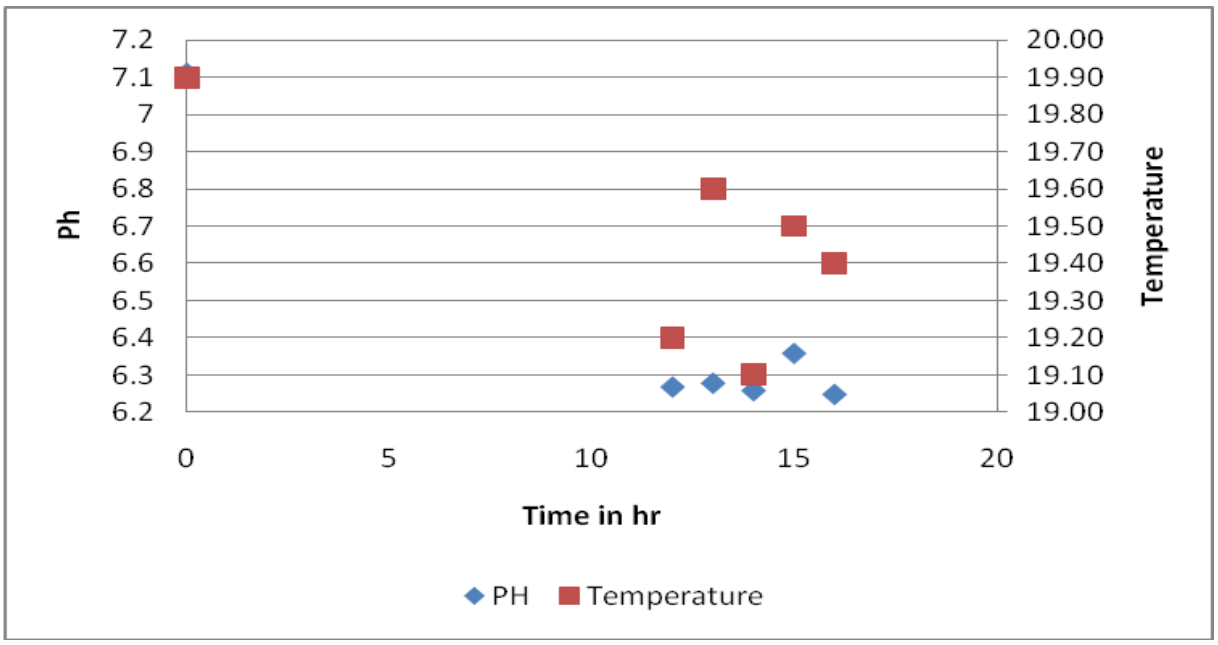

Figure 16: PH and temperature results against time for treated sample water for 12hrs

4.1.2.2. Turbidity of the Water

Before addition of African Spear plant the turbidity of water has been measured and it was 499NTU. The rate of change in turbidity without African Spear plant was recorded for five successive hours as presented in Table 9.

Table 9: Turbidity Test Result before without African Spear plant for 5 hours

Time of record	Turbidity in NTU	Standard Measurement
Before the test	499	<1 NTU
After 1hr	410	<1 NTU
After 2hr	397	<1 NTU
After 3hr	380	<1 NTU
After 4hr	319	<1 NTU
After 5hr	304	<1 NTU

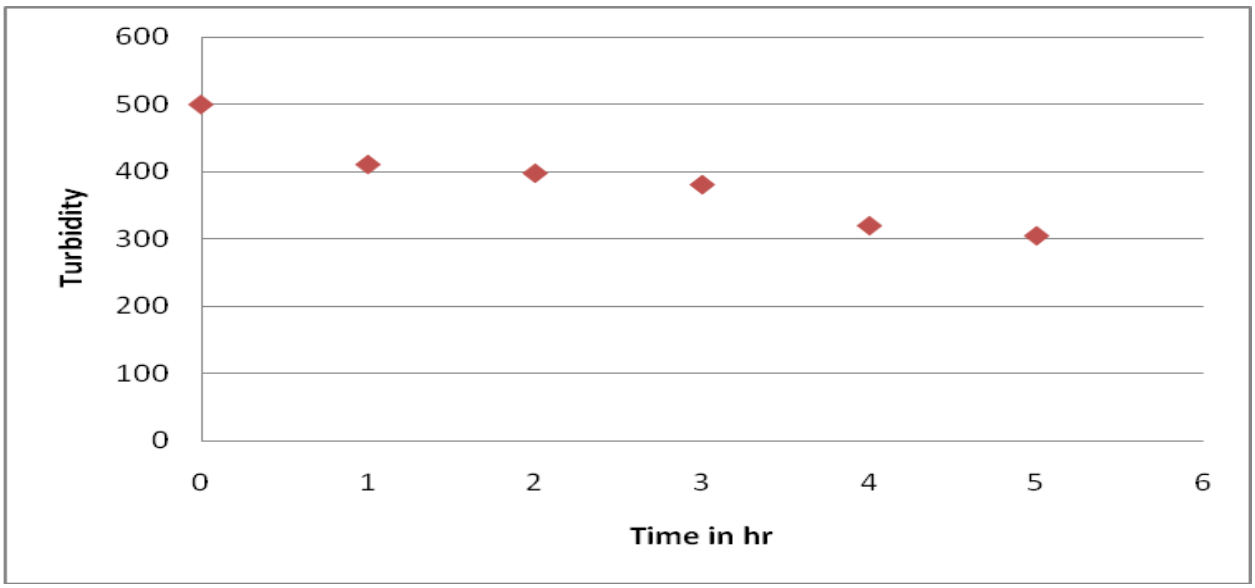

Figure.17: Turbidity result for untreated sample water against

After the addition of African Spear plant, the result after 1,2,3,4 and 5 hrs are 321 NTU, 231 NTU, 214 NTU, 184 NTU and 166 NTU respectively.

Table 10: Turbidity Tests Result after addition of African Spear plant for six hours

Time of record	Turbidity in NTU after addition of African Spear plant	Standard Measurement
Before the test	499	<1 NTU
After 1hr	312	<1 NTU
After 2hr	231	<1 NTU
After 3hr	214	<1 NTU
After 4hr	184	<1 NTU
After 5hr	166	<1 NTU

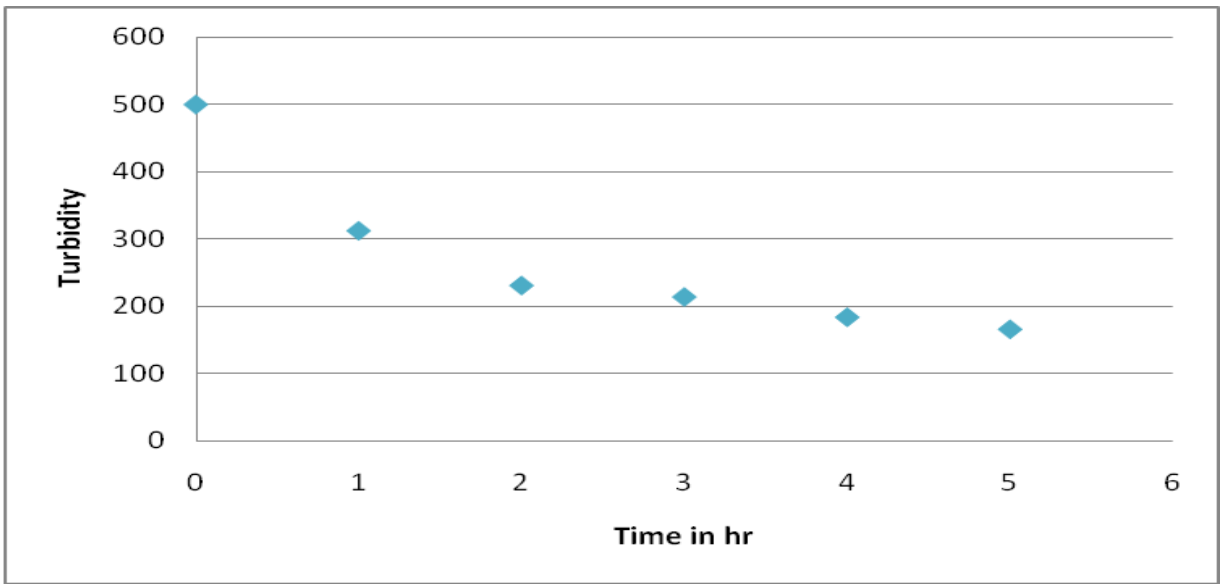

Figure.18: Change in turbidity with time of treated water sample for six hrs

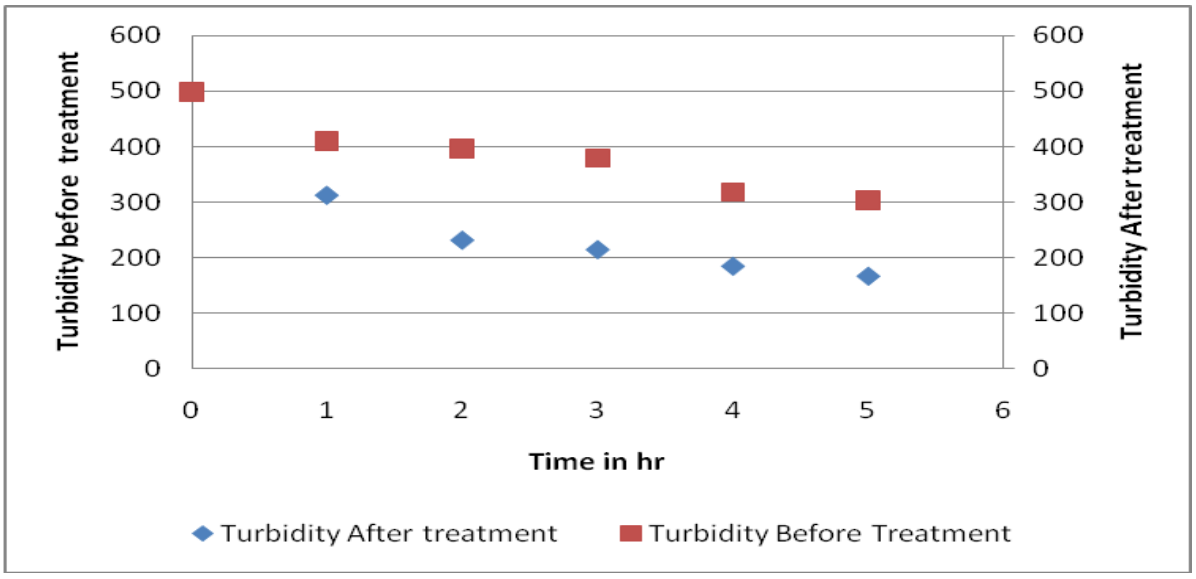

Figure 19: Turbidity removal before and after treatment with African Spear Plant

As clearly presented above in Table 9 and 10, one can understand the continuous reduction in turbidity in both cases. The only difference between the treated water with African Spear plant and the untreated one is, the turbidity reduction of treated one is faster than untreated one. The

turbidity of untreated samples has decreased from 499NTU to 304NTU after six hours which means the turbidity removal efficiency is 39.0%. But the turbidity of that of treated dropped to 166NTU after 5 hours, which is 66.7% turbidity removed.

To know the change in turbidity result after five hours, another sample with turbidity of 1680NTU was taken and treated with African Spear plant for 12 hours; and the change in turbidity was recorded as presented in Table 11.

Table 11: Turbidity Tests Result before addition of African Spear plant for twelve hours

Time of record	Turbidity in NTU Before Treatment	Turbidity in NTU After Treatment	Standard Measurement
Before the test	1680	1680	<1 NTU
After 12hr first hr	55.4	54.8	<1 NTU
After 13hrsecond hr	52.8	45.9	<1 NTU
After 14hr third hr	50	43.4	<1 NTU
After 15hr fourth	48.9	41.4	<1 NTU
After 16hr fifth hr	47	40.3	<1 NTU

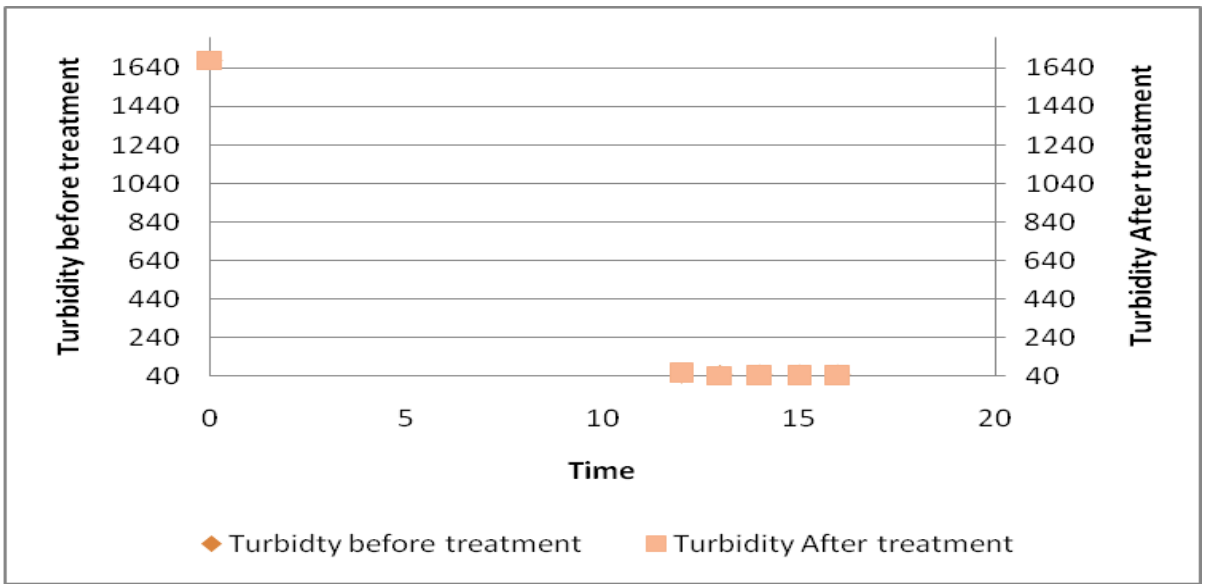

Figure 20: The turbidity of the untreated and treated water after 12 hr for five consecutive hrs

Turbidity Removal efficiency after treatment is calculated as

TRE= (Influent-Effluent)/influent*100, = (1680-40.3)/1680*100= 97.6%

TRE for untreated water is 97.2%

After 12hr the turbidity removal efficiency at optimum dosage of African Spear plant for untreated and treated water are the almost the same, 97.2% and 97.6% respectively.

This implies that, when time of settlement increases, the removal of turbidity is high.

4.1.2.3. Total Coliform and Fecal Coliform level of the water.

The sample water collected form Konso was first tested for the presence of Total Coliform and fecal Coliform. The test was performed in the standard laboratory of Addis Ababa City Administration Environmental protection laboratory. Before treatment of the water with African Spear plant, the number of total coliform and fecal coliform bacteria was 1170 bacteria /100 ml of water and 520 bacteria /100 ml of water respectively. After treatment of the water with African Spear plant, the number of the Total Coliform and fecal Coliform bacteria in the water was found to be 1250 bacteria/100 ml of water and 894 bacteria /100ml of water respectively.

The method used to test total Coliform and fecal Coliform in the water is the sample water was delivered to the laboratory first before the experiment and the test for presence of total Coliform and fecal Coliform was done. Then the crushed African Spear plant was put in the water for12 hours and then the sample was again taken to the laboratory for test, and the water was tested for the total Coliform and fecal Coliform in the laboratory. Then after 24hrs the result was found to be increment in number of bacteria after the application of the African Spear plant in the sample water.

The standard for drinking water total coli form and fecal coli form is zero bacteria/ 100 ml of water.

Table 12: Total Coliform and Fecal Coliform Tests Result, at AACAEPA

Time of Test	Total Coli form	Fecal Coli Form	Standard for Total Coli and Fecal coli Form (MCL)
Before the treatment of the water	1170 bacteria/ 100 ml of sample water	520 bacteria/ 100 ml of water.	0/100Ml
24 Hours after the application of the African Spear plant	1250 bacteria/ 100 ml of water	894 bacteria /100 ml of water.	0/100ml

4.1.2.4. Investigation of the effect of dosage on water quality parameter

To Investigation of the efficacy of dosage on water quality parameters, water sample was collected from Konso and water quality parameters tests has been conducted at Arbaminch University. The research tried to know the optimum dosage of African Spear plant required per litter. At the optimum dosage, the capacity of the African Spear plant to remove bacteria from the water has been conducted. African Spear plant with six different weights has been crushed with a grinder and mixed with 1liter water. The weights of African Spear plant are 7.3g, 11.9g, 13.2g, 15.2g, 17.5g, and 18.6g. The total Coliform presence in the sample before and after the addition of African Spear plant with different dilution levels is presented in the Table13. The number of total Coliform has measured at optimum dosage and result has presented in Table 13.

Table13: Total Coli form record after 15 Minutes with different dilution level

Dish code	Dilution(sample water/distilled water)	Total coli form before treatment	Total coli form after treatment
D3 (control)	100	0	0
D46	50/50	249	240
D32	20/80	240	232
D23	10/90	235	223
D26	5/95	210	202

The turbidity and PH of the sample before addition of African Spear plant was 57NTU and 7.97@25^{0}C respectively. Then the change has been recorded after mixing these different weights of African Spear with 1litter of water for 1minuts with 250 rpm. Table 14 presents the change in turbidity and PH after application of different weight of African Spear plant after 15minuts.

Table 14: Turbidity and PH with different weights of African Spear plant after 15 minutes

Weight of African Spear plant in gram	Turbidity in NTU	PH
7.29	37	7.73@25^{o}c
11.94	24	7.77@25^{o}c
13.20	44	7.72@25^{o}c
15.18	38	7.71@25^{o}c
17.50	39	7.73@25^{o}c
18.63	50	7.61@25^{o}c

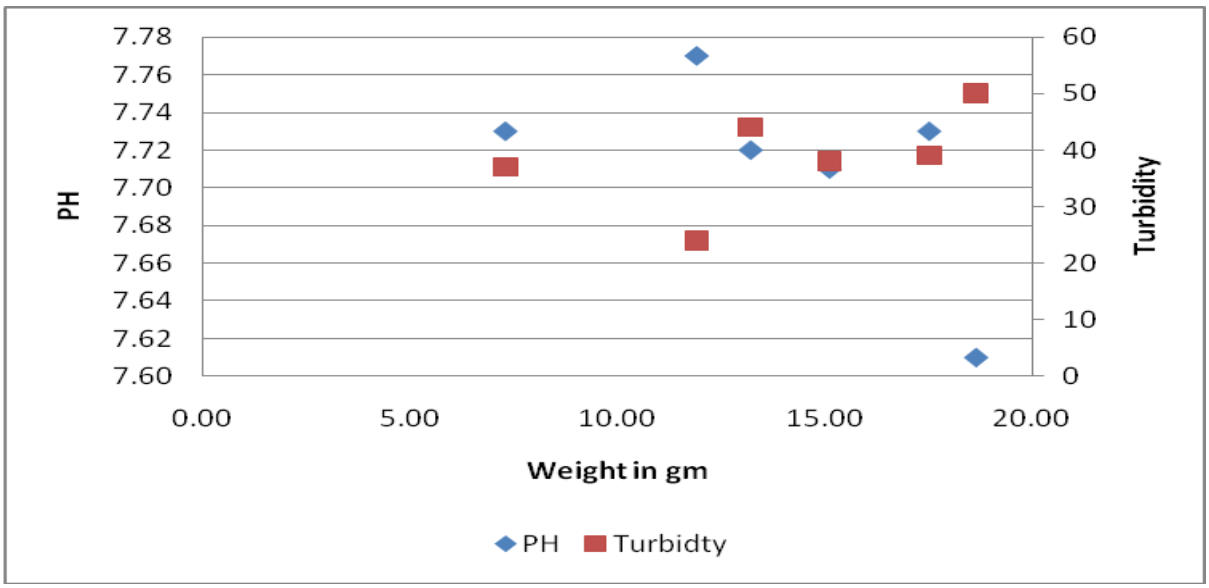

Figure 21: Turbidity vs Dosage of African Spear plant within 15 Minutes

At optimum dosage the turbidity removal efficiency within 15 minutes is 57.9%

From the Table 14 and figure 21 one can see that, the turbidity removal efficiency of optimum dosage of African Spear plant per 1liter is 57.9% within 15minuts.

After 2hrs the record of change in turbidity and PH has also conducted and presented in table below.

Table 15: Turbidity and PH with different weights of African Spear plant after 15 minutes

Weight of African Spear plant in g	Turbidity in NTU	PH
7.29g	39	7.76@25
11.90g	17	7.95@25.3
13.20g	32	7.86@25.2
15.1g	27	7.88@25.3
17.5g	29	7.86@25.1
18.63g	39	7.72@25.5

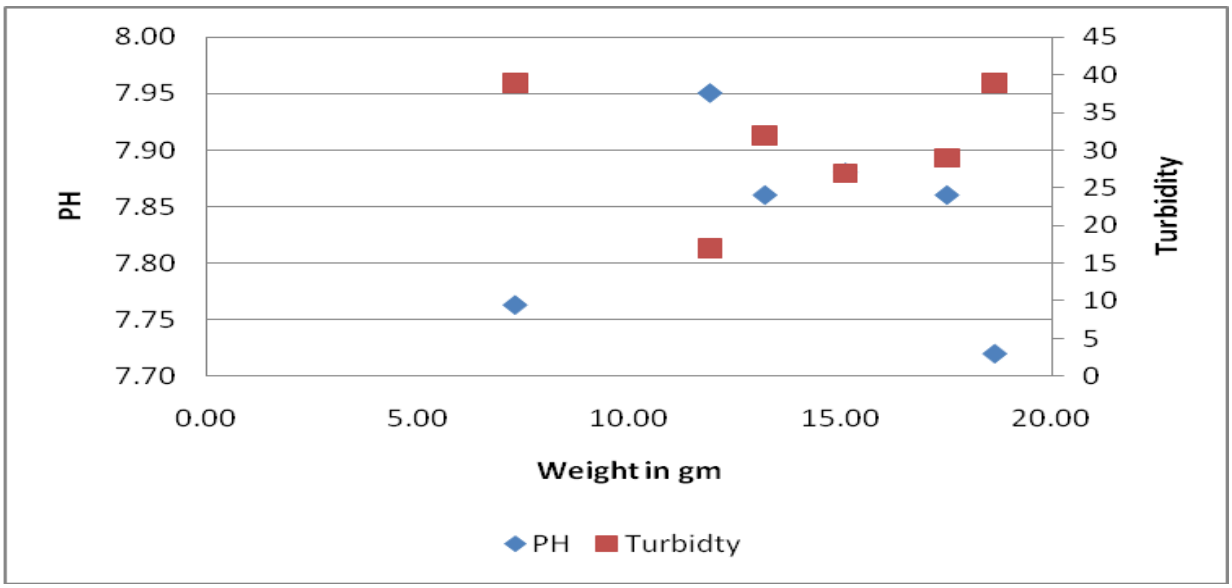

Figure 22: Turbidity removal, PH versus Dosage after 2hrs

After 2hr the turbidity removal efficiency of African Spear plant at optimum dosage is 70%.

By using jar test technique, the optimal dosage found in moderately turbid water, means water with turbidity of 70NTU was found to be 18gm/liter and in water relatively highly turbid water that is water with 156NTU turbidity was found to be 42gm/liter at optimal PH.

Dry African Spear plant has no significant effect on turbidity reduction implies that the element that aid in water purification might be mainly found in the juice of the plant rather that n in the fiber of the plant, which needs further study. The result of jar test has brought the optimum PH to be 6.8.

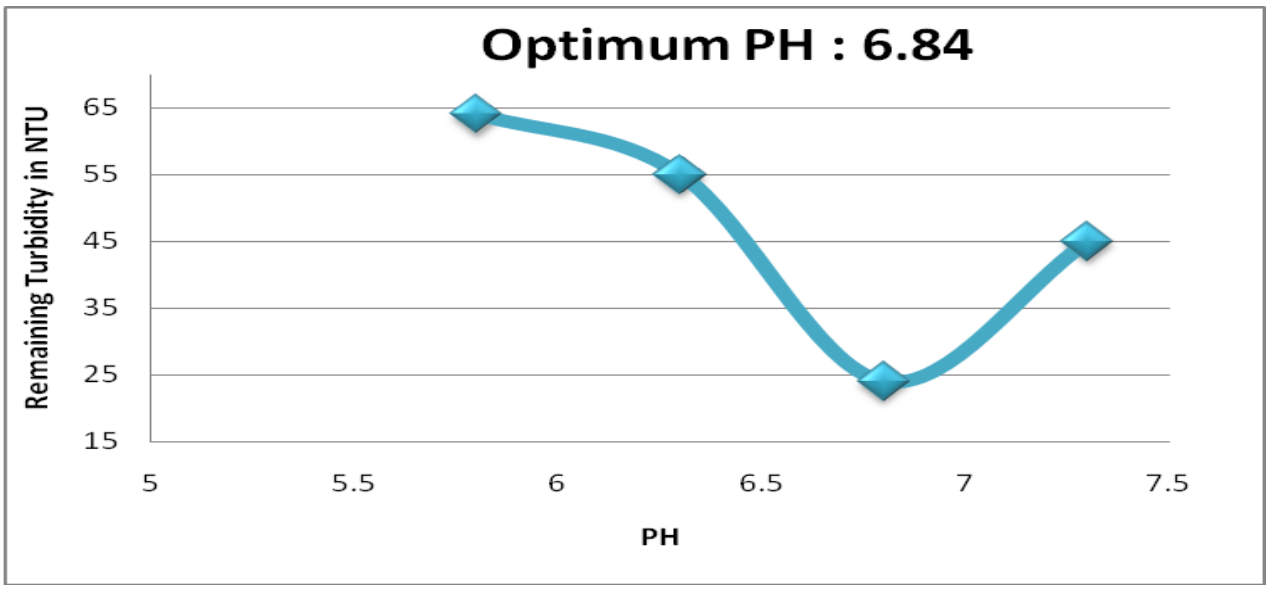

Figure 23: Result of jar test for optimum PH

Optimum dose of African Spear Plant

To determine the optimum dosage, the PH was adjusted at optimum PH which is 6.84 and different dose of fresh African spear Plant was added. The different weight of African Spear plant were (6, 9, 12, 15, gm). Then the graph of residual turbidity against African Spear Plant has plotted as shown below.

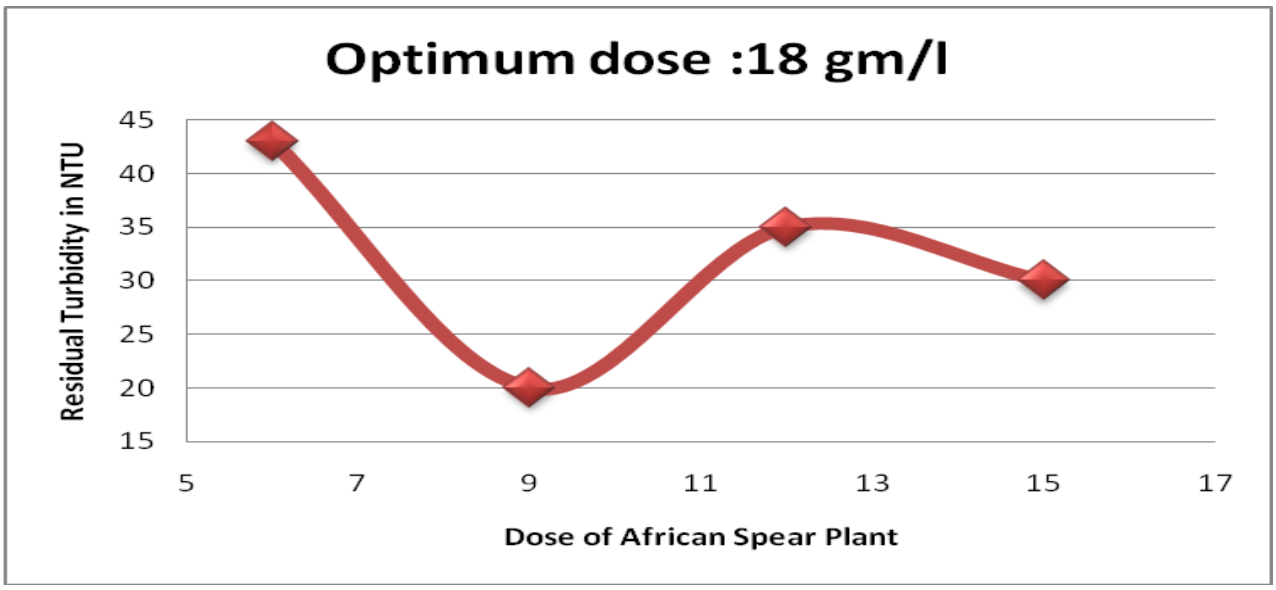

Figure 24: Optimal Dosage of African Spear plant.

Another test was conducted to determine the amount of dosage needed to purify relatively highly turbid water. Therefore five (5) liter sample water with turbidity and PH of 156NTU and 6.82@18.2^{0}C respectively has been taken and jar test was conducted. For optimum PH, the PH was adjusted from first beaker to the last one and the values of the PH in the beaker were (6.3, 6.8, 7.3 and 7.8). The dose of African Spear plant was 15g/500ml. The obtained turbidity decrements were 89NTU, 36NTU, 64NTU and 53NTU from first to fourth jar respectively. The optimum PH was red from graph of turbidity vs PH.

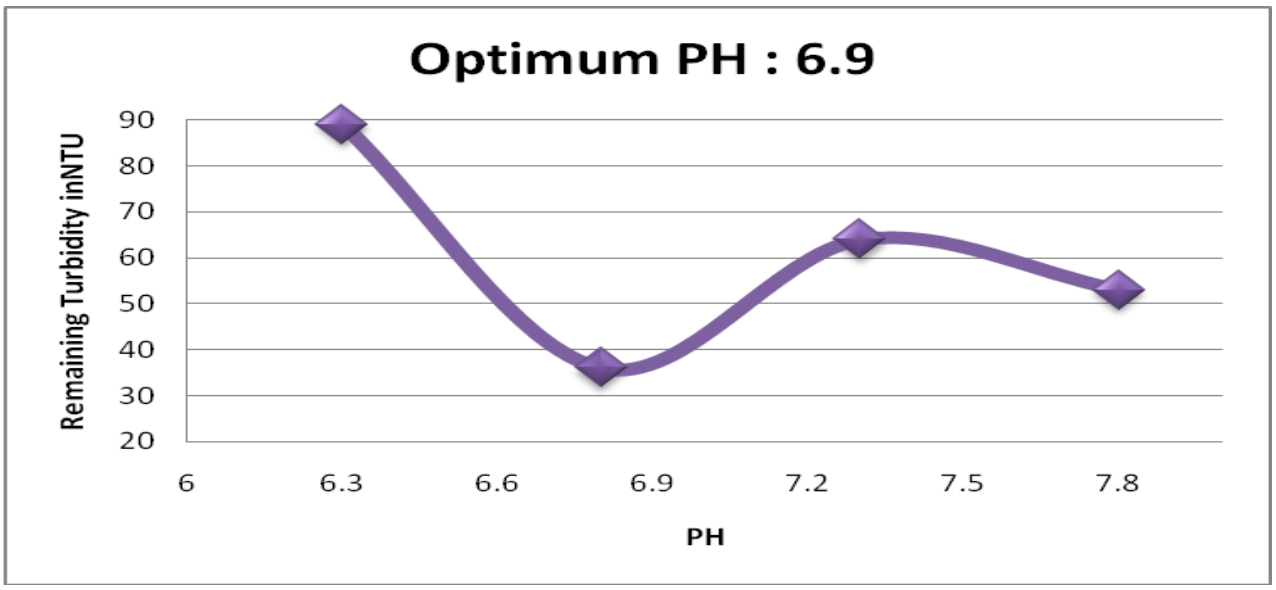

Figure 25: Optimum PH of sample with 156 NTU

The optimal turbidity reduction was found at 6.9 PH, which was taken as optimal PH.

Based on the above result, to determine optimal dosage, different weight of African spear plant (15, 18, 21, 24 gm) was added to sample with the PH of 6.9 which is the optimum PH. And the result was presented

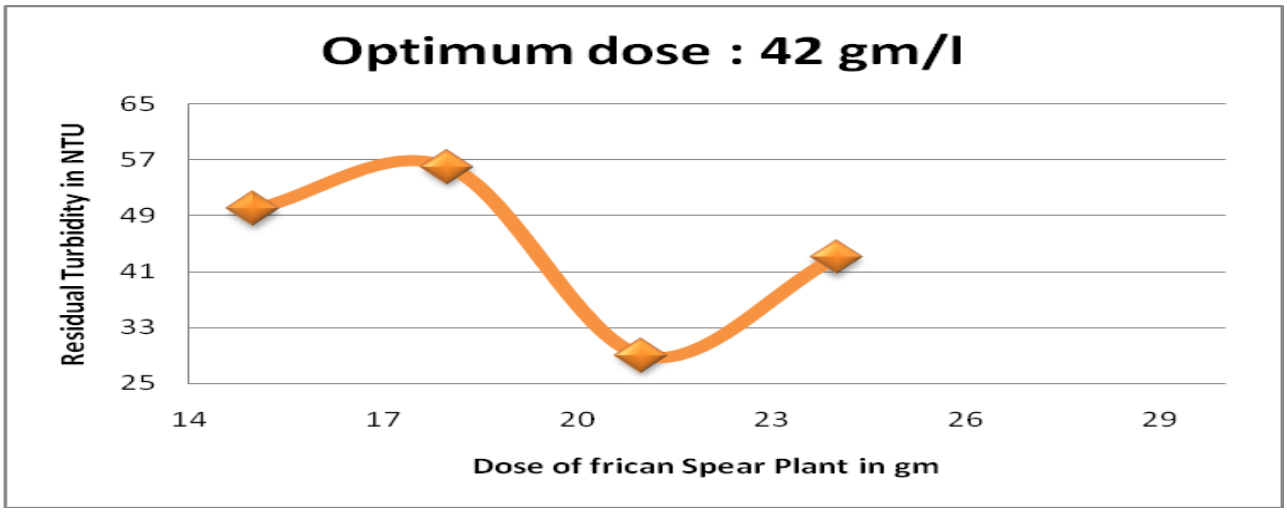

Figure 26: Optimal dosage of African Spear plant

The Effect of Dry African Spear Plant in Altering water Quality

For dry African Spear plant, the method followed was that the plant was first dried up in an oven. Then by using grinder the dry African Spear plant was crashed and mixed with sample water. The capacity of dry African Spear plant to remove turbidity was checked by conducting the same lab procedure. The synthetic turbid water with turbidity of 56NTU, 75NTU and 148NTU was taken. As community practice the grinded African Spear plant was added to the experiment water and the change was recorded. Simultaneously, water with similar turbidity with experiment sample was kept and checked for natural settlement after 15 minutes and the result was also recorded, then the difference was compared with the water that was treated with dried African Spear plant.

Fig 27: Dried African Spear Plant

Table 16: Comparison of water treated with dried African Spear Plant and naturally settled.

Dose of African Spear plant in gm/l	% of turbidity reduction for sample with 56NTU	% of turbidity reduction by Natural Settlement	% of turbidity reduction of sample with 75NTU	% of turbidity reduction by Natural Settlement	% of turbidity reduction for sample with 148NTU	% of turbidity reduction by Natural Settlement
20	2.67	2.67	4.00	3.33	2.70	2.02
30	3.57	2.67	6.00	3.33	2.70	2.02
40	3.57	2.67	6.00	3.33	3.04	2.02
50	5.35	2.67	6.66	3.33	2.37	2.02

As we can read from the table turbidity reduction efficiency using dried African spear plant and natural settlement are almost similar, the total range of change is between 0% as minimal and 3.3% as maximal percentage, indicating that dried African spear plant has no significance in water purification compared to wet African Spear plant as used by the community. The small change in turbidity removal efficiency can be related to presence of fiber in the plant that can catch and remove macro wastes in the water.

4.2. Discussion of Results

The research has come up with the results of the parameters desired to study in the objective. The first parameter tested was the PH of the water whether it is affected by the addition of African Spear plant or not. As presented above, the PH of the water before and after the experiment varied only very slightly. The result of PH before addition of African Spear plant was 6.93 and the result of PH after addition of African Spear plant was found to be in the range of 6.93 and 6.22 at temperature of the environment ranging between 20.1.and 20.7 ^{0}C. When we compare

the result obtained in the experiment with literature, the impact of African Spear plant in changing the PH of the water is very slight, and insignificant. The difference in PH Value before and after addition of African Spear plant is so insignificant and one can see it has almost no effect on alteration of PH value. According to National Drinking Water Quality monitoring and surveillance strategies, 2011, the permissible PH value for drinking water is at the range of 6.5 to 8.5. Therefore when we compare the result of the PH value tested in the experiment with the standard, it is within normal range and the difference before and after the experiment is insignificant.

According to the test done at Arbaminch University water quality laboratory, the PH of water was decreasing, means becoming acidic, with increment of dosage and time. Before application of the African Spear plant, the PH of the water was found to be 7.97@25C^{0}. · After treatment using minimum dosage to Maximum dosage over 15 minutes, the PH of the water was changed to 7.74 to 7.62. This implies that, the chemical in the plant juice might be acidic and if dosage increase can make the water more acidic but need further study.

Within optimal dosage, the change on PH is insignificant, and within WHO standard. The change may also be due to other factors. It can be discussed here that the issue of PH is not a problem in using African spear plant to purify water.

When we see the turbidity parameter, the experiment result shows reduction of turbidity of water over extended period time. As described earlier the water sample was so turbid before the experiment. Its turbidity unit was about 499 NTU. This implies that the water was so muddy and highly turbid.

After the application of the African Spear plant, the level of turbidity was reduced. The change ranges from 499NTU to 304NTU over six hours. The rate of settlement was found to be 89 NTU on the first hour, 13NTU on second hour, and 17 NTU on third hour. Totally, over six hours the reduced value of turbidity was found to be 195 NTU.

When we compare the effect of African Spear plant with other plants coagulants that help in purifying water, we can see that the application of African Spear plant also has positive effect on turbidity reduction. Since the traditional utilization of African Spear plant by Konso community is based on neither dose nor juice extraction, the experiment in this research followed the community experience of application of the African Spear plant. Therefore, before the experiment, the water was tested for its turbidity level, and follows the community procedure then the African Spear plant was crushed and put in the sample water. Then after, the test was made. As mentioned above, the water is highly turbid, 499 NTU.

The turbidity reduction was 19.9%, 20.44% and 23.85% respectively after one, two and three hours of application of African spear plant. Also the reduction after five and six hours for untreated water is 36.01%, 39.08% respectively.

According to the research, done by Asrafuzzaman MD, et.al (2011), reduction of turbidity can be done by using locally available natural coagulants. Among naturally available coagulants, the researcher used Moringa Olifera, Cicer arietimun, and Dolichos labalab. The result of the research showed that 50mg/l of Moringa Olifera put in a highly turbid water of 100NTU of turbidity got the result of turbidity reduction to be 86.9% and of medium turbidity of 48 NTU was found to result in 65.62% turbidity reduction and of low turbidity water of 25 NTU to 56 % of turbidity reduction. From that research we can conclude that Moringa Olifera is efficient in purifying highly turbid water.

Similar to Asrafuzzaman MD, et.al (2011), African Spear plant is efficient in turbidity reduction of highly turbid water. As it is observed in the result presented in table 10, the turbidity of water dropped from pretreatment level of 499 NTU to 312 NTU after seven hours of treatment. Then with each subsequent additional hour, it reduced to 231 NTU, 214 NTU, 184 NTU and 166 NTU respectively. This indicate that the Turbidity Removal efficiency of treated water for six hours is 66.7% The reduction rate is fast at first hour after six hours treatment and subsequently reduced slowly.

When we compare the result of treated and untreated water, their turbidity removal efficiency varies greatly. The Turbidity removal efficiency of untreated water for six hours is 39.1% but the turbidity removal efficiency of treated water for six hours is 66.7%. This indicates that treatment of water with African Spear plant has higher turbidity removal efficiency than natural settlement.

When water is settled for 12 hours without treatment with African Spear plant, the turbidity removal efficiency was found to be 97.2% and turbidity removal efficient of treated water after 12 hours settlement was found to be 97.6% which is similar. This indicates that lone time application of the plant in the water has insignificant effect on turbidity removal efficient.

When we see turbidity removal of treated water after 15 minutes, the turbidity removal of treated water was found to be 57.9%. This shows that as the time of treatment increases, turbidity removal increases but the rate of natural settlement also increases with time. If long time is needed for water purification, natural settlement will be preferred to avoid the drawbacks of bacterial multiplication and water color change due to African Spear plant.

We can conclude that high turbidity removal is seen with removal efficiency of 66.7 with treated water, the When we see the treatment of water with African spear plant for 12 hours, the turbidity removal is so fast in

Within one hour of African Spear plant application, the amount of turbidity reduced was 89 NTU but subsequently, the amount of reduced turbidity was found to be only 13 NTU. Over six hours, the total amount of turbidity units reduced was 195 NTU but within first one hour, the amount of turbidity units reduced was 89 NTU.

The research done by Asrafuzzaman MD, et.al (2011), presents the percentage of the turbidity reduction but does not show the time over which this change came. The research under study also shows how the African Spear reduces turbidity of water over some given time. The research understudy and the Asrafuzzaman MD, et.al (2011), researches only share that the plants reduce turbidity of water. In addition to Moringa Olifera, other natural coagulants mentioned above,

namely, *Cicer artienum* and *Dolichos lablab* also have turbidity reduction effect on turbid water. The Asrafuzzaman MD, et.al (2011), research showed that among the three natural coagulants, *Cicer artienum* has the greatest purification capacity, reducing the turbidity of the water to 95.89%. *Dolichos lablab* has the purification capacity of 88.9 % of turbidity reduction.

Since the objective of this research focus only on the capacity of African Spear plant to reduce the turbidity of water but not to the extent of identifying the final ability and the extent of the African Spear plant components that are involved in coagulation and purification method, the discussion will not go the level of type of coagulant in African Spear plant and its final capacity.

When we see the result of jar test, optimal dosage for optimal turbidity reduction was found around 6.8, which is slightly acidic in both moderately turbid and highly turbid water. Optimal dosage of the plant for optimal turbidity reduction was found to be about 18 gm/liter for 70NTU turbid water and 42gm/liter for highly turbid (156NTU) water, which implies that when the turbidity of water is high, it demands higher dosage of the plant and when the turbidity of water is less, it demands less dosage of the plant.

When wet African spear plant and dried African Spear plant are compared for their capacity of water purification, the research found that the wet African spear plant has great effect on turbidity reduction when compared with dried African spear plant effect on water purification. Rather dried African spear plant and natural settlement had almost similar effect, the range of TRE is between 0% to 3.3% for water treated with dried African spear plant when compared to natural settlement TRE. The slight change might be due to fiber present in the plant that can aid in catching macro waste material to settle, but the conclusion needs further study. Since the focus

of this research is only on the wet African Spear plant that the community use, no deep study done on the dry one. The result indicates that drying the plant is not right way to purify water.

The community of Konso does not have habit of using dried African Spear plant to purify their turbid water; rather they use the wet one as community experience. The research result supported the community experience of wet spear plant usage.

In general it can be discussed that the African Spear plant has water purification capacity, and is highly fast and effective in highly turbid water but the capacity and rate decreases when the turbidity of the water decreases. The dosage demanded to purify water as found in jar test is dependent on the level of turbidity of water to be treated. The more the water is turbid, the more dosage it demands, the less the water is turbid, the less dosage the water demands. Since the dried plant has no effect in water purification, the capacity to purify water mostly supposed to be found in the juice of the plant but it needs further research.

When we discuss the efficacy of African Spear plant in dirty water to reduce total Coliform and fecal Coliform, the result was found to be the number of bacteria decreased with optimal dosage[1] and short duration of time but increased with higher dosage after the application of the African Spear plant in the water. In the first test conducted at Addis Ababa City Environmental protection laboratory, before the test, the total number of coli form in the water was found to be 1170 bacteria/ 100 ml of water and 520 fecal Coliform bacteria /100 ml of the sample water. But after twelve hours of application of African Spear plant, the test result was found to be 1250 total Coliform bacteria/ 100 ml of sample water and 894 fecal Coliform bacteria/ 100 ml of sample water were found. This shows that the presence of African Spear plant in the water made the

[1] Optimal Dosage: is the dose at which the experiment found the maximum turbidity reduction in terms of dosage

environment favorable for bacteria and they multiplied over 24 hours. In the second test conducted at Arbaminch University water quality laboratory, the number of bacteria in the water before the experiment was found to high but after application of the plant in the water for one minutes and settlement for 15 minutes, the result was found to be low as presented in the result table.

This shows that when the plant stay for long time in the water, it become favorable environment for bacteria but with optimal dosage, about 11.9gm/liter and short time duration 10-15minute, the number of bacteria decrease. Use of African spear plant at optimal dosage with in shorter duration has the capacity to decrease bacteria in the water. The practical experience of Konso people in using African spear plant to purify water is in line with the experiment, that they use the crushed plant stirred in the water for about 1 minute and settled for about 10-15 minute. This shows that their experience in utilization of the plant, there is the possibility of decreasing bacteria from their water.

Chapter Five

5. Conclusion and Recommendations

5.1. Conclusion

This research investigates the efficacy of African Spear plant to purify water. Water quality parameters such as PH, Turbidity, and Total Coliform and fecal Coliform were tested. The research also investigated the existing practice of Konso community in using African Spear plant to purify water. The research found that purifying water using African Spear plant has insignificant effect on the PH of the water however the result indicates that there is reduction of turbidity over time. The efficacy of African Spear plant is significant in reducing turbidity in highly turbid water. When we see turbidity reduction, in relation to dosage of the plant, a highly turbid water demands higher dosage but less turbid water demands relatively less dosage.

The jar test has brought some conclusion about the dosage of wet African spear plant required per liter. Different level of turbidity demands different amount of African spear plant to be effective in altering water quality at optimum PH. The amount of wet African spear plant required to purify the sample water with turbidity less than 60NTU is 11.9g/liter, for 70NTU is 18g per liter and for 157NTU is 42g/liter. When a wet African spear plant and dried African Spear plant are compared, the dried plant has almost no significant effect on water purification while the wet plant has significant effect on water purification. The level of turbidity reduction by natural settlement and dried African Spear plant has only slight difference. This suggests that the element that aid in water purification might be found in the juice of the plant, but needs further study for the focus of this research is not on the dried plant experience of the community.

The slight change of turbidity reduction when compared to natural settlement can be due to the presence of fiber in the plant that can aid absorption of macro waste material in the water.

Concerning the bacterial presence, it was observed that there is reduction of bacteria immediately after application of African Spear plant. However, there is increase of bacteria was observed when the concentration or dose of the plant is high and when it stays in water for long time. This indicates that the application of African Spear plant results in reduction of bacteria when the dosage is optimal and time of application is short. However, the plant creates favorable environment for total Coliform and fecal Coliform bacteria when dosage is so high and time of application is long.

Overall, Konso people indigenous art of water purification by using African Spear plant has positive result in turbidity and bacterial reduction with in optimal dosage but negative effect in multiplying bacteria in the water. The effect on PH of the water is almost neutral. However further investigations is needed on its negative effect on multiplication of bacteria for high dosage and long application time of African Spear plant.

5.2. Recommendation

The indigenous method the Konso community use to purify water using African Spear plant indicates reduction of turbidity and bacterial presence for optimal time and dosage. However application of the plant in the water for long time and high dosage shows an increment in bacterial presence and change in color of the water. Hence, this research recommends that the community to use additional water treatment approaches such as water boiling and exposure to sunlight after treatment with African Spear plant.

Also further investigation on the negative impact of the plant with respect to an increase in bacterial presence is required.

The current research is limited to investigating the efficacy of the African Spear plant only using three water quality parameters. The capacity of the plant in purifying water should also be investigated using other water quality parameters.

Further research is also required to study the type of the chemical or substance found in the African Spear plant that aid in water purification.

References

Ademe, A.S., and Alemayehu, M. (2014). *Source and Determinants of Water Pollution in Ethiopia*: Distributed Lag Modeling Approach. Intel Prop Rights 2: 110. doi:10.4172/2375-4516.1000110

Asrafuzzaman, Md., Fakhuruddin, A.N.M., and Almgir Hossain Md. (2011). *Reduction of turbidity of water using locally available natural coagulants*, Hindawi, International Scholarly Research Notices, ISRN Microbiology, 2011

Benignos, A. (2012). *Rural Water Supply Manual Design* (Vol. Volume I). Malina: Published.

Garra, K. (2000). *Water and gods*, the tradition belief among the Konso people in relation to waters.

Gelebo, M. (2008). *Intra ethnic conflict and its management among the Konso*, MA thesis, A.A.U

Girma, A., Bamboro, S., Shimselis, B., Tadesse, C., Mokonnen, M., Gossa, T., et al. (2011). *National Drinking Water Quality Monitoring and Surveillance Strategy.* Addis Ababa: Unpublished.

Gupta, D.P., and Saharan, J. P. (2009). Physiochemical Analysis of Ground Water of Selected Area of Kaithal City (Haryana)India.*http://www.sciencepub.net,sciencepub@gmail.com*, ISSN:1553-9865

Hallpike, C. R. (1972). The Konso of Ethiopia: *A study of the value of Cushitic people*. P.3, Great Britain: Clarendon Press.

Http://www.conservation technology.com/pond filter gravel.html, (2016.)

Http://doi.org/10.24908/ijsle.v6i1.3212; International Journal for Service learning in Engineering, (2009)

Http://www.isd.gov.hk: Hong Kong Special Administrative Region Government, Information Services Department) (2016)

John, C. Crittenden, R.Rhodes TrusseII, David W.Hand, Kerry J.Howe, and George Tchobanoglous. (2012). *MWH's Water Treatment :Principles and Design Third Edition.* Hoboken, New Jersey: Published by John Wiley & Sons, Inc.

Kebreabe, A. G. (2004). *Moringa seed and Pumice as alternative natural materials for water treatment*, KTH land and water resources engineering, Traita-LWP-PHD 1013

Korra, A. (2014). Indigenous conflict handling among the Konso, MA Thesis, RISE, IICM, Florid

Lemke, Cal (2002-01-25). "Sanseviera cylindrica". *Plant of the Week*. University of Oklahoma Department of Biology and Microbiology. Retrieved 2008-04-02.

MOH, (2011). *National Drinking Water Quality monitoring and surveillance strategies*, Addis Ababa, Ethiopia

Muhammad, M., Samira, S., Fayal, A., and Farrukh, J. (2013). Assessment of Drinking Water Quality and its impact on Residents Health in Bahawalpur City. *International Jornal of Humanities and Social Science*, vol.3, No.15.

Nancy, J. M., Gunno, R., and Gunnar, J. study in (2007). *The Study of Water Supply and Traditional Water Purification Knowledge in Selected Rural Villages in Tanzania*

Olijira, G. (2005). Investigation of drinking water quality from source to point of distribution: (the case of Gimbi town, in Oromia regional state of Ethiopia).AAU, MSc Thesies

Otto, S. (2004). *Traditional Konso Culture and the Missionary Impact*. In: Annales d'Ethiopie. Volume 20, année.doi : 10.3406

Peter, H. G. (editor). (1993). Igor Shiklomanov's chapter "World fresh water resources", Water in Crisis: A Guide to the World's Fresh Water Resources (Oxford University Press, New York) Recommendations Geneva, Switzerland

Philip, D; Kaleena, PK; Valivittan, K & Girish Kumar, CP (2011), "Phytochemical Screening and Antimicrobial Activity of Sansevieria roxburghiana Schult. and Schult. F.", *Middle-East Journal of Scientific Research*, **10** (4): 512–8

Said, R. (1993). Nile river sediment fluctuations over the past 7000 years and their role in sapropel development

Said, R. (1993). *The River Nile, Geology, Hydrology and Utilisation*, Pergamon Press, UK.

Sharma, Shipra, Varshney, & Vinay. (2012). *Chemical analysis of Agave sisal juice for its possible utilization*. Acta Chimica & Pharmaceutica Indica.

South Jersy Water Test, (2018). www.southjersywatertest.com, accessed January 23, 2018

Taylor and Francis Group,LLC. (2007). *Handbook of Water Analysis.* Boca Raton London New York: Published

Thanh, N. C. (1982). *Surface Water Filtration for Rural Areas—Guidelines for Design, Construction, Operation and Maintenance.* Environmental Sanitation Information Center, Asian Institute of Technology, Bangkok, Thailand.

The American Journal of Clinical Nutrition, *(January 1980.)* . "Total body water volumes for adult males and females estimated from simple anthropometric measurements" *(PDF). **33** (1)*

Trees for life international, (2011), https://trees for life.org

UN- Habitat, (2003). *Water and Sanitation in the world's Cities*, http://unhabitat.org/year/2003/ retrieved on March 9, 2018.

United Nations report, (2005). *The millennium development goals report.* UN, NEW YORK.

United Nations report, (2006). *Water, a shared responsibility*, world water development report 2, executive summery, www.unesco.org/water/wwap.

USAID, (2007). Ethiopia *Water and sanitation profile,*

US Geographical Survey, *(2016).* http://water.usgs.gov/edu/earthhowmuch.html Page Last Modified: Friday, 02-Dec-2016 12:51:37 EST

Vigneswaran, S. and Visvanathan, C. (1995). *Water Treatment Processes—Simple Options.* Boca Raton:CRC Press

Vigneswaran, S.and Sundaravadivel, M. (1983). *Traditional and Household Water Purification Methods of Rural Communities in Developing Countries*, wastewater recycle, reuse, and reclamation – vol. Ii

Vigneswaran, S., Tam, D. M., and Visvanathan, C. (1983). Water filtration technologies for developing

Vigneswarana, S. (1983). traditional and household water purification of rural communities in developing countries, waste water recycle reuse-Volume II charity. 31

Water Aid Annual report, (2009). Water Sanitation, hygiene, P.6

WHO, (1993). *Drinking water Quality Guidelines[4 Vols]* Geneva: world health Organization

WHO, (2003). *The Global Water Supply and sanitation*

WHO, (2005). *Drinking water quality guideline*: WHO, volume 3 second edition Geneva,

WHO, (2006). Guidelines for drinking - water Quality First Addendum to Third Edition. Volume 1

WHO, (2010). *Water for Health, Guidelines for Drinking-water Quality*. Geneva, Switzerland

WHO, (2011). *Guidelines for Drinking-water Quality*, 4th Edition*;*

WHO/UNICEF, *(2010). Joint monitoring report: Progress on sanitation and drinking water-fast facts* WHO:http://www.who.int/water_sanitation_health/monitoring/fast_facts/en/index.html retrieved 15/10-2010

Zuane De, J. (1996). *Hand Book of Drinking Water Quality.* Published.