2020-03-17

SYSTEM DESIGN AND PERFORMANCE DETERMINATION OF CONTINUOUS DUAL FILTER DRINKING WATER TREATMENT DEVICE

Teketel, Fikade

BAHIR DAR UNIVERSITY

BAHIR DAR INSTITUTE OFTECHNOLOGY

SCHOOL OF RESEARCH AND GRADUATE STUDIES

FACULTY OF CHEMICAL AND FOOD ENGINEERING

SYSTEM DESIGN AND PERFORMANCE DETERMINATION OF CONTINUOUS DUAL FILTER DRINKING WATER TREATMENT DEVICE

By

Fikade Teketel Derib

July 2018

Bahir Dar, Ethiopia

SYSTEM DESIGN AND PERFORMANCE DETERMINATION OF CONTINUOUS DUAL FILTER DRINKING WATER TREATMENT DEVICE

By

FikadeTeketel

A thesis submitted to the school of Research and Graduate Studies Bahir Dar Institute of Technology, BDU in partial fulfillment of the requirements for the degree of MSc in Environmental Engineering in the faculty of chemical and food engineering.

Advisor name: Dr. Solomon Workneh

July2018

Bahir Dar, Ethiopia

Declaration

I, the undersigned, declare that the thesis comprises my own work. In compliance with internationally accepted practices, I have acknowledged and refereed all materials used in this work. I understand that non-adherence to the principles of academic honesty and integrity, misrepresentation/ fabrication of any idea/data/fact/source will constitute sufficient ground for disciplinary action by the University and can also evoke penal action from the sources which have not been properly cited or acknowledged.

Name of the student________________________________ Signature _____________

Date of submission: ________________

Place: Bahir Dar

This thesis has been submitted for examination with my approval as a universityadvisor.

Advisor Name: ___________________________________

Advisor's Signature: _______________________________

BAHIR DAR UNIVERSITY

BAHIR DAR INSTITUTE OF TECHNOLOGY

SCHOOL OF RESEARCH AND GRADUATE STUDIES

FACULTY OF CHEMICAL AND FOOD ENGINEERING

THESIS APPROVAL SHEET

Student:

Fikade Teketel ______ 14/11/2010 E.C

Name Signature Date

The following graduate faculty members certify that this student has successfully presented the necessarily written thesis proposal and oral presentation of this proposal for partial fulfillment of the thesis-option requirements for the Degree of Master of Science in environmental engineering.

Approved By:

Advisor:

Solomon Workneh (PhD) ______

Name Signature Date

External Examiner:

Agegnehu Abebe (Ph.D). ______ 18/11/2010 EC

Name Signature Date

Internal Examiner:

Dr Alemayehu Kefyalew ______ 14/11/2010 E.C

Name Signature Date

Chair Holder:

Tegen D ______ 14/11/2010 E.C

Name Signature Date

Faculty Dean:

Ali Seid ______ 14/11/2010 E.C

Name Signature Date

To my wife and family.

Acknowledgments

First of all, I would like to thank God for the time and the patience he gave me for completing this thesis.

I would like also to express my deepest gratitude to my advisor; Dr. Solomon workenh, for his critical guidance and encouragement with supportive personality. I am grateful thank all of Bahir Dar Institution of technology chemical Engineering departments taff members. My gratitude also extends to my wife Ms. Elsabeth Tsegaye for her continuousencouragement and to my family. I wouldlike also to thank all my friends and classmates who have been beside with me during this thesis work. Especially, I’m pleased to thanks Mr.Gemechu Kassaye, Mr.Asnake Baye, Mr.Kassaye Gizaw, Mr.H/Mariam Zewdu and Ms.LidiyaTesfeye for their special active involvement in providing me a vital support and encouragement throughout the work. Finally; I would like to thank Bahir Dar Institution of Technology for giving me this opportunity.

Abstract

Starting from the ancient time to the now developed world all human beings are battle withoutrest against waterborne diseases so as to minimize its health and environmental effect. In Ethiopia, peoples live in rural area drink un-treated water without any sort of treatment. But, it leads to different waterborne diseases and resultsfor the death of numerous peoples every day. Therefore, this study was initiated to design, assemble and performance evaluation of continuous dual filter treatment device used to treat drinking water. To check the performance of the device activated carbon from rice husk having a particle size of 2mm, sand filter having a size of 0.7mm, 1mm and 6mm and defatted moringa seed extract was used as filtering medium and disinfection solution respectively. Thestudy also investigatesthe effect of filter bed arrangement, filter bed ratio, the dosage of moringa for disinfection process and the effect of ceramic filter where analyzed. To check the treatment efficiency of the device samples was taken from Lake Tana and 3 replication experiments were done. Standing from the experimental result analyzed by independent sample T-test, one-way ANOVA, and MATLAB a maximum treatment efficiency of 84.7% reduction in turbidity, with a maximum flow rate of 34.6L/hr was achieved. During this treatment process a bed arrangement of sand at the top and activated carbon at the bottom, with a bed height ratio of 25% activated carbon and 75 % sand and 175mg/l of defatted moringa powder solution was used. Even if ceramic water filter results to high turbidity removal than any arrangement with any order because of its low flow rate (1.2 L/hr.), it is not recommended to use it as one filter bed in the continuous treatment process.

Keywords: - activated carbon, moringa, disinfection, dual filter

CONTENTS

LIST OF ABBREVATIONS

AC	Activated Carbon
ACS	Activated Carbon Sand
ANO	Analysis of Variance
BOD	Biological Oxygen Demand
BSF	Bio Sand Filter
BWV	Back wash valve
CFU	Colony-Forming Unit
COD	Chemical Oxygen Demand
DNA	Deoxyribonucleic Acid
DO	Dissolved Oxygen
DOC	Dissolved Organic Content
EC	Electrical Conductivity
HDPE	High Density Poly Ethylene
HCL	Hydrochloric Acid
LCD	Least Developed Country
LSD	List Significant Difference
MATLAB	Matrix laboratory
NaCL	Sodium Chloride
NaOH	Sodium Hydro Oxide
NOM	Natural Organic Matter
NTU	Nephelometric Turbidity Unit

RO	Reverse Osmosis
RNA	Ribonucleic Acid
SAC	Sand Activated Carbon
SSA	Sub-Sahara Africa
TMV	Treatment valves
TDS	Total Dissolved Solids
TH	Total Hardness
TSS	Total Suspended Solid
UV	Ultra Violet
VOC	Volatile Organic Compounds
WHO	World Health Organization
ZnCl	zinc chloride

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Background

Water is one of the most vital natural resources for all life on Earth. The availability and quality of water always have played an important part in determining not only where people can live, but also their quality of life. On the other hand, clean water is water that is free of pathogenic organisms, toxic substances, color, turbidity, taste, odor, and an acceptable level of minerals and organic material. Even if everybody on our planet has a fundamental right to a reliable supply of clean water. Yet, according to the World Health Organization, there are still 1.1 billion people in the world without access to an improved water supply (Brown & Sobsey, 2010).This translates to 6% of the global population lacking access in urban areas, and 29% lacking access in rural areas and results for2.2 million deaths. This equates to one water-related death every 15 seconds. The global water crisis remains the risk of highest concern, and ranks ahead of climatechange, extreme weather events, food crises and social instability. Across the globe, nearly one in ten people is without access to an improved drinking water source. Least Developed Countries (LDCs) especially in sub- Saharan Africa (SSA) are the most affected. Population growth, changing lifestyles, increasing pollution and accelerating urbanization will continue to widen the gap between the demand for water and available supply especially in rural area(Dos Santos et al., 2017). It is estimated that 80% of the Ethiopia population live in rural areas and many communities rely on surface water (rivers, lakes, ponds etc.) and some groundwater as a source for drinking water. However, drinking of both surface water and groundwater without any sort of treatment can affect the human health due to natural and/or anthropogenic contamination. Naturally occurring influences, such as seasonal precipitation patterns and runoff events, results in fluctuations of turbidity, nutrients, and suspended solids. Anthropogenic influences include industrial pollution, municipal wastewater treatment discharge, improperly designed septic systems and latrines, improper management of agricultural drainage, excessive or improper application of excreta-based agricultural fertilizer, and the culture of livestock in direct vicinity of the surface water. Widespread contamination of surface water has led to an emergence of parasitic Giardia and Cryptosporidium as a major cause of waterborne disease in humans. In fact, Giardia is the most commonly reported intestinal protozoan infection worldwide. Therefore, it is not surprising, that concerns about safe water and treatment methods have existed since the dawn of civilization. Because early man was not aware of the many naturally occurring contaminants that modern instrumentation and methods can now detect, they assumed good tasting water was safe for human consumption with no need for further treatment. The first known records referring to water treatment methods were found in early Sanskrit writings (4000 B.C.). These water treatment methods included filtering water through sand or charcoal filters and storing water in copper containers. Other suggestions were to boil the water, either heating by the sun or immersing a hot metal instrument in the water prior to consumption. As early as 1500 B.C., the Egyptians discovered that filtration could be enhanced by the addition of alum. Filtration, especially sand filtration, became more widespread, resulting in the first application of the technology in the early 1800s in the city of Paisley, Scotland. Filtration in American cities was first introduced in the 1890's. Dr. John Snow's work with the cholera epidemic in England in the mid-to-late 1850s led to the use of chlorination as a treatment option to disinfect drinking water in addition to filtration. The effectiveness of chlorine to control waterborne diseases led to the first use of chlorine as the primary disinfectant of drinking water in Jersey City(Miller & Watters, 2010). Not only these but still now many researchers were done and doing many projects and researchers to safe drinking water so as to improve the life of individuals.

1.2. Statement of the Problem

Water is the unique molecule that preserves the life on the Earth. All life forms on the Earth depend on water. About 70% of Earth is covered with water in that 97% is part of Oceans. Only a small percentage of the total water is fresh water, which is used by humans for different activities including drinking. On the other hand, safe drinking water is a major requirement for millions of individuals. Meanwhile, in this time, about 1 billion people are without safe drinking water worldwide because of this fact more than 840,000 people die each year from water-related disease among this 85% are children under 5 ages (http/ fact about water, 20/05/2018). In the case of pure water supply and sanitation, Ethiopia is amongst the lowest in Sub-Saharan Africa and the entire world as a result 61 million Ethiopians lack access to safe water and 65 million lack accesses to improved sanitation("Ethiopia's water and sanitation crisis," 2018). In rural Ethiopia, peoples drink the raw water without any sort of treatment, but it leadstowater-borne diseases like malaria, dental flourishes, kidney effect etc. Therefore, it needs sustainable, environmental friendly and reliable drinking water treatment alternatives. This is likely because many conventional treatment technologies are so complicated and use different synthetic chemicals that are risk to human health and to the entire environment. To solve those problems at different time and place, many researchers and organizations spent their golden time to design and manufacture treatment device and methods. But, most of them are manufacturing their treatment device only from a single treatment process (sand filter or ceramic filter or disinfection or any other) with high cost, low efficiency, limited applicability and poor design.

1.3. Objectives

1.3.1. General objective

The main objective of this study is system design and performance determination of continuous dual filter drinking water treatment device.

1.3.2. Specific objectives

- To design, manufacture and assemble the treatment device and its parts
- To determine the order of sand, ceramic, and activated carbon used for the treatment device.
- To investigate the diameter to height ratio of sand and activated carbon
- To investigate the effect of flow rate on the treatment process
- To investigate the effect of rice husk to clay ratio on the manufacturing of ceramic filter
- To determine the dosage of defatted moringa for disinfection process

1.4. Thesis Organization

To achieve the objectives of the study this document is organized into 7 chapters and different specific tasks as follows.

Chapter 1: -This section includes theintroduction parts to describe background knowledge in the area, research gap, statement of the problem and objectives of the study.

Chapter 2: -Is generally all about Literature reviewand try to illustrate the general water treatment process including coagulation, sedimentation, filtration and disinfection, water quality characteristics such as physical, biological and chemical characteristic and drinking water standards.

Chapter 3: -In addition to the general working principles of the device and experimental setup. This section presents material and methods, chemical used for thepreparation of sand filter, disinfection solution, activated carbon filter and a ceramic filter.

Chapter 4: -This section illustrates the laboratory result for the optimization of filter media order, bed height, moringa dosage, pottery clay with rice husk ration and treatment efficiency of the manufactured deviceincludes the scientific expiation of the result using MATLAB and two-way ANOVA statically analysis and try to demonstrate what is the result indicate related to the general truth and project outcome.

Chapter 5: -It presents the major investigation that can achieve within this study and gives indication or direction for other researchers to do a deeper investigation on the proposed research area.

Chapter 6: -In this section all relevant documents it can be journals, books, scientific investigations or any sources that can help to achieve the goal of this thesis.

1.5. The scope of the Study

The scope of the present study is limited on specific area water sample (Lake Tana water in front of Shum Abo). It also limited on less price and less durable material during the manufacturing of prototype. During water quality analysis the study concentrates only specific water quality parameters such as PH, TDS, turbidity, fluoride, total hardness, and total microorganisms.

1.6. The significance of the Study

In Ethiopia above 80% of the total population is living in the rural area and drink almost untreated water. Because of this factthe peoples exposed to different water-related problems. However, in the last few years ‘many researchers and organizations start to put their fingerprint on the treatment methods and techniques to supply treated water for the community. This study also tries to identify the problem and search the possible treatment techniques (continuous dual filter treatment device) to satisfy treated water demand of the end users. At the end of the study treated water having standard characteristics in terms of physical, chemical and biological aspects will be distributed to all individual especially in rural part of Ethiopia. Not only have these but it also reduced mortality rate.

2. LITERATURE REVIEW

2.1. Basic Introduction

Water is usually tasteless, odorless, colorless liquid in its pure state. But, Water is the universal solvent and in nature, and almost any substance will dissolve in it to some degree. This is why it is seldom found in its “pure” state. No matter how isolated from sources of contamination, it will always have several impurities (gases, solids, color, chemicals, Gases or minerals). The water sources can be surface waters that come from rivers, streams, ponds, lakes, and reservoirs, while ground waters come from wells, mines, and springs. Groundwater usually contains large amounts of dissolved substances (minerals) because it percolates (slow filters) through rock and soil formations. The greater the depth below ground from which the groundwater comes, the higher the level of dissolved minerals in the water. On the other hand, surface water usually contains a large number of suspended solids dissolved chemicals, microorganisms, dissolved solids etc(Parsons & Jefferson, 2006).

Table 2.1. Water quality assessment of surface water and groundwater(Parsons & Jefferson, 2006)

	Concentrations found in groundwater	Concentrations Found in surface water
Total Hardness	300 - 400 ppm	75 - 200 ppm
Alkalinity	250 - 350 ppm	45 - 250 ppm
Dissolved Oxygen	Near 0	2 - 14 ppm
Carbon Dioxide	1 - 10 ppm	Low
Calcium Hardness	High	Sometimes high, usually low
Magnesium Hardness	Tends to be high	Sometimes high, usually low

Standing from the above general truth whatever the source of water it needs some sort of treatment to supply safe drinking water for all individuals.

2.2. Common Water Treatment Process

Drinking water treatment is a process of removing contaminants and undesirable components or reduces their concentration from raw water to produce water that is pure enough for human consumption without any short-term or long-term risk of any adverse health effect. Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, and minerals such as iron and manganese. The processes involved in removing the contaminants include physical processes such as settling andfiltration, chemical processes such as disinfection and coagulation and biological processes such as slow sand filtration.

2.2.1. Filtration

It is a process used to separate solids from liquids or gases using a filter medium that allows the fluid to pass, but not the solid. The fluid that passes through the filter is called the filtrate. The filter medium may be a surface filter, which is a solid that traps solid particles, or a depth filter, which is a bed of material that traps the solid. The filtration system consists of filters with varying sizes of pores and is often made up of sand, gravel, and charcoal. Filtration can also remove bacteria, protozoa, and viruses, and produces essentially clean water, though it is still advisable to use a disinfectant as a precautionary measure (Miller & Watters, 2010).

Even if there are different types of filtration generally it can be classified as follows.

a) **Membrane filter: -** Reverse Osmosis water filters are typically used to improve drinking and cooking water quality in households. It is one of the finest water filtration methods and reduces almost all organic and inorganic chemicals, bacteria, microorganisms, salt, metals, and particulates that are found in contaminated water. It also improves tastes, odor, and appearance. Reverse osmosis water filtration system includes a semi-permeable membrane and a booster pump (Miller & Watters, 2010). These ultra-fine membranes have pores of approximately 0.0005 microns in size. Water is pressurized to about 40-45 psi and then forced through the membrane, removing anything that’s larger than 0.001 microns. Pre-and post-filtrations are usually combined in a reverse osmosis filtration system(Çeçen& Aktas, 2011).

b) **Sand filter: -** are constructed with a bed of fine sand as the filtration media, and gravel to support the sand. In which as water passes through the sand layer, particles of foreign matter and dissolved organic material are adsorbed and metabolized (Chan, Chan, & Wang, 2009).

i **Rapid sand filtration**: - It is much more common than slow sand filtration and developed in the early 20th century. Today rapid sand filtration is a physical process that removes suspended solids from water with high flow rates and requires relatively little space to operate.

ii **Slow sand filtration: -** slow sand filtration is a biological processbecause it uses bacteria to treat the water. The bacteria establish a community on the top layer of sand and clean the water as it passes through, by digesting the contaminants in the water. The layer of microbes is called a schumtzdecke(biofilm) and requires cleaning every couple of months when it gets too thick and the flow rate declines(A. Mohamed & Mamdouh A. EL-Messiry, 2006), (Iran Baraee, 2015).

Components of sand filter

Bio-sand filters are typically constructed from concrete, metal or plastic in which at the top of the filter, a tightly fitted lid prevents contamination and unwanted pests from entering the filter. Below this, the diffuser plate prevents disturbance of the biofilm when water is poured into the filter. Water then travels through the sand column, which removes pathogens and suspended solids. Below the sand column, a layer of gravel prevents sand from entering the drainage layer and clogging the outlet tube. Below the separating layer is the drainage layer consisting of coarser gravel that prevents clogging near the base of the outlet tube(Chan et al., 2009).

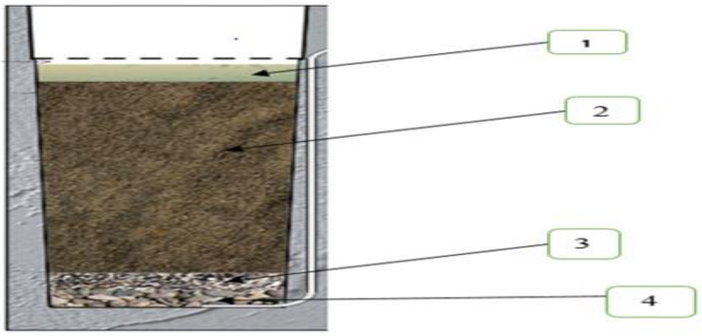


Figure 2.1. Sand filter arrangement (Chan et al., 2009)

1) **Diffuser –** Prevents disturbing the filtration sand layer and protects the biolayer when water is poured into the filter.
2) **Filtration Sand Layer –** is made up of sand having a diameter of 0.7 mm and used to Removes pathogens and suspended solids. Pathogens and suspended solids are removed through a combination of biological and physical processes that take place in the biolayer and within the sand layer. These processes include mechanical trapping, predation, adsorption, and natural death.

   Mechanical trapping: - Suspended solids and pathogens are physically trapped in the spaces between the sand grains.

   Predation: -Pathogens are consumed by other microorganisms in the biolayer.

   Adsorption: -Pathogens become attached to each other, suspended solids in the water, and the sand grains.

   Natural death: -Pathogens finish their life cycle or die because there is not enough food or oxygen for them to survive.
3) **Separating Gravel Layer –** is made up of sand having a diameter of 1 mm Supports the filtration sand and prevents it from going into the drainage layer and outlet tube.
4) **Drainage Gravel Layer –** is made up of sand having a diameter of 6 mm and used to Supports the separating gravel layer and helps water to flow into the outlet tube.

c) Activated Carbon Filters: -Carbon is known as a popular absorbent of impurities. Activated carbons are the most versatile and commonly used adsorbents because of their extremely high surface areas micro pore volumes, large adsorption capacities, fast adsorption kinetics, and relative ease of regeneration. The most precursors used for the production of activated carbons are organic materials that are rich in carbon(Tongpoothorn, Sriuttha, Homchan, Chanthai, & Ruangviriyachai, 2011). Because of this property, activated carbon is commonly used in water treatment systems. Activated carbon can be used alone to improve tastes and odors, and it is most effective at removing organic compounds including Volatile organic compounds, radon, and chlorine. It can also be used as pre-treatment for other water purification systems such as reverse osmosis and ultraviolet water filters(Çeçen& Aktas, 2011).

Principles of activated carbon filtration

There are two basic types of water filters: particulate filters and adsorptive/reactive filters. Particulate filters exclude particles by size, and adsorptive/reactive filters contain a material (medium) that either adsorbs or reacts with a contaminant in water(Lina Fuentes-López, 2018). The principles of activated carbon filtration are the same as those of any other adsorption material. The contaminant is attracted to and held (adsorbed) on the surface of the carbon particles. The characteristics of the carbon material (particle and pore size, surface area, surface chemistry, density, and hardness) influence the efficiency of adsorption. When the activated carbon becomes saturated (all adsorption sites filled), contaminants can flow from the carbon back into solution(Tongpoothorn et al., 2011).

Chemical Activation: - is achieved by degradation or dehydration of the, usually cellulosic, raw material structure by using different chemicals such as NaOH, KCl, HCl and ZnCl. An important advantage of chemical activation is that the process normally takes place at a lower temperature and for a shorter time than those used in physical activation. In addition, very high surface area activated carbons can be obtained. Moreover, the yields of carbon in chemical activation are usually higher than those in physical activation because the chemical agents used are substances with dehydrogenation properties that inhibit the formation of tar and reduce the production of other volatile products(Jianan Li, 2018). Carbonization is a thermal decomposition which occurs at a temperature above 500ºC and which eliminates non-carbon species, producing a fixed and porous mass of carbon, generally in an inert atmosphere (with the presence of nitrogen and the absence of oxygen). As a result of the pyrolysis process, a much richer carbon content material with a much more ordered structure is produced, and once the chemical agent is eliminated after the heat treatment, the porosity is highly developed(Tongpoothorn et al., 2011).

d) **Ceramic Filters: -** is one of the most economical filtration methods and it is already being widely used in some third world countries. The ceramic filter blocks anything larger than a water molecule, allowing only water to pass through the pores(Kallman, Oyanedel-Craver, & Smith, 2010). Or it is an inexpensive and effective type of water filter, that rely on the small pore size of the ceramic material to filter dirt, bacteria and other contaminants from water(Brown & Sobsey, 2010). This type of filter can be made from pottery clay and combustible materials such as rice husk sawdust or coffee husk. Clay is a natural product dug from the earth, which has decomposed from rock within the earth's crust for millions of years. Decomposition occurs when water erodes the rock, breaks it down, and deposits them. But, Pottery clay differs from other clays and fine sand because of its ability, when wet with the proper amount of water, to form a cohesive mass and to retain its shape when molded. This quality is known as clay's plasticity. When heated to high temperatures, pottery clay also partially melts, resulting in the tight, hard rock-like substance known as a ceramic material(Chan et al., 2009).

Table 2.2. Filter comparison (Chan et al., 2009)

	Arsenic	Bacteria and Viruses	Bad Tastes & Odors	Chlorine	Fluoride	Hydrogen Sulphide	Heavy Metals	Nitrates	Radon	Sediment	Iron	VOC's
Ultraviolet	○	●	○	○	○	○	○	○	○	○	○	○
Reverse Osmosis**	●	●	●	●	●	◐	●	●	○	●	●	◐
Slow Sand	◐	●	◐	○	○	○	●	○	○	●	●	◐
Activated Carbon	○	○	●	●	○	◐*	◐	○	●	●	○	●
Ceramic	○	●	◐	○	○	○	○	○	○	●	○	○

● = Effectively Removes ◐ = Significantly Reduces ○ = Minimal or No Removal

* At high contaminant levels, filter life will be reduced significantly. Manganese greensand (whole house iron reduction filter) or KDF filter is recommended for Hydrogen sulphide.

** Even though reverse osmosis is effective in removing bacteria and viruses, it is not recommended that you rely upon reverse osmosis solely if your water is contaminated with bacteria or viruses. Ultraviolet (UV) purification is also recommended.

Table 2.3. Advantages and disadvantages of various water filters (Chan et al., 2009).

Filter Type	Advantages	Disadvantages
Ultraviolet	Inactivates bacteria	Requires electrical power Should not be used alone since it only inactivates bacteria Expensive
Reverse Osmosis	Filters most contaminate out of all other filter types	Expensive to make Need pressure to work system Requires pre-filtering
Slow Sand	Cheap and easy to make Does not need electrical power or chemicals Material easily obtained	Large in volume Heavy Slow filtration rate
Activated Carbon	Cheap to make Material readily available Usually used as pre-filter for other filtration systems	Does not remove bacteria Not very good at removing heavy metal
Ceramic	Cheap and easy to make Can be combined with activated carbon No advanced technology required	High maintenance, need to be cleaned periodically

2.2.2. Disinfection

It is a process or a series of processes intended to inactivate human pathogens such as viruses, bacteria, and protozoa, potentially present in influent water before the water is delivered to the first consumer. Inactivate the microbes can be achieved by denaturation of proteins (structural proteins, transport proteins, enzymes) nucleic acids (genomic DNA or RNA or lipids (lipid bilayer membranes, other lipids)(Baptista et al., 2017).The selection of an appropriate disinfection process depends upon site-specific conditions and raw water characterization that is unique to each drinking-water system. Process selection decisions must consider and balance the need to inactivate human pathogens while minimizing the production of disinfection by-products, cost and residue effect. In order to fight waterborne diseases, different disinfection methods are used to inactivate pathogens among those some of them are listed below.

A) **Ultraviolet (UV) Water disinfection: -**is a disinfection process that works by having water pass by a special light source. The light source emits ultraviolet waves which inactivate harmful microorganisms. UV rays alter the nucleic acid (DNA) of viruses, bacteria, molds, and parasites so that they cannot reproduce and are considered inactive. The process does not add chemicals to water, but the inactivated microorganisms are also not removed from the water (Zoschke, Börnick, & Worch, 2014). This treatment method is not intended to treat wastewater or water that is visually contaminated because Particles in water can block the UV rays and allow harmful particles to survive. Therefore, UV water treatment is usually combined with pre or post filtration device to produce safe, potable water (Betancourt & Rose, 2004).

B) **Chlorination: -** is one of many methods that can be used to disinfect water. This method was first used over a century ago and is still used today. It is a chemical disinfection method that uses various types of chlorine or chlorine-containing substances for the oxidation and disinfection of what will be the potable water source(Betancourt & Rose, 2004). Chlorine inactivates a microorganism by damaging its cell membrane. Once the cell membrane is weakened, the chlorine can enter the cell and disrupt cell respiration and DNA activity(Betancourt & Rose, 2004).

Point of chlorination

Chlorination can be done at any time/point throughout the water treatment process there is not one specific time when chlorine must be added. Each point of chlorine application will subsequently control a different water contaminant concern, thus offering a complete spectrum of treatment from the time the water enters the treatment facility to the time it leaves.

i **Pre-chlorination**: -is when chlorine is applied to the water almost immediately after it enters the treatment facility. In the pre-chlorination step, the chlorine is usually added directly to the raw water or added in the flash mixer (a mixing machine that ensures quick, uniform dispersion of the chlorine). Chlorine is added to raw water to eliminate algae and other forms of aquatic life from the water so they won't cause problems in the later stages of water treatment. Pre-chlorination in the flash mixer is found to remove tastes and odors, and control biological growth throughout the water treatment system, thus preventing growth in the sedimentation tanks and the filtration media. The addition of chlorine will also oxidize any iron, manganese and/or hydrogen sulfide that are present so that they too can be removed in the sedimentation and filtration steps(Betancourt & Rose, 2004).

ii **Post-Chlorination**: - in which chlorine is added in the final step of the treatment process, which is usually done in most treatment plants. The main objective of this chlorine addition is to disinfect the water and maintain chlorine residuals that will remain in the water as it travels through the distribution system. In this system the water has been through sedimentation and filtration, a lot of the unwanted organisms have been removed, and as a result, less chlorine and a shorter contact time are required to achieve the same effectiveness. To support and maintain the chlorine residual, a process called re-chlorination is sometimes done within the distribution system. This is done to ensure proper chlorine residual levels are maintained throughout the distribution system(Betancourt & Rose, 2004).

C) Organic disinfection: -chlorination has numerous disadvantages such as the production of trihalomethanes and chlorinated hydrocarbons which are considered health hazards. It combines with the inorganic material in water to form chloride salts, and with organic material in water to form chlorinated organic chemicals. These chlorinated compounds are less likely to degrade and can cause the same hazards as that of chlorine. Chlorination also producelarge amount of sludge which is again an environmental pollutant(Ndabigengesere & Narasiah, 1998). Due to these demerits of chlorine and high expense of another physical method, there is a requirement of safe and cheap water treatment method. To overcome this problem, naturally occurring disinfection like moringa Oleifera can be used for water purification for many centuries. Most of these extracts are derived from the seeds, leaves, pieces of bark or sap, roots and fruit extracts of trees and plants, because they produce much lower sludge volume, the natural alkalinity is not consumed during the treatment process, they are biodegradable, safe to human health, cost-effective since they can be locally grown and have a wider effective dosage range for disinfection(Camacho, Sousa, Bergamasco, & Teixeira, 2017).Moringa Oleifera is a medicinal species, belonging to a monogenetic family that grows very fast, with flowers and fruits appearing within 12 months of planting. They grow up to a height of 5-12 meters and pods 30-120 cm longand distributed in any country including Ethiopia(Achour & Chabbi, 2014).

Table 2.4. Proximate analysis of moringa oleifera (Achour & Chabbi, 2014).

Parameter	%
Carbohydrate	5.54
Protein	38.7
Crude fiber	3.6
Ash	9.48
Fat	36.2
Moisture	6.10

Even if the exact form of the protein is not yet known. One of the proteins found in the tree’s seeds is a cationic protein, a positively-charged protein, which contains a little peptide sequence that acts like a molecular knife. So, this little molecular knife goes through the bacterial cell wall and kills it, and these proteins also act as a cationic polyelectrolyte which attaches to the dyed organisms and soluble particles to create bindings between them, leading to large flocs(Lynch & Spafford).

2.3. Water Quality Characteristics

Water is a transparent, tasteless, odorless, and nearly colorless chemical substance that is the main constituent of Earth's streams, lakes, oceans, and the fluids of most living organisms. Water quality is determined by physical, chemical and microbiological properties of water. These water quality characteristics throughout the world are characterized by wide variability. Therefore, the quality of natural water sources used for different purposes should be established in terms of the specific water-quality parameters that most affect the possible use of water(Lakeh et al., 2017).

2.3.1. Physical Characteristics of Water

Physical characteristics of water (temperature, color, taste, odor and etc.) are determined by senses of touch, sight, smell, and taste. For example, temperature by touch, color, floating debris, turbidity and suspended solids by sight, and taste and odor by smell.

Temperature: -The temperature of water affects some of the important physical properties and characteristics of water: thermal capacity, density, specific weight, viscosity, surface tension, specific conductivity, salinity and solubility of dissolved gases and etc. Chemical and biological reaction rates increase with increasing temperature. Reaction rates usually assumed to double for an increase in temperature of 10 °C. The temperature of water in streams and rivers throughout the world varies from 0 to 35 °C.

Color: -Color in water is primarily a concern of water quality for an aesthetic reason. Colored water gives the appearance of being unfit to drink, even though the water may be perfectly safe for public use. On the other hand, color can indicate the presence of organic substances, such as algae or hemic compounds. More recently, color has been used as a quantitative assessment of the presence of potentially hazardous or toxic organic materials in water.

Taste and Odor: -Taste and odor are human perceptions of water quality. Human perception of taste includes sour (hydrochloric acid), salt (sodium chloride), sweet (sucrose) and bitter (caffeine). Relatively simple compounds produce sour and salty tastes. However sweet and bitter tastes are produced by more complex organic compounds. Human detects many more tips of an odor than tastes. Organic materials discharged directly to water, such as falling leaves, runoff, etc., are sources of tastes and odor-producing compounds released during biodegradation.

Turbidity: -Turbidity is a measure of the light-transmitting properties of water and is comprised of suspended and colloidal material. It is important for health and aesthetic reasons.

Solids: -The total solids content of water is defined as the residue remaining after evaporation of the water and drying the residue to a constant weight at 103 °C to 105 °C. The organic fraction (or volatile solids content) is considered to be related to the loss of weight of the residue remaining after evaporation of the water and after ignition of the residue at a temperature of 500 °C. The volatile solids will oxidize at this temperature and will be driven off as gas. The inorganic (or fixed solids) remind as inert ash. Solids are classified as settleable solids, suspended solids, and filterable solids. Settleable solids (silt and heavy organic solids) are the one that settles under the influence of gravity. Suspended solids and filterable solids are classified based on particle size and the retention of suspended solids on standard glass-fiber filters(http/water characteristics, 20/05/2018).

2.3.2. Chemical Characteristics of Water:

The chemical characteristics of natural water are a reflection of the soils and rocks with which the water has been in contact. In addition, agricultural and urban runoff and municipal and industrial treated wastewater impact the water quality. Microbial and chemical transformations also affect the chemical characteristics of water

Inorganic Minerals: -Runoff causes erosion and weathering of geological formation, rocks, and soils as the runoff travel to the surface-water bodies. During this period of contact with rocks and soils, the water dissolves inorganic minerals, which enter the natural waters. Inorganic compounds may dissociate to varying degrees, to cations and anions.

Carbonate Equilibrium: -The carbonate - bicarbonate system is presumably the most important chemical system in natural waters. The carbonate system provides the buffering capacity essential for maintaining the pH of natural water systems in the range required by bacteria and other aquatic species.

pH and Alkalinity: - pH is a measure of the hydrogen ion concentration in water. pH is measured on a scale ranging from 0 to 14 with seven considered neutrals. At a pH below 7, the water is acidic; at a pH above 7, the water is alkaline. The lower the pH, the greater the acidity and become corrosive on the other hand the higher the pH, the greater the alkalinity and tends to produce scale.

Hardness: -Hardness in water is caused by significant amounts of calcium or magnesium components. The hardness is classified into carbonate or non-carbonate hardness depending on what molecules are combined with the calcium or magnesium. If they are combined with carbonate ions (CO_3), the hardness is carbonate hardness; if combined with other ions, it is non-carbonate hardness.

Total dissolved solids (TDS): - is a measure of salt dissolved in a water sample after removal of suspended solids. TDS is residue remaining after evaporation of the water.
Conductivity: -The concentration of total dissolved solids (TDS) is related to electrical conductivity or specific conductance. The conductivity measures the capacity of water to transmit electrical current. The conductivity is a relative term and the relationship between the TDS concentration and conductivity is unique to a given water sample and in a specific TDS concentration range. The conductivity increases as the concentration of TDS increases.

Organic Materials: -Organic chemicals are made up of carbon (C), hydrogen (H), as well as nitrogen (N) and oxygen (O). Organic compounds are derived from living organism as well as industrial sources. A wide variety of assortments of organic compounds are produced in the chemical and petrochemical industries. Organic compounds also may contain sulfur (S), phosphorus (P), fluorine (F), chlorine (Cl), bromine (Br), and iodine (I).Organic compounds in water also affect the water quality. Organic chemicals cause disagreeable tastes and odors in drinking water. Vinyl chloride, benzene, and other organic contaminants are known carcinogenic agents, while chloroform is a cancer-suspect agent.

Biological Oxygen Demand (animation): -Biological oxygen demand (BOD), the most widely used parameter, is a measure of the amount of oxygen used by indigenous microbial population in water in response to the introduction of degradable organic material. This parameter depends on water characteristics: dilution, essential nutrients (N, P, K, Fe, etc), and bacteria seed. The 5-day BOD (BOD_5) is most widely used. The BOD_5 of natural water is related to the dissolved oxygen concentration, which is measured at zero time and after 5 days of incubation at 20 °C. The difference is the dissolved oxygen used by the microorganisms in the biochemical oxidation of organic matter.

Chemical Oxygen Demand: -The chemical oxygen demand (COD) test of natural water yields the oxygen equivalent of the organic matter that can be oxidized by a strong chemical oxidizing agent in an acidic medium. Potassium permanganate is the oxidizing chemical. Silver sulfate is added as a catalyst and to minimize the interference of chloride on the COD test. Mercuric sulfate is also added to inhibit interferences of metals on the oxidation of organic compounds. The reaction of the dichromate with organic matter is presented here in a general way.

Dissolved Gases: -Transfer of gas in natural water is the transfer of oxygen from the atmosphere to the water. However, the gas transfer is also used to strip hydrogen sulfide (H_2S), ammonia (NH_3) and volatile organic compounds (VOC) from the water. In both processes, the material is transferred from one bulk phase to another across a gas-liquid interface. For example, oxygen is transferred from the bulk gaseous phase (atmosphere) across the gas-liquid interface into bulk liquid phase (water). In the case of stripping volatile organic compounds (VOC) from the liquid, the VOC is transferred from the bulk liquid phase (water) across the liquid-gas interface into the bulk gaseous phase (atmosphere).

The solubility of Gases: - The equilibrium of each phase, concentration of gases or volatile organic compounds dissolved in water, depends on the temperature, the type of gas or volatile compounds, and the partial pressure of the gas or volatile compounds adjacent to the water (http/water characteristics, 20/05/2018).

2.3.3. Microbiological Characteristics

Some of the physical and biological characteristics of organisms important for water quality considerations are many bacteria, viruses, and protozoa.

Algae: - Algae (one-celled, microscopic, and larger) aquatic plants, some microscopic, can be quite abundant in a surface water source, especially during the summer months and especially if the water contains nutrients that encourage their growth, such as phosphorus from domestic run-off or industrial pollution. Algae may cause taste and odor problems, clog filters, and produce nuisance slime growths on intake pipes and equipment.

Bacteria: -Bacteria are microscopic one-celled organisms that multiply by simple division. Bacteria are universally distributed. Many of them are essential. For example, they aid in the decomposition of the dead organic material. However, there are numerous disease-producing bacteria that the water industry needs to guard against. These may cause typhoid fever, dysentery, cholera, and gastroenteritis. Some bacteria, although not harmful, may cause taste and odor problems. Examples of such bacteria are sulfur bacteria, which may produce hydrogen sulfide or crenothrix iron bacteria which can produce disagreeable taste, odors, and stains. Disease-causing bacteria are called pathogenic bacteria. It is often hard to test for and identify them. Therefore, their presence is determined by testing for the presence of an indicator organism, usually coli form bacteria. This group of bacteria is found in the intestines of warm-blooded animals; it is also common in soil. A more specific group of bacteria are the fecal coli forms, which are directly associated with contamination from human or animal wastes. Presence of coli form bacteria indicates general bacterial contamination.

Protozoan's: - Protozoan's are single-celled, usually microscopic, organisms. Some protozoan's, such as Giardia and Cryptosporidium, are commonly found in rivers, lakes, and streams contaminated with animal feces or which receive wastewater from sewage treatment plants. When a water system uses surface water as its source, Giardia and Cryptosporidium must be removed in the clarification process because they are very difficult to kill with the usual forms of disinfection. If a person is infected, the symptoms may last seven or more days and include diarrhea, stomach cramps, nausea, fatigue, dehydration, and headaches. Protozoan's are very difficult to test for; 100 or more gallons of water must be piped through a filter with openings less than one micron in size at 1 ppm or less. The particles trapped by the filter are then analyzed using very sophisticated methods to determine if any protozoa are present.

Viruses: - Viruses are the smallest living organisms capable of producing infection and causing disease. Viruses that may be carried by water include hepatitis and poliovirus. They are very difficult to test for; usually, large amounts of water have to be tested by using very sophisticated methods (http/water characteristics, 20/05/2018).

2.4. Drinking Water Standards

Water is essential to sustain life, and a satisfactory supply must be made available to consumers. Every effort should be made to achieve a drinking-water quality as high as practicable. The primary aims of the Guidelines for drinking-water qualityis the protection of public health. The guidelines are intended to be used as a basis for the development of national standards that, if properly implemented, will ensure the safety of drinking-water supplies through the elimination, or reduction to a minimum concentration, of constituents of water that are known to be hazardous to health. It must be emphasized that the guideline values recommended are not mandatory limits. In order to define such limits, it is necessary to consider the guideline values in the context of local or national environmental, social, economic, and cultural conditions(S. Water & Organization, 2006).

Table 2.5. Who drinking water standards(S. Water & Organization, 2006).

Parameters	Existing standard
pH at 25^{o}c	6.2 – 8.8
Color	Not exceeding 5 Hazen units
Turbidity	Not exceeding 1.5 NTU
Iron as Fe	Not exceeding 0.1mg/l
Manganese as Mn	Not exceeding 0.05mg/l
Aluminum as Al	Not exceeding 0.1mg/l
Free residual chlorine	0.5 – 1.5 mg/l
Fluoride as F	0.45 – 0.55mg/l
Test and color	Unobjectionable
Total plat count coli forms	Absent
TDS	25 – 500mg/l
Salinity	Below 1000ppm
Nitrate	not exceeding 1mg/l
Total Hardness	50mg/l Ca
TSS	Below 25mg/l
Conductivity	0.5 – 1.5 mg/l

Table 2.6. Ethiopia drinking water standards(E. N. D. Water, 16/04/2018)

Parameters	Ethiopia drinking water standard
PH at 25^{o}c	6.5 – 8.5
Color	Not exceeding 5 Hazen units
Turbidity	1.5mg/l
Iron as Fe	0.3mg/l
Manganese as Mn	0.5
Aluminum as Al	0.2mg/l
Free residual chlorine	0.5mg/l
Fluoride as F	1.5mg/l
Test and color	Unobjectionable
Total coli forms	Must not be detectable
TDS	1000mg/l
Salinity	Below 1000ppm
Nitrate	3mg/l
Total hardness	300mg/l
TSS	Below 30mg/l
Conductivity	2mg/l

2.5. Review on Rural Drinking Water Treatment Technologies

Most of the people in third world countries do not have easy access to clean drinking water. While safe drinking water is essential for living, lack of access has resulted in many water-related diseases. To reduce and eliminate these effects many researchers and organizations were done a great influence on the area. To gain more insight knowledge on the existing water filtration systems, research was done on five most common types of home use water filters. These are UV water treatment, reverse osmosis filters, slow sand filters, activated carbon and ceramic filters. Different filter types were studied at different time and place. Therefore, in these topics, a fairevaluation of them will be done based on some relevant factors including price, functionality, manufacturing process and effectiveness.

A) Louis chan, marcuschan, and jingwenwang were done a design of water filter for third world countries in 2009. They reported about a treatment device having a combination of activated carbon filter from coconut seed and ceramic filter from red clay and rice husk for household water treatment in Kenya. During their design and manufacturing process ceramic filter filled with activated carbon was used to treat Lake Ontario water. At the end of their work TOC, turbidity and disinfection measurements provided in the sample tests were used to generalize the presence organic matters and disinfectants. Data suggests that the dual filter reduced the impurity on average of 48% from the initial concentration. This thesis tries to use a combination of activated carbon and ceramic filter but it does not use any disinfection process to treat harmful pathogens, lack of backwash system also as we absorb from the result the treatment efficiency if below half present (50%) therefore it will be better to use disinfection and increase the treatment efficiency by improving the design of the device(Chan et al., 2009).

B) According to Miller and Watters, a ceramic filter is designed in the household label, manufactured from clay and rice husk, and test the performance in north Ghana. At the end of their work with the experimentalresult, the device has an overall efficiency of 92% with 1.5l/h flow rate. From these result, we can say that they can manufacture a device with high efficiency but very slow flow rate because of clay with husk ratio and porosity of the ceramic filter(Miller & Watters, 2010).

C) According to Cawst training in the titleof design, construction, installation, operation and maintenance of bio sand filter, bio-sand filter having diffuser, filtration sand layer, separating gravel layer, drainage gravel layer with the different size of particle and bed length to treat any source of water such as rainwater, deep groundwater, shallow groundwater, rivers or lakes. the total efficiency of the device was around 85%meanwhile at the end of their work they conclude that even if treated water look clear after filtration, it is still necessary to disinfect it by any disinfection processes to ensure the best water quality as much as possible because bio-sand filter removes most, but not all of the bacteria and viruses. Depend on the above and other investigations, we can say that there is a clear gap in the area especially on the coat treatment efficiency, applicability and capacity of small drinking water treatment. Because most of them are a batchprocess in small-scale, highly costlyto afford by single individuals and theyare also using one single treatment bed to remove impurities from raw water. Not only this but they also difficult to manufacture, maintenance and washing process. Therefore, in this study dual filter device that can operate continuously by using locally available raw materials such as rice husk, moringa seed, and black pottery clayis designed assembled and optimized to satisfy the need of all individuals in the rural area(CAWST, 2009).

3. MATERIAL AND METHODS

3.1. Chemicals and equipment used

Table 3.1.Chemicals and equipment used

Process	Chemicals	Equipment's	Raw materials	Reagents
Preparation of Activated carbon	NaOH (99%) HCL (35%)	Sieve (0.7mm – 6mm) Oven and Furnace Analytical Balance	Rice husk (from woreta)	Water
Preparation of disinfection solution	Hexane (analytical grade) NaCl (Normal salt)	Grinder and Sieve, Sox let extractor Analytical Balance, Different Beaker, White mean Filter paper Centrifuge	Moringa seed (from Gerger)	water
Preparation of sand filter	No	Sieve (7mm – 6mm) washer dish	See sand (from lake Tana)	Water
preparation of ceramic filter	No	Grinder, sieve, plastic mold Furnace	pottery clay(from Addiszemn) rice husk(woreta)	Water
Manufacture of device	No	Grinder cutter welding machine	carbon sheet metal electrode	No

Process	Chemicals	Equipment’s	Raw materials	Reagents
Manufacture of device	No	roller machine	Angle iron, round tube squire tube small HDPE tank	No
Assembling	No	HDPE welding machine	1/2’’ HDPE pipe Valves, Elbow Connectors	No
Laboratory testing	Fluoride no1 Fluoride no 2 Hardicol no 1 Hardicol no 2	pH Meter Photometer (spectro) Turbinado meter Ysi-pre30 TDS meter Sterilizer Collin counter Incubator Different test tubes Petridish	Treated water Untreated water (Tana water)	Nutrient agar Peptone water Buffer solution (pH= 7)

3.2. Methods for Sand Filter

In order to prepare sand filter for drinking water treatment, first sand and gravel is collected from lake Tana to use as filtering media and the collected material being washed gently until it becomes clear and free from dust, clay or any other suspended solid impurities. Then the washed sand must be dry at a normal atmospheric temperature for 2 days to remove moisture contents and other volatile impurities so as to make the sand easy for screening and further treatment process. The dried sand and gravel is being sieved with standard sieving machine up to acceptable particle size range from 0.7mm to 6mm. finally,sand having an average particle size of 0.7mm is used for filtering medium as treatment medium, sand having a particle size of 1mm can be used as separating gravel layer were as sand having an average particle size of 6mm is used for drainage gravel layer(Chan et al., 2009).Generally, the preparation of sand filtering medium can be summarized in the following simple diagrammatical flow sheet.

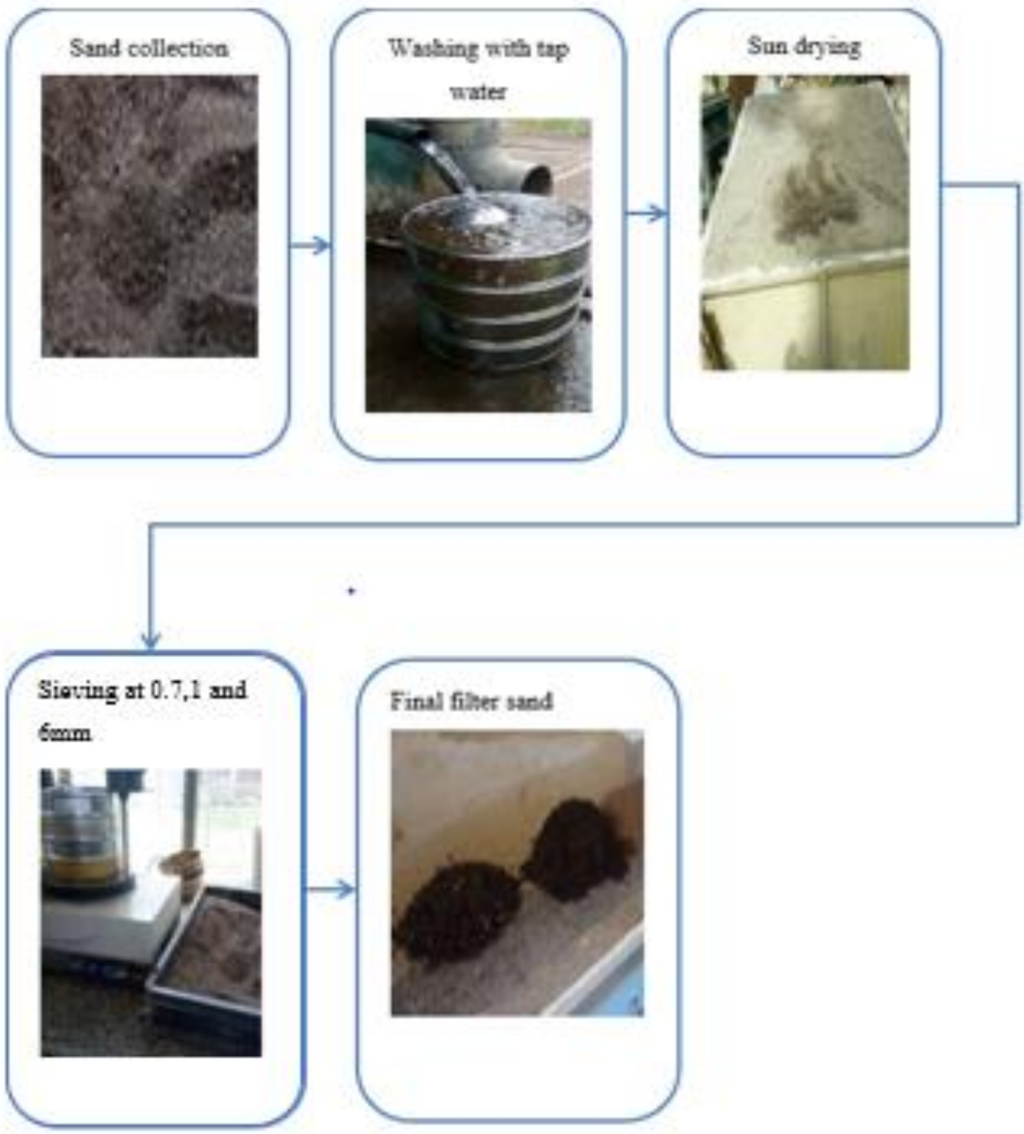


Figure 3.1. Preparation procedure of sand filter

3.3. Methods for Disinfection Solution

Collect matured moringaoleiferaseed from north showa, Ensaroweredaspecific name of Gerger. The matured moringa seed should be dry in the oven at 105^{o}c to minimize the moisture content of the seed. Next to this peel and mill the seed to an acceptable and recommender particle size of 0.2mm (because the particle size of powder moringa can affect the oil extraction rate. These means when the powder particle size is low the particle can form agglomeration and the extracting solvent become difficult to pass between the particle because of the fact it can reduce the amount of oil extract. On the other hand, when the size of the powder is the course the surface area to volume ratio will be law and it also leads to minimize the oil extraction)(Suleyman A. Muyibi, 2013). After reducing the particle size, Extract the oil content using sox let extraction chamber by using hexane as extraction solvent because Moringa_Oleifera seeds contain a cationic protein for treatment and 40% (w/w) oil or fat having a negative charge and it can reduce the water treatment efficiency by covering the positively charged proteins(Jerri, Adolfsen, McCullough, Velegol, & Velegol, 2011). During oil extraction, weighing of 50 gm of Moringa Oleifera seed powder and setting it in the thimbles of thermal sox let extraction chamber; Adding 200 ml of Hexane in the heating chamber and extract for 3 hours. The extracted oil can be separated from the solvent hexane by using simple distillation. After oil extraction, Moringa Oleifera cake residue from the sox let thimbles will be dry. Then Extract the disinfection active component from the dry cake by using NaCl. Because NaCl solution acted as a better solvent than pure water in breaking protein-protein or protein-polysaccharide or other associations in the seed powder, which led to increasing protein solubility. Therefore, as the level of protein raises, the higher the disinfection activity; consequently, the better is the efficiency of removal.(Bichi, Agunwamba, & Muyibi, 2012).To extract the active proteins add 50ml 1m NaCl to 5gm of dry Moringa Oleifera cake residue (Luqman, Srivastava, Kumar, Maurya, & Chanda, 2012). Mix the solution for 30 minutes at room temperature and Centrifuged the extraction solution at 4000 rpm for a period of 10 minutes finally filter the disinfection solution with what man filter paper. Finally, the filtrate can be directly used as disinfection solution to kill harmful pathogens from raw water. Generally, this extraction process can be summarized in the following manner.

Figure 3.2. Preparation procedure of moringa disinfection solution

3.4. Methods for Preparation of Activated Carbon

Collect rice husk from Woreta because rice husk can be available throughout the year in the area and it also has high carbon content and less ash content. Sieve the rice husk to an acceptable average particle size of 2mm. Because Particle size of rice husk can affect the amount of activated carbon produced and the quality of activated carbon by changing the absorption surface area. Then the Sieved rice husk should be washed thoroughly with tap water initially to remove mud and other water-soluble impurities and it became Steep with 1M sodium hydroxide solution for 24hr. because (NaOH solution can lower the ash content of the rice husk by leaching process and also can remove natural fats, waxes and low molecular weight lignin compounds from the rice husk surface thus revealing chemically reactive functional groups like –OH(Chen et al., 2013). The removal of the surface impurities also improves the surface roughness of the fibers or particles thus opening more hydroxyl groups and other reactive functional groups on the surface). After steeping the husks with NaOH solution, the sample will be dried in an oven at 105 °c for 24 h. finally dried rice husk sample is taken in a porcelain crucible and carbonized at 500 °c for 5 hr and the activated carbon is then washed with 0.3 M HCl solution and distilled water to increase the number of active pores, arrange the pH. and to remove very file products(Chen et al., 2013; Muniandy, Adam, Mohamed, & Ng, 2014).

Figure 3.3. Preparation procedure of activated carbon filter

3.5. Methods for Preparation of Ceramic Filter

During the manufacture of ceramic water filter from pottery clay and rice husk, first, collect the required amount of black pottery clay from Addis Zemn and rice husk from worota. Then dry the sample at atmospheric temperature until the moisture content of the sample removed because it can create cracking and leakage during the firing process. After complete removal of moisture content, the dried sample is then crushed up to 1mm particle size (Christopher, 2012)for the sake of uniform mixing. While completing this process measure required amount of crushed pottery clay and 1mm size rice husk with a proportion range from 10% - 30% of rice husk in the mixture and mix them for 10 minutes in the absence of water(Barajas & Pagsuyoin, 2017) (dry mixing) then the mixture is being changed in to mud by mixing with 1.25L of tap water for every kilogram of rice husk. Give required shape for the mud using plastic molds. After the shape of this particular mud, to prevent cracking the mud must be placed in a prevented area free from air flow and sunlight until it removes its moisture contents. Then dry the sample for 6 days but the drying time is dependingon the size of the filter as well as the drying environment. Before firing process, the dried sample must be smooth and free from rough surfaces in both internal and external parts by the process known as Surface finishing using smooth and flat Scraping tools this ensures the effectiveness of the water filtering process. Finally, ceramic part is to be placed in a kiln or pottery oven to complete the firing process. There are two stages in the firing process – dehydration and Vitrification(Brown & Sobsey, 2010). Water molecules are dried off in dehydration under low-temperature firing. Vitrification is the process of creating the firm bonds of the ceramics – this is done in higher temperature firing. Rice husks mixed into the clay also burn off, thus creating pores in the pot to allow water to pass through. The elements are heated at 100^{o}C for two hours for drying off water excess within the ceramics. Then, the temperature is gradually increased to 800 ^{o}C over 8 hours. The firing temperature and time depend heavily on the number of elements and the unique properties of the clay mixture(Ndabigengesere & Narasiah, 1998).

Figure 3.4. Preparation procedure of ceramic filter

3.6. Methods for System Design, Material Selection, Sizing and Manufacture of Prototype

3.6.1. System design

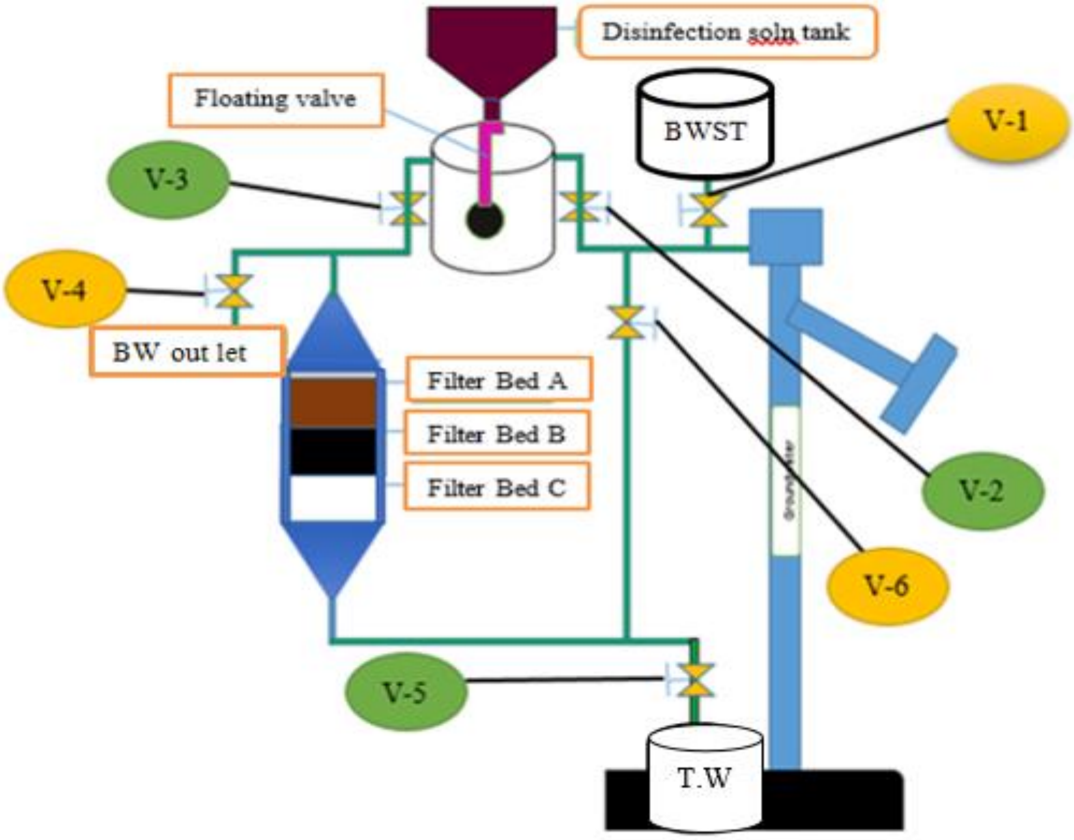


Figure 3.5. Designed device

Where

- ✓ All green valves are treatment valves
- ✓ All yellow valves are backwash valves
- ✓ BW = back wash
- ✓ BWST = back wash solution tank
- ✓ TW = treated water

The treatment process can be done simply by opening the green valves (V-2, V-3, and V-5) and close the green valves (V-2, V-4, and V-6). And the reverse is true for backwash or regeneration process.

3.6.2. Material selection for a prototype

Table 3.2. Material selection for prototype testing

Types of equipment	Selected material For this thesis	Recommended Material	Reason for selection
Filtration tank	Carbon steel	Stainless steel	Less cost
Disinfection tank	HDPE	Stainless steel or HDPE	Less cost, durable, non-corrosive, flexible
Backwash solution tank	HDPE	Stainless steel or HDPE	Less cost, durable, non-corrosive, flexible
Disinfectant solution tank	HDPE	Stainless steel or HDPE	Less cost, durable, non-corrosive, flexible
Pipes	HDPE	Stainless steel or HDPE	Less cost, durable, non-corrosive, flexible
Valves	HDPE	Stainless steel or HDPE	Durable non-corrosive
Supports	Carbon steel	Concrete	Durable non-corrosive

3.6.3. Selected sizes for prototype

To manufacture the device in small-scale or pilot plant for the sake of checking the functionality of the system and to optimize different parameters and process, the following materials and its size were selected based on cost, availability of materials and simplicity of manufacturing and assembling.

- Filtration tank having a diameter of 20cm and height of 80cm was constructed from carbon steel metal sheet
- Disinfection tank and backwash solution tank having a diameter of 30 cm and height of 30cm made up of HDPE was selected from the available market
- All valves and tubes made up of HDPE with a diameter of ½''
- Single phase pump having a power of 0.75 HP and a maximum head of 30m
- Carbon steel metal sheet

The image and other specifications on selected materials are put on the appendix - 1

3.6.4. Prototype manufacturing process

Before starting the manufacturingprocess collect all necessary materials such as HDPE pipes, valves, metal sheet, different fittings HDPE and metal welding machine, cutter, grinder, electrode etc. then start manufacturing of small parts independently according to the selected prototype size and finally assemble each part it one system.

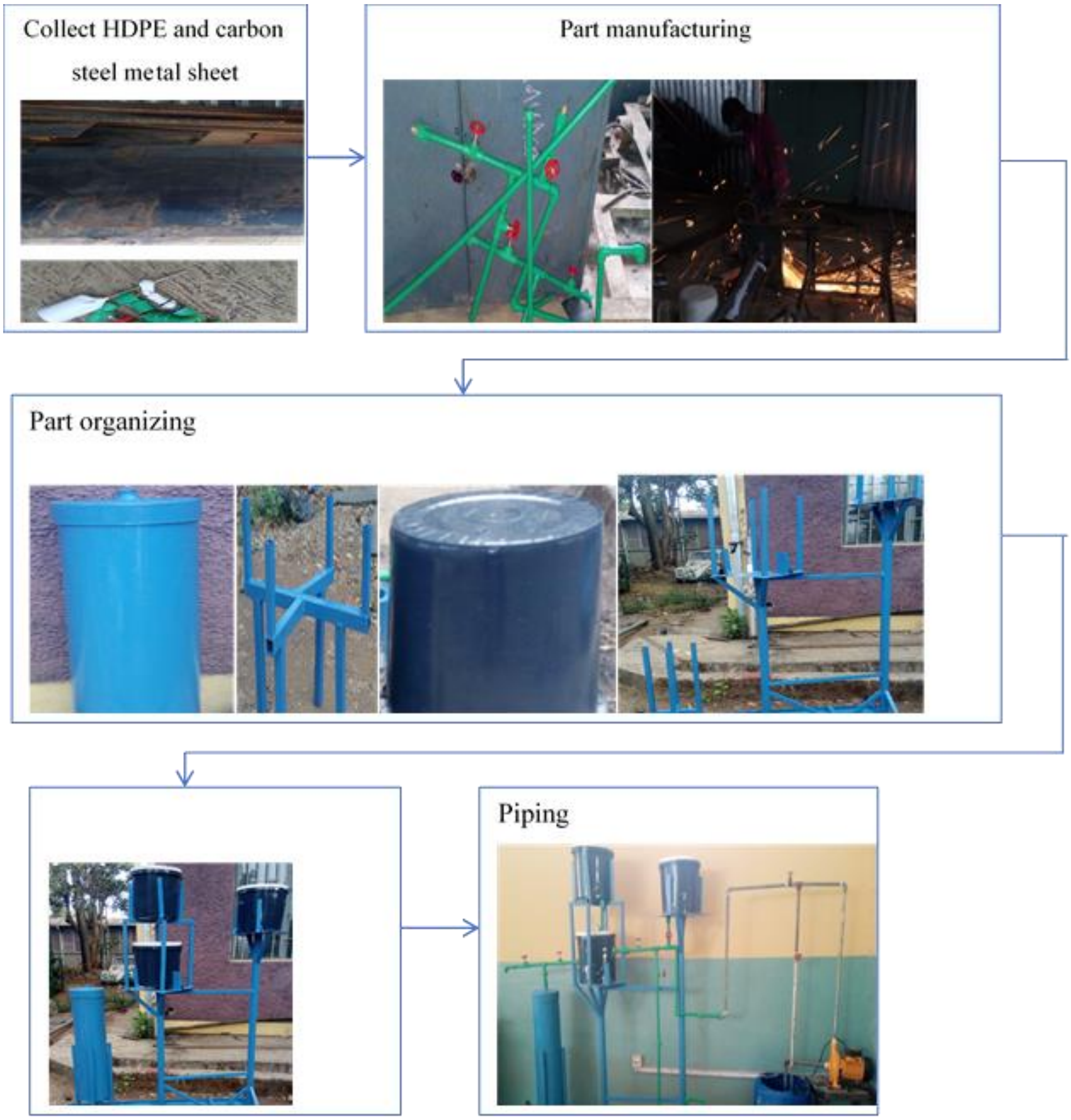


Figure 3.6. Device manufacturing procedure

3.6.5. Prototype working principle and unit description

Figure 3.7. Assembled prototype device

Where

- PA = untreatedwater source
- PB = pump
- PC = flow distribution pipes
- PD = flow regulator valves
- PE = backwash solution tank
- PF = floating valve
- PG = disinfection solution tank
- PH = disinfection tank
- PI = filtration tank
- PJ = stand
- PK = clear water outlet pipe

3.6.6. Prototype partdescription

PA: - untreated water source: - is water having physical, chemical and biological impurities and need a treatment to be pure drinkable water.
PB: - Pump: - used to move raw and untreated water from the source to the system and push the treated water to release from the system continuously.
PC: -Distribution (pipes): - HDPE pipes are used to transport both untreated and treated water from one unit to another means from the pump to treatment unit and from treatment unit to distribution
PD: - Flow regulator valves: - gate valve and float valve made of plastic and metal are used to regulate the flow rate of untreated and treated water within the system.
PE: -Backwash solution tank: - is tank filled with backwash solution (NaOH solution having a concentration of 0.8% or 10% NaCl solution) and used to feed the backwash solution in to filtration unit and remove any impurities that accumulated on the surface of the filter media and regenerate the filtration unit by passing the solution countercurrent to the filter arrangement. During this process, the flow rate of backwash solution should be optimized by using gate valves so as to prevent overflow of filtering beds from the filtration tank. Regenerate period of the system is depending on the flow rate of untreated water, operational period and quality of raw water.
PF:-Disinfection solution tank: - is another part of the system used to store moringa solution and feed the solution in to disinfection unit by the help of floating valve which means when the water label inside the disinfection unit is rise up the floating valve start to open the disinfection solution, on the other hand when the water label drops from the disinfection unit the floating valve start to close the flow of disinfection solution slightly. If the disinfection unit is empty of untreated water, no moringa solutions flow into the disinfection unit.
PG: -Floating valves: - regulate the flow of disinfection solution with the help of water label inside the disinfection tank.
PH:-Disinfection tank: - is a special unit used for removal, deactivation or killing of harmful microorganisms from untreated water by using moringa disinfectant solution. During this process, cationic protein, (positively-charged proteins) contains a little peptide sequence that acts like a molecular knife. So, this little molecular knife goes through the bacterial cell wall and kills it, and these proteins also act as a

cationic polyelectrolyte which attaches to the dyed organisms and soluble particles to create bindings between them, leading to large flocs.

PI: - Filtration tank: - is a combination of the activated carbon filter, ceramic filter and sand filter arranged in a good manner to removes died microorganisms and other impurities and by particle size difference and adsorption process.

PJ: - Stands: - used to carry all process units and protect from different external and internal activates or processes the can damage the system.

PK: - pure water outlet pipes: - supply treated water for the end user.

3.6.7. Working principle of the treatment process

To get clean water from this water treatment device first untreated water is feed in to disinfection solution tank and when the water label inside this tank becomes high it rice's the floating valve and release moringa disinfection solution at the same time when untreated water and moringa solution mix in the disinfection unit harmful pathogens will be killed by moringa solution and then the outlet from disinfection unit feed in to filtration tank. In this unit died microorganisms and other impurities such as suspended solids, heavy metals, fluorides, nitrate and other will remove on the surface of the filtering medium after removing those impurities pure drinking water will be out from the system continuously.

3.6.8. Working principle of backwash process

This process is required if the head loss is so high that the filter no longer produces water at the desired rate or flocs starts to break through the filter and turbidity in the filter effluent increases because the filter media becomes coated with flocs, which plugs the voids between the filter grains, making the filter difficult to clean. The media must be expanded to clean the filter during the backwash using treated water and back wash solution. This expansion causes the filter grains to violently rub against each other, dislodging the flocs from the media. The filter backwash rate has to be great enough to expand and agitate the filter media and suspend the flocs in the water for removal. However, if the filter backwash rate is too high, media will be washed from the filter into the troughs and out of the filter. Therefore, for this system backwash can occur by using 0.8% NaOH solution OR 10%NaCL solution.

3.7. Experimental Set Up

3.7.1. Experimental set up for the treatment process

Once the treatment device is assembled and if there is a clear experimental design testing and treatment process can be done starting from washing all filter beds so as to remove any dirt particle on the surface of the media because those impurities can affect the purity of treated water and also minimize the surface life of filter beds. Then arrange the filter bed by Putting the bed stand and sieve before any filter media to carry all filter beds and water load into the system. Then fill the activated carbon with a bed height of 10cm at the bottom. Then fill the drainage gravel layer having a diameter of 6mm with a bed height of 5cm to Supports the separating gravel layer and helps water to flow into the outlet tube then fill the separating gravel layer having a diameter of 1 mm with a bed height of 5cmto Supports the filtration sand and prevents it from going into the drainage layer and outlet tube next to this fill the filtration sand layer having a diameter of 0.7 mm with a bed height of 20cm to Removes pathogens and suspended solids or any other impurities through a combination of mechanical trapping, predation, adsorption, and natural death, To prevent disturbance insert diffuser at the top of the filter bed it also protects the bio layer when water is feed into the filtration tank. Because fluidization process in the filter bed must always be at fixed bed not on mobilized or expanded bed. While completing the bed arraignment effectively,Cheek all valves, fittings, the volume of disinfection solution and power sources to run the system finally run the system and take a water sample from the outlet tube for laboratory analysis.

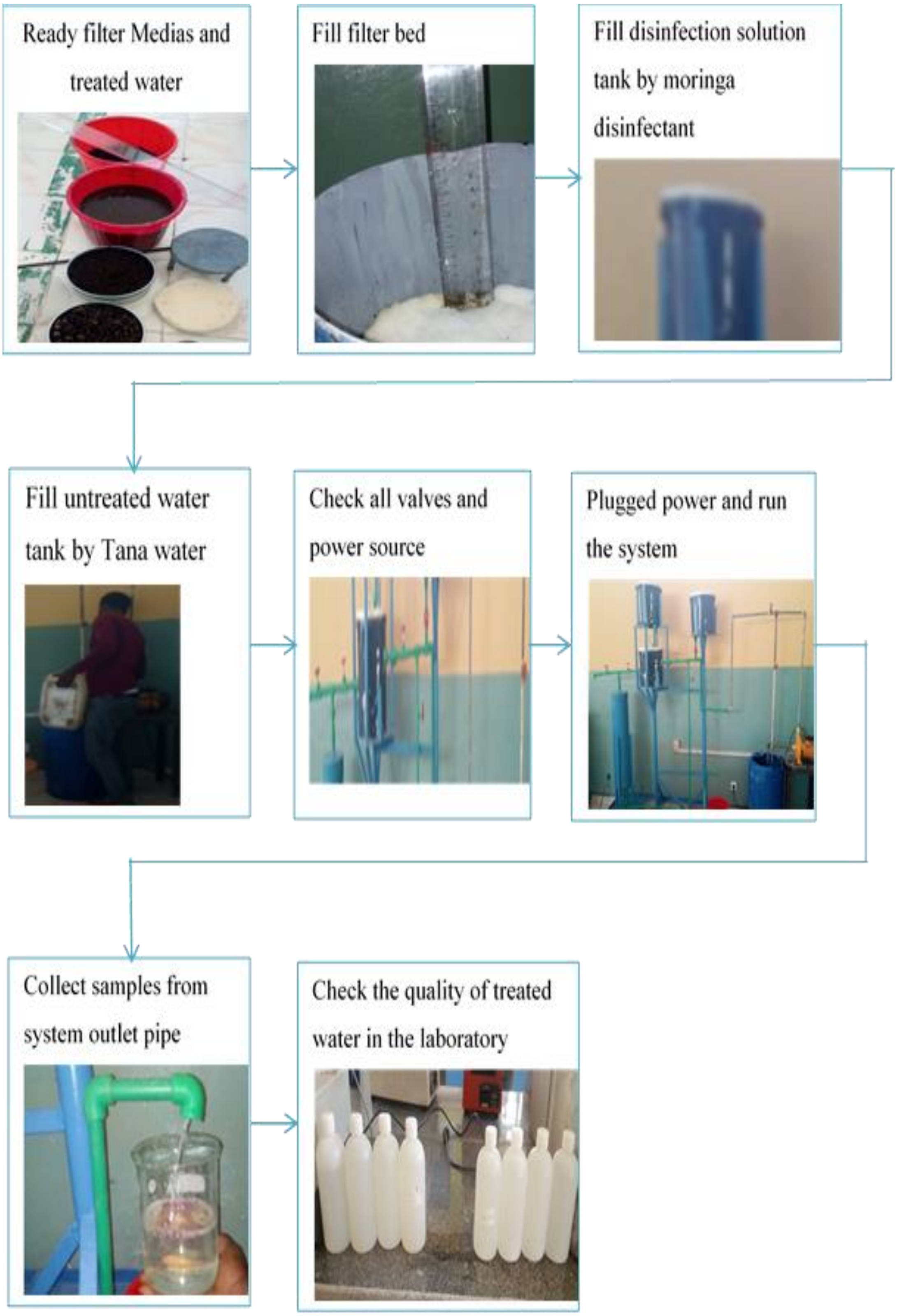


Figure 3.8. Device testing and treatment process

3.7.2. Experimental set up for water quality analysis

After treatment process,samples are taken from the device outlettubeand the efficiency of the system was checked by measuring some selected water quality parameters. In this study, the fluoride and total hardness concentration of treated water was done using Spectrophotometer in hydraulics lab under the faculty of civil and water resource engineering. To check the fluoride concentration standard fluoride No 1 tablet and fluoride No 2 tablet was used but for total hardness concentration palintest hardicol No1 Tablets and palintest hardicol No2 tablets was used. Where us the presence of microorganisms was done in food microbiology lab by doing total plate count method in1mL of water sample was dissolved in 9 mL Maximum Recovery Diluents and subjected to serial dilution up to a factor of 10^{-5}.1mL of serially diluted sample from 10^{-3} to 10^{-5} were dispersed in to sterile Petri plates to which Plate Count Agar was poured, mixed and allowed to solidify. The plates after solidification were incubated at 37 ºC for 24. Duplicates were maintained for each dilution. After incubation plates with colonies counter were selected to know the presence and absence of microorganisms in the sample. All media were prepared according to manufacturer’s instructions and sterilized by autoclaving at 121°C for 15 min(Ndabigengesere & Narasiah, 1998). In addition to this, the concentration of TDS, turbidity, and PH was done in Blue Nile water lab using YSI –PRE30 TDS meter and MICRO IPW turbido meter. But, the flow rate of treated water was calculated by using simple stopwatch during the treatment process in mechanical unit operation laboratory under chemical engineering department.

3.8. Experimental Design

For the experimental results, independent sample t-test for determination of bed arrangement and one-way ANOVA for filter bed ratio (sand/AC) was used. But for moringa dosage and for ceramic filter simple statically analysis was done related to the objectives of the study. The levels of factors were selected based on the literature which have done before on drinking water treatment therefore for all experiment with 3 label replication a total of 42 experiments were done and these can be summarized as follows

Parameters:

- Filter medium order;

- Bed height,
- Ceramic pore.
- moringa dosage

To see the effect of those parameters single factor experiment with their corresponding levels was conducted.

Table 3.3 Experimental design.

Parameter	Levels	Replication
Filter medium order	Sand + activated carbon (SAC)	3
	Activated carbon + sand (ACS)	3
Bed height	25% sand + 75% activated carbon	3
	50% sand + 50% activated carbon	3
	75%sand + 25% activated carbon	3
	10% rice husk	3
Ceramic filter	15% rice husk	3
	20% rice husk	3
	25% rice husk	3
moringa dosage	100mg/l	3
	125mg/l	3
	150mg/l	3
	175mg/l	3
	200mg/l	3

4. RESULTS AND DISCUSSION

4.1. Determination of Ceramic Filter

Experimental result from ceramic filter having 1L in volume and a thickness of 1.3mm

Table 4.1. Ceramic filter experimental result

Ratio 1= 10% rice husk					
Parameters	Before treatment	After treatment			
		Run 1	Run 2	Run 3	AVG% of removal
Flow rate (l/hr.)		0.8	1.0	0.7	0.83
Turbidity (NTU)	42.7	2.3	2.5	2.7	94.1
Ratio 2 = 15%rice husk					
Parameters	Before treatment	After treatment			
		Run 1	Run 2	Run 3	AVG% of removal
Flow rate (l/hr.)		1.2	1.4	1.6	1.4
Turbidity (NTU)	42.7	3.4	3.6	3.1	92.1
Ratio 3 = 20%rice husk					
Parameters	Before treatment	After treatment			
		Run 1	Run 2	Run 3	AVG% of removal
Flow rate (l/hr.)		1.8	1.6	2.1	1.83
Turbidity (NTU)	42.70	5.2	5.4	5.2	87.6

From the above experimental result, even if there is a significant difference between turbidity removal and flow rate between ceramics prepared from a pottery clay rice husk ratio of (10 %, 15%, and 20%) we have enough evidence to say there is treatment process. But, for ceramics prepared from a ratio of 25%, there was no uniform shaped ceramics produced after drying process and fairing process in the oven. Because as we know that the main function of pottery clay in the manufacturing of ceramic water filter is acting as a binder or glue to contact the rice husk in micro label whereas the function of rice husk is making a pores or opening between pottery clay to pass the water .because of this fact and from the result of ceramic having a ratio of 25% rice husk we can say that even if the treatment efficiency also depends on the type of pottery clay and different process parameters, if the amount of rice husk is higher it is difficult to prepare structured ceramic water filter because rice husk is a combustible material and it can burn totally inside the oven this result to increase the number and size of large pores those large pores result to make leakage, crack and finally dis structured. Therefore, during the preparation of ceramic water filter from pottery clay and rice husk having a particle size of 1mmthe amount of rice husk should not exceedfrom 25%. Butwhen we see the result from (10%,15%, and 20%) ceramic filter, there was a treatment process by removing the turbidity of raw water with different removal efficiency and flow rate. from the above 3 alternatives ceramic filter prepared from 10%, rice husk is the best choice because it has an average turbidity removal of 94.6% with an average flow rate of 0.83L/hr. meanwhile, even if it has a high percent of impurity removal, because of its low flow rate related to a continuous treatment process at community label it is not ideal and recommended to use as one filter bed. But it is effective to treat drinking water in the batch process. Therefore, this study using only activated carbon and sand as filtering bed inside the filtration unit but, relating to the objective of the study to treat the raw water as a low impurity as possible with a continuous process having acceptable flow rate.

4.2. Determination of Moringa Dosage

The optimum dosage of moringa was done by changing the dosage concentration from (100mg/l - 200mg/ l) (Bichi et al., 2012)and check its effectiveness by doing total plat count experiment to check either any microorganism has detected or non-detected on the sample.

Table 4.2. Experimental result for moringa dosage determination

Dosage 1 = 100mg/l		
Parameters	Before treatment	After treatment
Total plat count	Detected	Detected
Dosage 2 = 125mg/l		
Parameters	Before treatment	After treatment
Total plat count	Detected	Detected
Dosage 3 = 150mg/l		
Parameters	Before treatment	After treatment
Total plat count	Detected	Detected
Dosage 4 = 175mg/l		
Parameters	Before treatment	After treatment
Total plat count	Detected	Non-detected
Dosage 5 = 200mg/l		
Parameters	Before treatment	After treatment
Total plat count	Detected	Non-detected

Standing from the above laboratory result and microbial analysis of Tana water using defatted moringa below a dosage of 175mg/l will lead to water born disease.

Therefore, to killing microorganisms present in raw water from Tana, 175mg/l of defatted moringa seed extract is recommended.

When we compare moringa disinfection to chemical disinfectants like Na or Ca hypochlorite it is safe to the environment and to human but chlorination has numerous disadvantages such as the production of trihalomethanes and chlorinated hydrocarbons which are considered health hazards. It combines with the inorganic material in water to form chloride salts, and with organic material in water to form chlorinated organic chemicals. These chlorinated compounds are less likely to degrade and can cause the same hazards as that of chlorine. Chlorination also produces a large amount of sludge which is again an environmental pollutant because of its non-decomposable property. But moringa sludge are bio degradable and environmental friendly(Ndabigengesere & Narasiah, 1998).

4.3. Determination of Filter Bed Arrangement

This can be done by using a bed height of 50% activated carbon and 50% sand filter arranged from top to bottom.

Table 4.3Arrangement 1 = sand at the top + activated carbon at the bottom (SAC)

Parameters	Before treatment	After treatment			
		Run 1	Run 2	Run 3	AVG % removal
Flow rate (l/hr.)		52.3	53.4	54.6	53.43
TDS (mg/l)	106.6	97.3	95	100	8.599
Turbidity (NTU)	42.7	10.2	10.53	10.54	75.58
Fluoride(mg/l)	0.92	0.9	0.9	0.88	2.89
PH	6.8	6.7	6.8	6.7	0.98
Total plate count	Detected	Non-detected	Non-detected	Non-detected	
Total hardness(mg/lCaCo3)	92	84	82	86	8.69

Table 4.4. Arrangement 2 = activated carbon at the top + sand at the bottom (ACS)

Parameters	Before treatment	After treatment			
		Run 1	Run 2	Run 3	AVG % removal
Flow rate (l/hr)		47.43	50	45.84	47.75
TDS(mg/l)	106.6	95.5	96.4	95.8	10.3
Turbidity(NTU)	42.7	12.3	12.5	12.3	71.03
Fluoride(mg/l)	0.92	0.9	0.9	0.88	2.89
PH	6.8	7.1	7.3	7.1	5.39
Total plate count	Detected	Non-detected	Non-detected	Non-detected	
Total hardness(mg/lCaCo3)	92mg/l	83	85	83	9.05

In this analysis, the study concentrates on the turbidity removal related to the study objectives ‘’ continuous drinking water treatment with high quality and acceptable flow rate’’. Depend on the above two interrelated factors this thesis tries to select the best alternatives.

Parameter	Flow rate (L/hr)
Arrangement 1 (SAC)	53.4
Arrangement 2 (ACS)	47.7

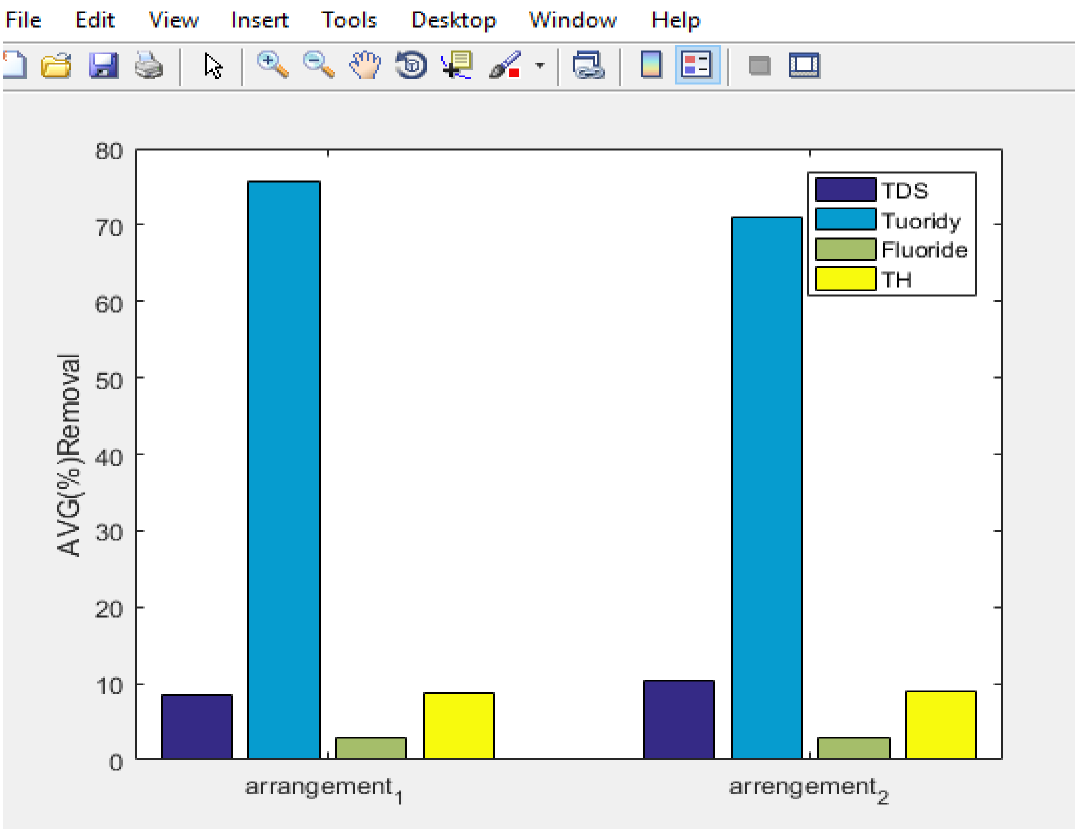


Figure 4.1. Bed arrangement result

Standing from the above result arrangement 1 having sand at the top and activated carbon at the bottom results to high flow rate around 53.4L/hr. and also high turbidity removal efficiency 75.58%. Because sand particles are hard solid and denser then activated carbon molecules because of this fact they can form a strong bed with low porosity and it results to pass only water molecules without disturbing the bed and separate turbid materials on the top of the surface because it is difficult for turbidmaterials to pass through the strong sand bed. But AC removes impurities by the process of adsorption. As a result of the high surface area and millions of pores, very fine particles can attach to the surface of the adsorbent.

The flow rate of sand activated carbon arrangement is higher than that of activated carbon sand arrangement because of incoming water flow and pressure drop. These means when the bed is filled with activated carbon at the top the incoming water flow drops its pressure by activated carbon layers and rich the sand layer with low velocity and low pressure therefore it becomes difficult to pass the strong sand layer with is short periods of time. The reverse is true for sand activated carbon arrangement.

4.4. Determination of Bed Height Ratio

Table 4.5. Bed height ratio 1 = 25% sand + 75% activated carbon

Parameters	Before treatment	After treatment			
		Run 1	Run 2	Run 3	AVG % removal
Flow rate (l/hr.)		96.8	98.4	95.6	
TDS(mg/l)	106.6	81.7	81.2	82.1	23.38
Turbidity(NTU)	42.7	15.9	15.5	15.7	63.23
Fluoride(mg/l)	0.92	0.89	0.9	0.87	2.89
PH	6.8	7.2	7.3	7.3	6.86
Total plate count	Detected	Non-detected	Non-detected	Non-detected	
Total H/(mg/lCaCo3)	92mg/l	87	85	90	5.07

Table 4.6. Bed height ratio 2 = 50% sand + 50% activated carbon

Parameters	Before treatment	After treatment			
		Run 1	Run 2	Run 3	AVG % removal
Flow rate (l/hr.)		52.3	53.4	54.6	53.43
TDS(mg/l)	106.6	97.3	95	100	8.59
Turbidity(NTU)	42.7	10.2	10.53	10.54	75.59
Fluoride(mg/l)	0.92	0.9	0.9	0.88	2.89
PH	6.8	6.6	6.8	6.8	0.98
Total plate count	detected	Non-detected	Non-detected	Non-detected	
Total H/(mg/lCaCo3)	92	84	82	86	8.69

Table 4.7. Bed height ratio 2 = 75% sand + 25% activated carbon

Parameters	Before treatment	After treatment			
		Run 1	Run 2	Run 3	AVG % removal
Flow rate (l/hr.)		34.6	32.5	35.6	34.23
TDS(mg/l)	106.6	103.5	103.8	102.9	3.00
Turbidity(NTU)	42.7	6.5	6.7	6.5	84.62
Fluoride(mg/l)	0.92	0.9	0.86	0.91	3.26
PH	6.8	6.9	7.1	6.9	2.45
Standard Plate Count (CFU/ml)	detected	Non-detected	Non-detected	Non-detected	
Total hardness(mg/lCaCo3)	92mg/l	77	75	78	16.6

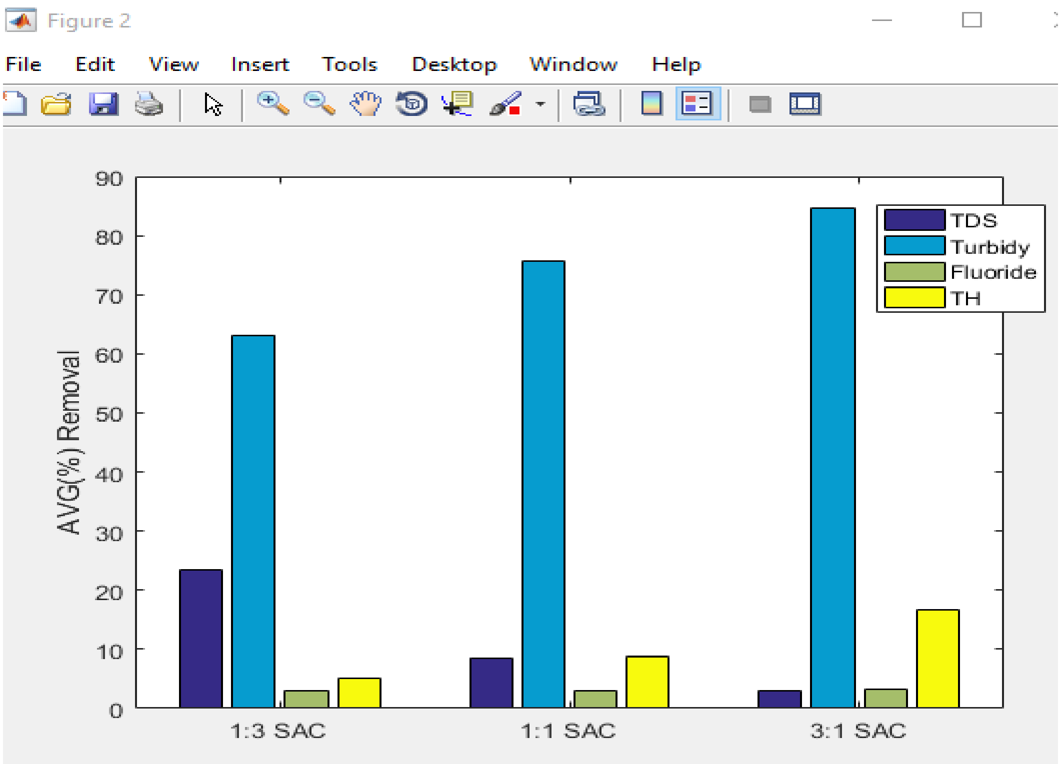


Figure 4.2. Bed height ratio result

In this study, the bed height ratio indicated the amount of sandand amount of activated carbon present in the filtration unit. Therefore, the efficiency and other investigation also related to this amount and properties of sand filter and activated carbon filter. From the above bar chart, it is clear that bed height having 75% sand at the top and 25% activated at the bottom gives the maximum impurity removal of around 84.2% with 34.6L/hr flow rate. Because as the amount of sand in the bed increases it result to high turbidity removal and decrease water flow rate because of strong sand layer.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

During continuous drinking water treatment with dual filtering bed, the treatment process is highly dependent on the order of filtering media. Because not only the quality of treated water by the flow rate of treated water also varied by the order of filtering bed. In this study to achieve the maximum treatment efficiency with acceptable flow rate of the device, different bed arrangement was analyzed. At the end of experimental result, a maximum performance of the device was achieved by using a bed order of sand at the top and activated carbon at the bottom.

Not only the order of sand and activated carbon in the filtration unit affect the treatment efficiency of the device but the amount of sands and activated carbon can also change the performance of continuous drinking water treatment device. As investigated in this study a maximum treatment efficiency of 84.7% was obtained by using 75% of sand and 25% of activated carbon inside the filtration unit.

To kill or deactivate harmful pathogenic microorganisms still in many water treatment industry different hypochlorite solutions is applicable but its leads to high environmental pollution and health effect. This point out, it is relatively safer to use organic disinfectants like moringa by investigating its maximum dosage for the specified un-treated water. In this study the dosage of defatted moringa seed extract was analyzed by taking un-treated water sample from Lake Tana and. From total plat count experimental result, to remove harmful micro-organisms of the raw water sample from Lake Tana an optimum dosage of 175mg/L moringa seed extract was used.

Standing from the experimental result even if ceramic water filter results to high turbidity removal than other trial arrangements, because of its low flow rate it is not recommended to use as one filter bed like activated carbon or sand in continuous treatment process.

5.2. Recommendations

During disinfection processes using defatted moringa seed extract, the system consumeslarge amount of disinfection solution because of low residence time in the disinfection tank. Therefore, it needs further analysis to minimize the dosage of moringa with a continuous process.

During the preparation of activated carbon from rice husk, the product quality is highly dependent on the particle size, carbonization temperature and carbonization time. In thisthesis,only rice husk with a particle size of 2mm, and carbonization temperature of 500^0c for 5 hours were selected. But to increase the treatment performance of the device, it needs further analysis on particle size and carbonization process during activated carbon preparation.

In this thesis, experimental results were done with three replication Using T-test and One-way ANOVA by changing one parameter at one time and keep the other remain constant but to increase the confidence interval and to know the interaction effect it is better to do experimental design and analysis by changing two factors at one time.

In this study, the analysis of microorganisms was done only by checking the presence and absence of total plat count without magnitude. But it is better to know the magnitude of microbial analysis because it indicates the exact dosage of disinfectant solution.

In this study from the experimental result and statically analysis 84.7% of turbidity removal (from 42.7NTU to 6.5NTU) can be achieved but still it needs some improvement on the treatment device to rich the turbidity labels up to standard (1.5NTU).

REFERENCE

Retrieved from https://www.dosomething.org/us/facts/11-facts-about-water-developing-worl accssed 20/05/2018

Retrieved from http://www.yourarticlelibrary.com/water/5-physical-characteristics-of-water-water-management/28342 accssed 20/05/2018

A. Mohamed, A. H. H., & Mamdouh A. EL-Messiry, R. A. H. (2006). Removal of Trihalomethanes by Dual Filtering Media (GAC-Sand) at El-Manshia Water Purification Plant Manal

Achour, S., & Chabbi, F. (2014). Disinfection of drinking water-Constraints and optimization perspectives in Algeria. *LARHYSS Journal ISSN 1112-3680*(19).

Baptista, A. T. A., Silva, M. O., Gomes, R. G., Bergamasco, R., Vieira, M. F., & Vieira, A. M. S. (2017). Protein fractionation of seeds of Moringa oleifera lam and its application in superficial water treatment. *Separation and Purification Technology, 180*, 114-124.

Barajas, J. R., & Pagsuyoin, S. (2017). *Assessment of Moringa-functionalized carbon based biofilter for disinfection through column experiments.* Paper presented at the Systems and Information Engineering Design Symposium (SIEDS), 2017.

Betancourt, W. Q., & Rose, J. B. (2004). Drinking water treatment processes for removal of Cryptosporidium and Giardia. *Veterinary parasitology, 126*(1-2), 219-234.

Bichi, M., Agunwamba, J., & Muyibi, S. (2012). Optimization of operating conditions for the application of Moringa oleifera (Zogale) seeds extract in water disinfection using response surface methodology. *African Journal of Biotechnology, 11*(92), 15875-15887.

Brown, J., & Sobsey, M. D. (2010). Microbiological effectiveness of locally produced ceramic filters for drinking water treatment in Cambodia. *Journal of water and health, 8*(1), 1-10.

Camacho, F. P., Sousa, V. S., Bergamasco, R., & Teixeira, M. R. (2017). The use of Moringa oleifera as a natural coagulant in surface water treatment. *Chemical Engineering Journal, 313*, 226-237.

CAWST, C. (2009). BioSand Filter Manual–Design, Construction, Installation, Operation and Maintenance. *Alberta: Center for Affordable Water and Sanitation Technology (CAWST)*.

Çeçen, F., & Aktas, Ö. (2011). *Activated carbon for water and wastewater treatment: Integration of adsorption and biological treatment*: John Wiley & Sons.

Chan, L., Chan, M., & Wang, J. (2009). Design of water filter for third world countries. *Department of Mechanical and Industrial Engineering*.

Chen, Y., Zhai, S.-R., Liu, N., Song, Y., An, Q.-D., & Song, X.-W. (2013). Dye removal of activated carbons prepared from NaOH-pretreated rice husks by low-temperature solution-processed carbonization and H3PO4 activation. *Bioresource technology, 144*, 401-409.

Christopher, D. (2012). The Effect of Granular Activated Carbon Pretreatment and Sand Pretreatment on Microfiltration of Greywater.

Dos Santos, S., Adams, E., Neville, G., Wada, Y., de Sherbinin, A., Bernhardt, E. M., & Adamo, S. (2017). Urban growth and water access in sub-Saharan Africa: Progress, challenges, and emerging research directions. *Science of the Total Environment, 607*, 497-508.

Ethiopia's water and sanitation crisis. (2018). Retrieved from https://water.org/our-impact/ethiopia/ accssed 12/03/2018

Iran Baraee, S. M. B., Afshin Takdastan, Amir Hesam Hasani & Amir Hosseyn Javid. (2015). Performance of biofilters in GAC-sand and anthracite-sand dual-media filters in a water treatment plant in Abadan, Iran.

Jerri, H. A., Adolfsen, K. J., McCullough, L. R., Velegol, D., & Velegol, S. B. (2011). Antimicrobial sand via adsorption of cationic Moringa oleifera protein. *Langmuir, 28*(4), 2262-2268.

Jianan Li, Q. Z., Luiza C. Campos. (2018). The application of GAC sandwich slow sand filtration to remove pharmaceutical and personal care products.

Kallman, E. N., Oyanedel-Craver, V. A., & Smith, J. A. (2010). Ceramic filters impregnated with silver nanoparticles for point-of-use water treatment in rural Guatemala. *Journal of Environmental Engineering, 137*(6), 407-415.

Lakeh, R. B., Andrade, D., Miller, K. J., Du, B., Pham, J., Modabernia, M. M., . . . Mena, C. (2017). *A Case Study of Decentralized Off-Grid Water Treatment Using Reverse Osmosis.* Paper presented at the ASME 2017 International Mechanical Engineering Congress and Exposition.

Lina Fuentes-López, C. A.-M., Luz Edith Barba-Ho, Camilo Hernán Cruz-Vélez and Patricia Torres-Lozada. (2018). Application of double filtration with activated carbon for the removal of phenols in drinking water treatment processes.

Luqman, S., Srivastava, S., Kumar, R., Maurya, A. K., & Chanda, D. (2012). Experimental assessment of Moringa oleifera leaf and fruit for its antistress, antioxidant, and scavenging potential using in vitro and in vivo assays. *Evidence-Based Complementary and Alternative Medicine, 2012*.

Lynch, C., & Spafford, H. (2016). Determining fruit fly (Family Tephritidae) host status of moringa tree pods, Moringa oleifera Lam., in Hawai

Miller, T. R., & Watters, T. R. (2010). Pure Home Water Ceramic Filter Manufacturing Manual. In.

Muniandy, L., Adam, F., Mohamed, A. R., & Ng, E.-P. (2014). The synthesis and characterization of high purity mixed microporous/mesoporous activated carbon from rice husk using chemical activation with NaOH and KOH. *Microporous and Mesoporous Materials*, *197*, 316-323.

Parsons, D. S., & Jefferson, B. (2006). *Introduction to potable water treatment processes*: Wiley Online Library.

Suleyman A. Muyibi, M., A. Idris, Saedi Jami, Parveen Jamal, Mohd Ismail Abdul Karim. (2013). Statistical Optimization of Process Conditions for Disinfection of Water Using Defatted Moringa oleifera Seed Extract.

Tongpoothorn, W., Sriuttha, M., Homchan, P., Chanthai, S., & Ruangviriyachai, C. (2011). Preparation of activated carbon derived from Jatropha curcas fruit shell by simple thermo-chemical activation and characterization of their physico-chemical properties. *Chemical Engineering Research and Design, 89*(3), 335-340.

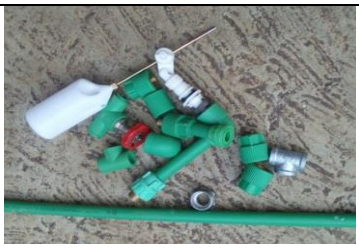
Water, E. N. D. Retrieved from https://www.google.com/search?q=https%3A%2F%2Fwww.cmpethiopia.org%2F...%2FNational%2520drinking%2520water%2520quality%2520monit...&cad=h accsed 16/04/2018

Water, S., & Organization, W. H. (2006). Guidelines for drinking-water quality [electronic resource]: incorporating first addendum. Vol. 1, Recommendations.

Zoschke, K., Börnick, H., & Worch, E. (2014). Vacuum-UV radiation at 185 nm in water treatment–a review. *Water research, 52*, 131-145.

Appendix

Appendix A: - selected sizes of equipment for prototype

Parts or units	Selected material	Height (cm)	Diameter(cm)	Volume(l) $V=\pi D^2/4 * h$	Image
Filtration tank	Carbon steel having 2mm thickness	80	20	25	
Disinfection, backwash solution and disinfection solution tank	HDPE	30	30	21	
pipes and valves	HDPE	800	1.27	-	
Device	Power(HP)	flow rate(L/min)	Head (m)	Model	Image
Pump	0.75	120	30	CPM7501	

Appendix B: -Statistical analysis using independent sample T-test for bed aggangnment.

Group Statistics					
	Filter arrangement	N	Mean	Std. Deviation	Std. Error Mean
Turbidity	SAC	3	32.2767	.19348	.11170
	ACS	3	30.3333	.11547	.06667

The above group statistics show that the first order SAC result in higher turbid removal. Independent sample t-test used for statistically

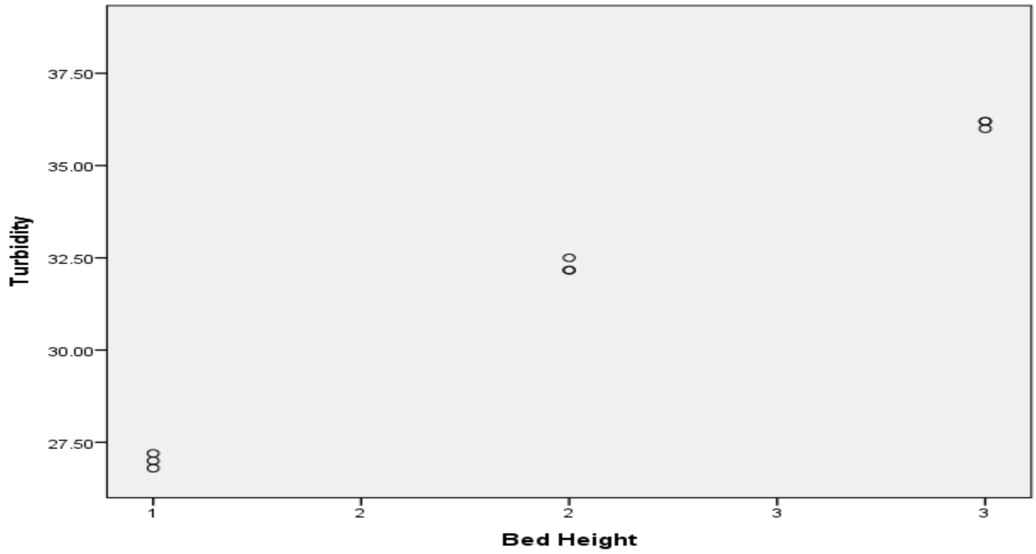
Independent Samples Test

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
turbidity	Equal variances assumed	1.907	.239	14.939	4	.000
	Equal variances not assumed			14.939	3.264	.000

Appendix C:- ANOVA statistical result for bed height ratio

t-test for Equality of Means			
		95% Confidence Interval of the Difference	
Mean Difference	Std. Error Difference	Lower	Upper
1.94333	.13009	1.58216	2.30451
1.94333	.13009	1.54768	2.33899

Here $t_0 = 14.939$ working on 95 % of confidence interval, $t_{0.025,4} = 2.776 t_0 > t_{0.025,4}$ So the two means are different.



Scatter plot of turbidity versus bed height

Bed height 1, 2, and 3 indicate the three levels of the factor. From the graph the third bed height where 75 % of sand filter plus 25 % gives the highest turbidity removal. To be a more objective analysis of variance carried out.

Turbidity					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	126.135	2	63.067	2084.491	.000
Within Groups	.182	6	.030		
Total	126.316	8			

$$F_0 = 2084.491 \; F_{\alpha,a-1,N-a} = F_{0.05,2,6} = 5.14$$

Here F_0 differs greatly $F_{0.05,2,6}$ there is a huge significant difference between the treatment means.

Appendix D: - Post hoc analysis of bed height ratio

Multiple Comparisons						
Dependent Variable: Turbidity LSD						
(I) Bed Height	(J) Bed Height	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
0.25S+0.75 AC	0.5S+0.5AC	-5.27667*	.14202	.000	-5.6242	-4.9292
	0.75S+0.25 AC	-9.13333*	.14202	.000	-9.4808	-8.7858
0.5S+0.5AC	0.25S+0.75 AC	5.27667*	.14202	.000	4.9292	5.6242
	0.75S+0.25 AC	-3.85667*	.14202	.000	-4.2042	-3.5092
0.75S+0.25 AC	0.25S+0.75 AC	9.13333*	.14202	.000	8.7858	9.4808
	0.5S+0.5AC	3.85667*	.14202	.000	3.5092	4.2042
The mean difference is significant at the 0.05 level.						

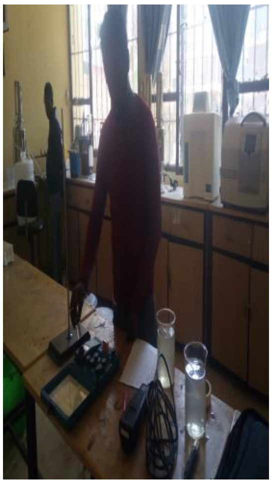
Looking at the mean difference value under this column all are significant but highest difference occurred between 1 and 3 (i.e. 9.1333), followed by 1 and 2(i.e. 5.27667), and 2 and 3 (i.e. 3.85667). This comparison indicates 75 % of the sandfilter with 25 % activated carbon gives the highest turbidity removal.

Appendix E: - determination of raw water and treated water in the laboratory

Water samples

Laboratory equipment's

Checking the result



Write the result in table form

Photometer for TH and fluoride

Cheek the fluoride and TH

Appendix F: - laboratory analysis of microorganisms

Water sample

Autoclave at 121°c

Nutrient agar with sample water

Serial dilution

Colony counting