THE EFFECTIVENESS OF MORINGA OLEIFERA COAGULANT IN THE TREATMENT OF DRINKING WATER

BY

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DECLARATION

I hereby declare that this submission is my own work towards the award of bachelor degree in industrial chemistry of Kampala International University (KIU) that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

STUDENT	XXX	29th SEPTEMBER-2017
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APPROVAL

I confirm that work in this study was done by Makoona Zubairi under my supervision and therefore approved for submission.

SUPERVISOR .... 29th September 2017

MR. KULABA GOERGE . Signature Date

DEDICATION

This project report is dedicated to all members of Sowede's family, Magumba's family and Kata's family more my sister Nabagereka Hadijja, beloved mum Nakasango Jalia,valued dad Kata Goloba Muhammadand my honored Uncle Kato Hussein.

To my supervisor Mr. Kulaba George, my Friends like Hiirya Oscar Nelson, Mahi Bashir and Gift swal.

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ABSTRACT

This research study aimed at assessing the effectiveness of Moringa oleifera coagulant in the treatment of safer, cleaner, adequate and cheaper drinking water for all Ugandans. Water samples from Lake Victoria and hand dug wells both found in Ggaba were treated using Moringa oleifera and Alum coagulant in different sets according to ISO 93081-1 and Association of Official Analytical Chemist (AOAC) jar test procedures. Then pH, turbidity, conductivity and total coliform levels of water samples before and after treatment with 50mg/L, 75mg/L and 100mg/L of Moringa coagulant in the first set were measured and compared with that-treated using 50mg/L, 75mg/L and 100mg/L of alum coagulants in the second set. Control experiments (water without both coagulants) were included in the first set and their water parameters were also determined. Efficient turbidity reduction was observed at 75mg/L concentrations of Moringa for lake and well water from an initial value of 126.12NTU to 3.65NTU and 98.84NTU to 3.45NTU respectively. Alum concentration of 100mg/L reduced turbidity to 1.92NTU for Lake Victoria water and 2.83NTU for well water samples. Conductivity gradually increased for both coagulants with increasing concentrations but ranged within the WHO standards for the drinking water. Moringa concentrations did not influence pH of water. The pH values were observed to range between 7.61 to 7.06 for lake water and 6.88 to 6.58 for well water, however, alum concentrations reduced pH drastically. Bacterial removal of 76.47% and 86.67% was observed for 75mg/L of Moringa oleifera concentration for lake and well water samples respectively whereas alum coagulant of 75mg/L concentration recorded 52.94% and 66.67% bacterial removal for lake and well water samples Findings from this study indicate that Moringa oleifera coagulant at optimum dosage of 75mg/L can be a potentially viable substitute to alum as a coagulant in the treatment of the drinking water.

LIST OF ACRONYM

MO	-	Moringa Oleifera
DWD	-	Directorate of Water Development
NWSC	-	National Water and Sewerage Cooperation
NTU	-	Nephelometric Turbidity Unit
WHO	-	World Health Organisation
MOC	-	Moringa Oleifera coagulant.
UNGMA	-	United Nation Generally Meeting Assembly.
AWWA	-	American Water Works Authority.
ISO	-	International Standard Organisation.
GDWQ	-	Guidelines for drinking water.
AOAC	-	Association of Official Analytical Chemist.
UNBS	-	Uganda National Bureau of Standards.
UNICEF	-	United Nations International Children's Emergency Fund.

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CHAPTER ONE

1.0. INTRODUCTION

In addition to food, shelter, medical care and clothing, water is one of the major basics of human needs on the planet earth. However, water can be problematic if it is not available in right and safe conditions therefore levels of the water quality being consumed is very critical since it has a direct effect on the health.

Today, the quality of water becomes a major problem that needs serious attention. Good quality water has become an expensive item due to the drastic water pollution from various human activities. In provision of clean and safe potable water, besides the quantity and continuity, quality meet standards for drinking water where the ideal water should have some characteristics such as clear, colorless, tasteless, odorless, pathogen-free, chemical-free and non-corrosive in order to prevent the occurrence and spread of waterborne diseases. To achieve those standards, there is one common technique applied in water treatment process called coagulation-flocculation. Coagulation is the process of coagulating colloidal particles by adding synthetic chemicals (coagulants) to destabilize/neutralize stabilized charged particles thus forming a precipitate due to the force of gravity. Coagulants can be either synthetic materials such as ferrous sulfate (Fe ($S0_4$)), aluminum sulfate [Alum]-$Al_2(S0_4)_3$ and Poly aluminum chloride-$(Al_2(OH)_3Cl_3)_{10}$ or natural coagulants like MO coagulants, Beans, Okra and amongst others. Flocculation is the slow mixing technique which promotes agglomeration and helps the particles to settle down with the aid of flocculants. Both coagulation and flocculation improves on the water quality by minimizing turbidity, microbes, colour, odor, heavy metal ion, organic and inorganic matters.

1.1. BACKGROUND

Uganda has been independent since 1962 up to date its Government structure is still changing. However, it is so sad that about 8 millions of Ugandans have no access to basic and safe drinking water causing 75% of diseases in Uganda where over 4000 children less than five years dies every year from preventable diarrheal diseases. In Africa as whole, 2000 children dies of diarrhoea every day caused by drinking dirty water. Diseases caused by drinking dirty water and poor sanitation kill more children every year than AIDS, malaria and measles combined (WHO/ UNICEF 2000).Generally in the world about one billion people lack safe drinking water and more than six million people (of which 2 million are children) die from diarrhoea every year (Post note, 2002). Yet access to both safe drinking water and sanitation is a human right as recognized in 2010 by the UNGMA.

In the developing countries like Uganda water treatment has been done by NSWC using Alum coagulant and chlorine as a disinfectant imported from abroad Uganda. However, both chemicals are not only expensive but also they can impart hazard on both human health and environment (Crapper et al., 1973; Christopher et al., 1995; Kaggwa et al., 2001 and Post note et al., 2002). This has been dictating many Ugandans in both rural and urban communities to undesirably resort to the highly polluted and contaminated water sources such as rivers, lakes, springs, wells and small streams. In 2003 around 54% of the population in Uganda consumed untreated drinking water and number were even higher in the rural areas, up to 84% (Uganda Bureau of statistics, 2009).

Moringa seeds powder coagulant has been used in many parts of Asia and Africa in treatment of the drinking waters. Many comparatives studies show that MO seeds powder can replace Alum coagulant in water treatment. (Abaliwano JK et al 2008 ,Ndabigengesere et al.,1995 ,Eliert et al, 2003 Ghebremichael et al.,2005 and Jahn et al.,2008)

1.2. PROBLEM STATEMENT

NWSC seems to encounter challenges in the treatment and production of adequate, safe and clean drinking water to sustain all Ugandans. This is due to many problems such as increased water pollution which require expensive treating chemicals and increased population which increase in the water demand resulting into not only an increase in water prices but also water production is limited. Consequently, many Ugandans are forced to drink unsafe water from contaminated sources. Therefore this study proposes to assess the effectiveness of moringa oleifera coagulant in the treatment of adequate, safer, cleaner and cheaper drinking water for potable use at all levels.

1.3. MAIN PURPOSE OF THE PROJECT

The main objective of this study is to access and evaluate the effectiveness of Moringa oleifera in the treatment of drinking water from both ground (Well) and surface (Lake Victoria) water sources hence improving on its quality in terms of turbidity, pH, conductivity and total coliform levels.

1.4. RESEARCH OBJECTIVES

1. To establish the effectiveness of Moringa seed powder in the treatment of ground and surface water for potable use.

2. To establish the optimum dosage of Moringa oleifera coagulant required for best result in terms of water quality and safety.
3. To evaluate the comparative advantage of Moringa oleifera versus Alum coagulant in the treatment of drinking water.

1.5. RESERCH QUESTIONS/HYPOTHESIS

1. Is Moringa oleifera coagulant effective in production of potable water?
2. What is the optimal dosage of Moringa oleifera coagulant required?
3. Is use of Moringa oleifera coagulant more advantageous than Alum in production of potable water from ground and surface sources?
4. Use of Moringa oleifera coagulant is cheaper and safer than use of Alum in the treatment of drinking water.

1.6. SCOPE OF THE STUDY

This project dealt wholly on treatment of drinking water at household level. Treatment was done on water samples from ground and surface source using Moringa oleifera in comparison with alumcoagulant. The parameter of water quality tested includes; PH, conductivity, turbidity and total coliform in conformity with the Uganda standard (US201:2008) specification for potablewater with reference to (WHO standards-2006).

1.7. SIGNIFICANCE OF THE STUDY

The importance of the study is that use of Moringa seeds powder will enable getting clean safe water for drinking more easily at lower costs than the conventional methods.

Furthermore, it will elevate the household income to the farmers involved in the cultivation ofMoringa oleifera.

CHAPTER TWO
LITERATURE REVIEW

2.1. INTRODUCTION

Water is a precious natural resource vital for sustaining life. It is in a continuous circulation movement (i.e., hydrological cycle), and is not uniformly distributed in time and space. Due to its multiple benefits and the problems created by its excesses, shortages and quality deterioration, water, as finite resource requires special attention (Pinderhughes et al., 2004).

A combination of several processes is usually needed to improve the quality of raw water depending on the type of water quality problems present, the desired quality of the treated water, the costs of different treatments and the size of the water system (Kalibbala et al., 2007).

2.2. MAIN SOURCES OF POTABLE WATER IN UGANDA AND HOW THEY ARE POLLUTED.

Main sources of raw potable waters in Uganda are generally categorized into two groups viz;

1. Ground water sources.
2. Surface water sources.

2.2.1. GROUND WATER SOURCES

Ground water sources are sources with water held in the soil and previous rocks. Ground water is the major source of water supply in the rural, semi-arid and arid areas in Uganda. Ground water development via DWD has been going on since 1930s via construction of protected springs, shallow well, deep boreholes and ponds to increase on the quality and quantity of safe potable waters but is still being contaminated by pollutants likes sewerage and amongst others.

DEEP BOREHOLES

Boreholes are narrow holes drilled with motorized rigs or by hands using an augur (jetting) into the ground that tap the ground water. Boreholes have been usually providing good quality to many Ugandans. However, its waters sometimes contain harmful chemicals like fluoride and arsenic, or nuisance chemical such as iron.

In additional to heavy metals, boreholes are also being contaminated by the deep local latrines.

PROTECTED SPRINGS

A spring is where underground water flows to the surface. They are two main types of springs in Uganda viz; contact and fracture springs. Fracture is very susceptible to contaminations and drying up while contact springs are more reliable. There is wide spread concern about the quality of the protected springs in Uganda. The recent studies suggest a in between the incidence of cholera during the epidemic in 1997-1998 and use of contaminated protected springs. Furthermore Nasinyama et al, .2013 reported a correlation between the uses of non-piped water and acute diarrhoea.

SHALLOW DUG WELLS

Shallow wells are very reliable source of the water supply to Ugandans. However, well water is highly contaminated by hazardous wastes like excreta, urine amongst others. According to engineer Soffi Byamukama the director of DWD in the ministry of water and environment, on 13th-June-2003 water sample from nine shallow wells in Kampala were tested and out of those, only 2 had water with acceptable coliform levels which means that most water that people use is contaminated.

2.2.2. SURFACE WATER SOURCES

Surface water sources are sources of water obtained from the top of the earth's crust. They include; rivers, lakes and streams. The department of water resources in Uganda generally catergorised the surface water into eight main drainage sub-basins viz; Lake Victoria, Lake Kyoga, Lake Edward, river Nile, river Aswa, Albert-Nile and kidepo valley. Surface water mostly from Lake Victoria and river Nile has been traditionally used as the main source of the drinking water. However their quality is degrading because of the increasing pollutants and non-point sources from human activities like industrialization, agriculture, and mining and amongst others.

2.2.3. RAIN WATER

In addition to surface and ground waters sources, Ugandan also utilizes rain waters for drinking. Rain waters are accessed via the process of rain water harvesting where during raining water is collected using house tops/roofs and kept in the tanks. Although rain water can be a good source of water for and domestic use, it may be seasonal.

On addition the seasonal factor, rain waters may be contaminated by not only the dust or microbes on the roofs but also the corroded heavy metals from the roofs and the tanks.

2.3. EFFECT OF WATER POLLUTION (WATER BORNE DISEASES)

Microbial indicators of waterborne pathogens in water

A suitable indicator should fulfill the following criteria:

1. Safe water does not have to contain the indicator but contaminated water should always carry these organisms.
2. The indicator should neither be pathogenic nor multiply in the environment.
3. The number of indicators should exceed the number of pathogens.
4. The identification, enumeration and isolation of the indicators should be easy.
5. The indicators and pathogens should share the same characteristic relative to their common environment and water treatment processes.

Microbial indicators is mainly total coliform group.

The Coliform Group

The Coliform group is composed of 2 subgroups of microorganisms that are used to identify pathogens more or less related to faecal pollution. The first subgroup, the Total Coliform, includes bacteria that multiply at 37°C. The second subgroup, the thermo tolerant, is composed of bacteria that are able to grow at 44.2°C, among them, Escherichia coli, which is the typical indicator of faecal contamination. In case of water contamination by any Coliform, whether thermo tolerant or not, subsequent water treatment is required to discover the source of the pollution (Dufuor et al., 2003).

In the laboratory TC are grown in or on the medium containing lactose, temperatures of 35-37^{0}c and they are provisionally identified by the production of acid and gas from the fermentation of lactose. They are detected in the water commonly by using of fermentation tube (Most Probable number MPN) and membrane filter technique.

Waterborne diseases

Waterborne diseases occur in potable water because of the impurities found in water sources. The numerous illnesses caused by waterborne pathogens indicate that the transmission of microbes in water remains a significant cause of outbreaks. Even in developed countries where the regulations are restricted in terms of water pathogen concentration, drinking water might still carry pathogenic microorganisms after treatment.

These pathogens cause occasional illness within the community supplied with this drinking water (e.g., diarrhoea). Diseases associated with water are typically placed in four classes: waterborne, water-washed, water-based, and water-related insect vectors (Gleick et al., 2002). Waterborne diseases are caused by the ingestion of water contaminated by human or animal faeces or urine containing pathogenic bacteria or viruses. These include cholera, typhoid and bacillary dysentery and other diarrhoeal diseases. Water-washed diseases are caused by poor personal hygiene and skin or eye contact with contaminated water. These include scabies, trachoma and flea, lice and tick-borne diseases (Gleick, 2002).

Four classes of microbial organisms contribute to the spread of diseases with drinking water. These pathogens can infect humans via ingestion, inhalation or contact with skin, wounds, eyes, or mucous membrane. These are bacteria, viruses, protozoa, and helminths (WHO, 2004).

2.4.DRINKING WATER GUIDELINES IN UGANDA

In Uganda, DWD and UNBS is expected to monitor the quality of drinking water provided by NWSC. However in practice, NWSC monitors its drinking water per Uganda standard (US201:2008) specification for potable drinking water in reference to GDWQ (WHO-2006).

2.4.2. WHO GDWQ

The W.H.O GDWQ was published in 1993 and in 1996 a second edition of guideline for drinking water quality intended for use by countries. In order to define standards, it is necessary to consider this recommendation like environmental, social economic and cultural conditions.

Table 1.WHO GDWQ for minimum levels of various parameters.

PARAMETERS	UNITS	WHO guidelines
pH	pH scale	6.0-8.0
Odour and test	-	Not
Turbidity	NTU /JTU/FTU	<5
Dissolved oxygen	Mg/l	>4
Total hardness	$mgCaCO_3/l$	<500
Total alkalinity	$mgCaCO_3/l$	<500
Fluoride	Mg/l	<1.5
TSS	Mg/l	<1500
Chloride	Mg/l	<250
Sodium	Mg/l	<200
Sulphate	Mg/l	<400
Iron	Mg/l	<0.3
Manganese	Mg/l	<0.1
Nitrate	MgN/l	<10
Lead	Mg/l	<0.05
Mercury	Mg/l	<0.01
Cyanide	Mg/l	<0.01
Total coliforms	No/100ml	<10
Faecal coliforms	No/100ml	NIL

2.5. CONVETIONAL DRINKING WATER TREATMENT

Water treatment usually comprises water clarification and disinfection processes (Suarez et al., 2003).In conventional drinking water treatment a series of processes including but not limited to; coagulation, flocculation, sedimentation, filtration and disinfection are often used (AWWA et al., 1990).However Coagulation and flocculation are the most critical unit process (other than disinfection) determining success or failure of the whole system and their bottlenecks for up grading treatment plants.

Figure 1.A flowchart showing conventional treatment ofdrinking water with moringa coagulant.

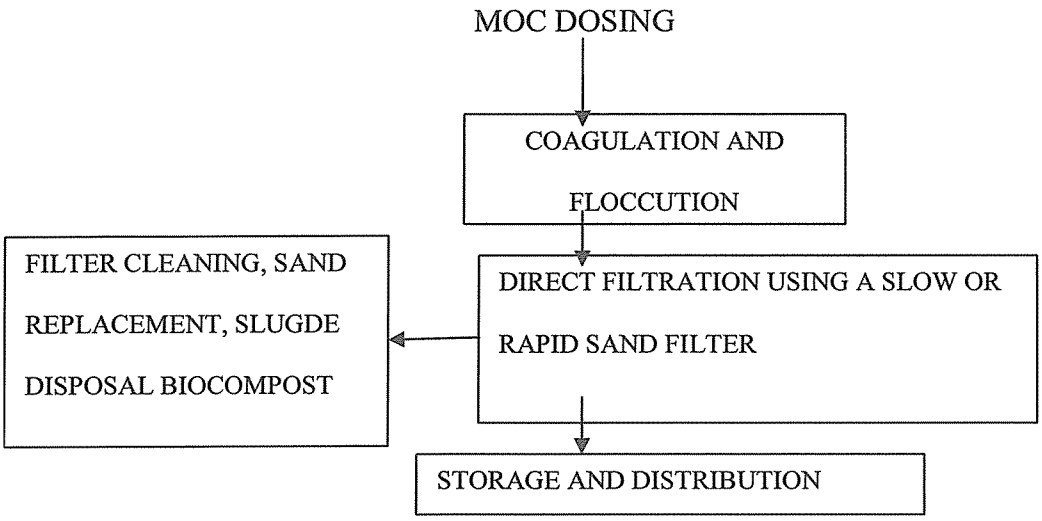
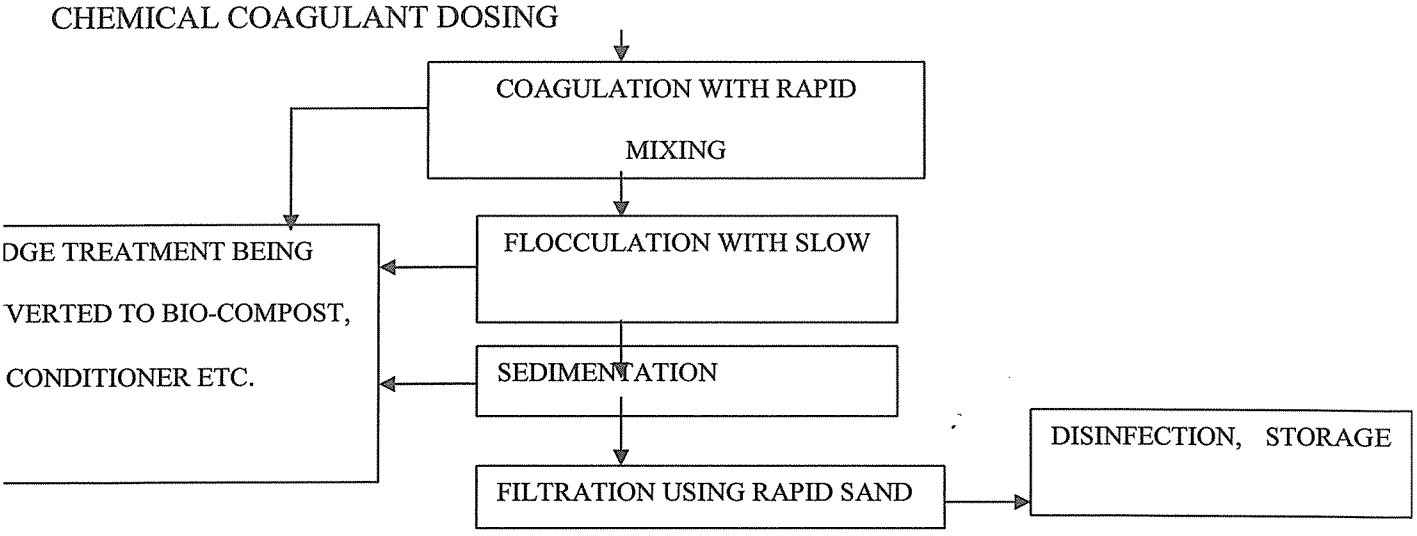


Figure 2.A flowchart diagram showing conventional water treatment with chemical coagulants.



2.5.1. COAGULATION

Coagulation is defined as the process of forming semisolid lumps in a liquid. Coagulation describes the consolidation of smaller metal precipitate particles into larger metal precipitate particles (flocs). Coagulants reduce the net electrical repulsive force at the surface of the metal precipitate particles.

The purpose of adding coagulants to acidic drainage waters is to increase the number of flocs present in the treatment water. As flocs density increasesparticle contact increases due to Brownian motion, promoting agglomeration of colloidal particles into larger flocs for enhanced settling (Qasim et al., 2000).

The turbidity of water often results from the presence of colloidal particles that have a net negative surface charge. Thus, electrostatic forces prevent them from agglomerating, making it impossible to remove them by sedimentation without the aid of coagulants (Diaz et al., 1999).

The high cationic charge of these two metal salts makes them effective for destabilising colloids. They act by neutralising the negative charges of the stable colloidal particles. Coagulants enhance particle collision and agglomeration of neutral particles to form dense flocs that can settle easily. Destabilisation of colloidal particles in water is accomplished via adsorption and charges neutralisation, adsorption and inter-particle bridging, enmeshment in a precipitate and double layer compression (Amirtharajah and O'Melia et al., 1990; Gregory and Duan et al., 2001).

ALUM COAGULANT.

(Al_2 $(SO4)_3.14H_2O$) is a basic product of the reaction between sulphuric acid and a mineral despite such as bauxite. It is available commercially in industrialized countries in lumps, ground or liquid form. Lump or ground alum whether purified or not contain not less than 9.0 % of available water-soluble aluminium as Al or 17 % as Al_2O_3 (AWWA et al., 1990).

Liquid alum is about 49 % solution, or approximately 8.3 % by weight aluminium as $A1_2O_3$.

Treatment plants designed to use alum may be minimised where its dosage may be reduced in some instances by

1. Direct filtration of low turbidity waters
2. Pre-treating excessively turbid river waters.
3. Use of coagulant aids.
4. Optimum pH adjustment.

Alum coagulation works best for a pH range of 5.5 to 8.0; however, actual removal efficiency depends on competing ions and chelating agent concentrations .Chemical coagulation with alum is aimed at removing turbidity, inorganic or organic, harmful pathogens, colour, taste and odour producing substances.

MORINGA COAGULANTS.

ORIGIN, TYPES AND HISTORY OF MORINGA

This tree species originally came from India and was introduced to both Kenya and Uganda at the turn of the 20th century by Indian coolies who came to Africa to build the Mombasa-Kampala railway line (Mundia et al, 2003).

It includes 13 number of Moringa species viz; Moringa oleifera, Magnifera indica and Prunus armeniaca Jatropha curcas, Hibiscus sabdarifa, Pleurotustuberregium Azardiratica indica, Solanum melongena, Cynodon dactylon, Alternantherasessilis, Anisochilus carnosuss, Musa paradisiaca. Moringa oleifera lam Moringa oleifera Lam is the most widely cultivated species of the monogeneric family Moringaceae (order Brassicales) is distributed in the sub-Himalayan tracts of India, Sri Lanka, North Eastern and South Western Africa, Madagascar and Arabia. Today it has become naturalized in many locations in the tropics and is widely cultivated in Africa, Sri Lanka, Thailand, Burma, Singapore, West Indies, Sri Lanka, India, Mexico, Malabar, Malaysia and the Philippines (Fahey, 2005).

This rapidly-growing moringa tree is also known as the horseradish tree, drumstick tree, benzolive tree, kelor, marango, mlonge, moonga, mulangay, nébéday, saijhan, sajna or Ben oil tree. Moringa oleifera seeds are round (1 cm in diameter) with a brownish semi-permeable seed hull, with 3 papery wings. The hulls of the seed are brownish to blackish but can be white if kernels are of low viability. The whitish wings of hull run from top to bottom at 120 intervals. Each tree can produce around 15000 to 25000 seeds/year. Average weight is 0.3 mg/seed. The kernel to hull ratio is 75:257. The most important part used for water treatment is the waste product of the seed

PHYTOCHEMICAL CONSTITUENTS IN MORINGA OLEIFERA SEED

A careful examination of the phytochemical constituents present in the seed reveals vast abundant compounds rich in glucosinolates and isothiocyanates. Common phytochemicals found in the seed irrespective of the solvent used in the extraction includes alkaloids, resins, tannins, flavonoids, glycosides, saponin, steroidal rings and terpenoids.

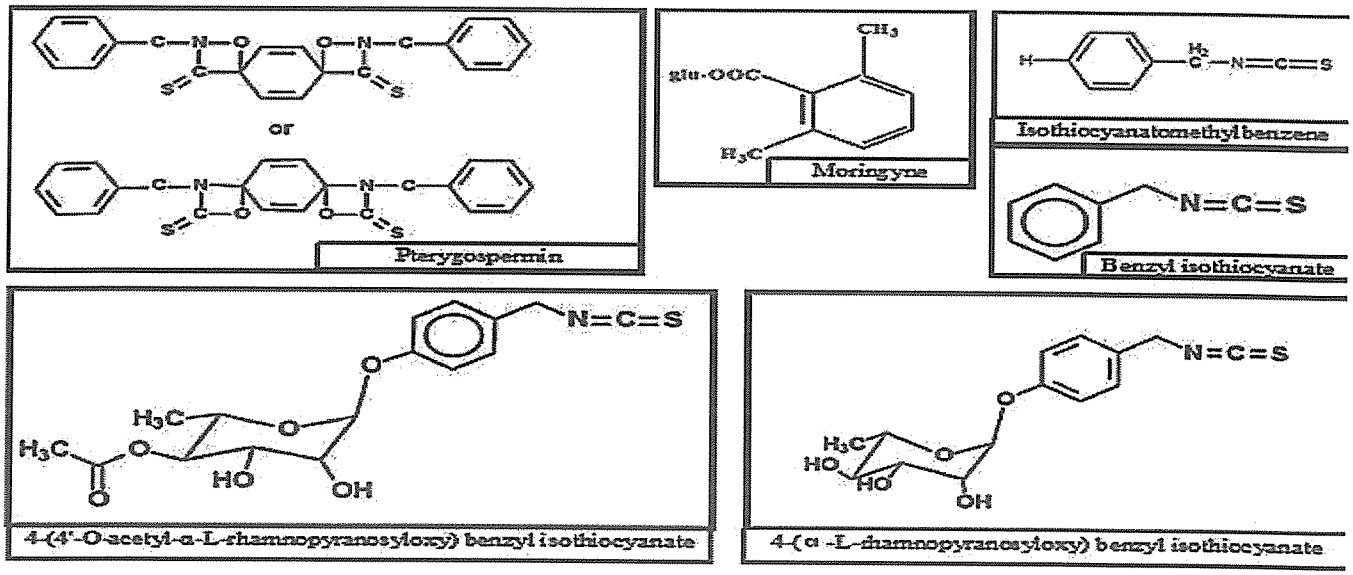
An enormous literature has shown that the seeds have been extracted with various solvents, which has led to the presence of different phytochemicals and commonly used solvents are water, ethanol, methanol, etc. The extracts obtained by using water solvent has shown to possess antibacterial activity but plant extracts from organic solvent have been found to possess more antimicrobial activity than water extract. Thus the use of other organic solvent such as ethanol, acetone, and methanol increases more phytochemicals to be released because they

are more effective against cell walls, penetrate cellular membraneto extract the intracellular ingredient, and degrade seeds.

CHEMICAL CONSTITUENTS OF SEED

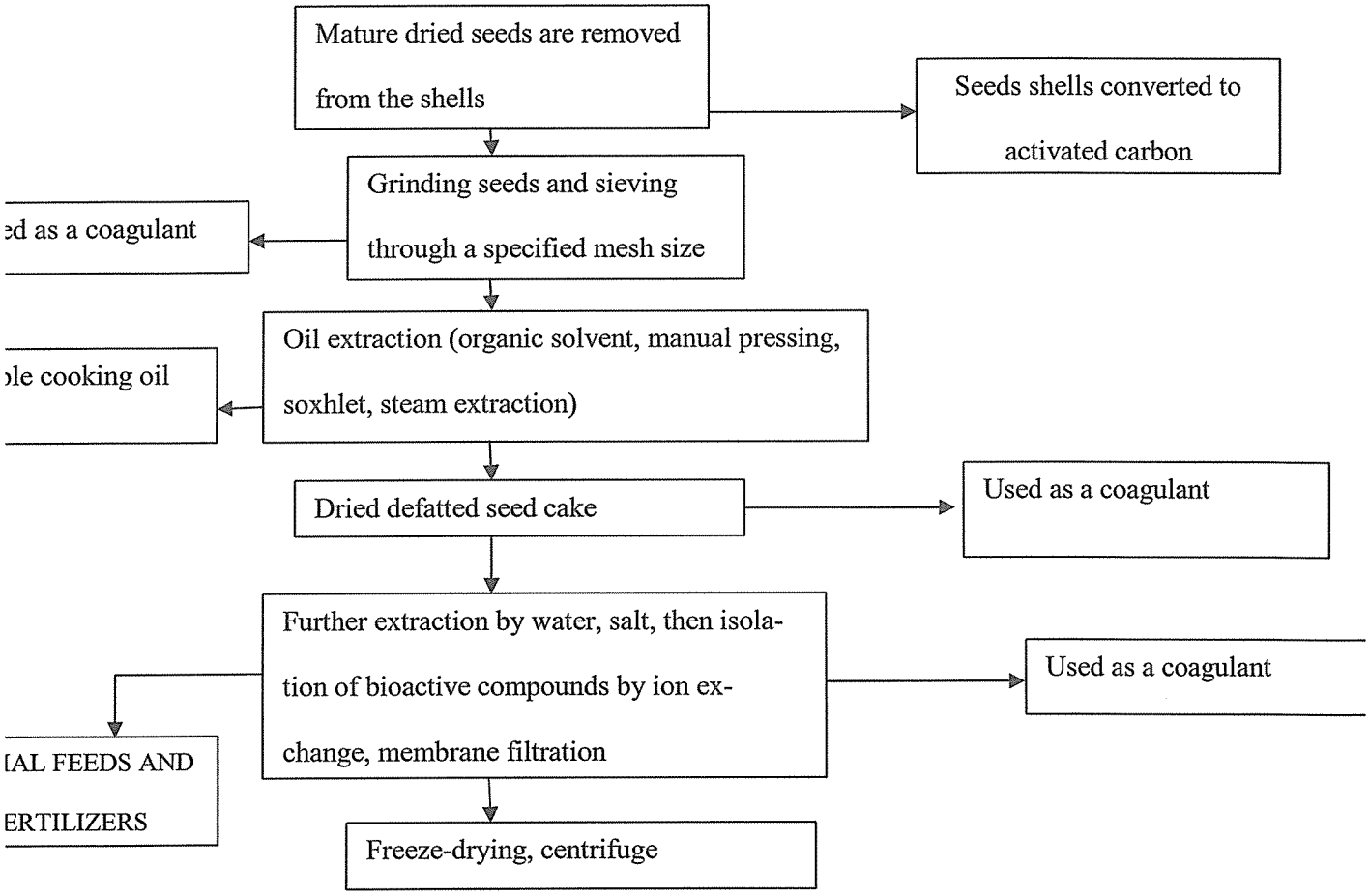
The seeds contains 4(alpha-L-Rhamnosyloxy) benzyl isothiocyanates, 4(-L-rhamnosyloxy) phenylacetonitrile, 4-hydroxyphenylacetonitrile, and 4-hydroxyphenyl-acetamide, 4-(alpha-l-rhamnopyranosyloxy)-benzylglucosinolate Roridin E, Veridiflorol, 9-Octadecenoic acid, O-ethyl-4 -(alpha-L- rhamnosyloxy) benzyl carbamate, niazimicin, niazirin, beta- sitosterol, glycerol-1-(9-octadecanoate), 3-O-(6'-O oleoyl- beta-D-glucopyranosyl)-beta-sitosterol and beta-sitosterol-3- O-beta-D-glucopyranoside . Out of these chemical constituent, An active antimicrobial agent ascribed to plant synthesized derivatives of benzyl isothiocyanates known as 4(α-L- rhamnosyloxy) benzyl isothiocyanates was identified from earlier researches and about 8-10% of this compound is present in both defatted (after removing oil) seed and crude seed. This antimicrobial active agent has been reported to exert in vitro bactericidal activity against both gram positive and gram-negative bacteria in raw water.

Figure 3.Showing major phytochemical constituents of moringa oleifera seeds.



PREPARATION OF MORINGA.

Figure 4. A flow chart diagram showing Moringa oleifera seed coagulant processing techniques



Traditionally, in Northern Sudan, Moringa oleifera seed extracts are prepared by manually removing the dry seeds from their shells, grinding in mortal and pestle then soaking in water, and finally sieving the solution using a sieve of a particular mesh size or through a Mushin cloth the resulting extract is then used in treating water. This is considered as a low technology of Moringa oleifera seed processing because it is suitable for households and the sludge produced can be used as a bio-compost.

Over the time, the removal of the seed oil either by organic solvent extraction (by using normal hexane), cold pressing, or steam extraction gained popularity after which the defatted (removal of oil) seed cake extract is used in purifying water.

This type of seed processing is considered as medium technology because it is suitable for medium to large communities and there are other by-product such as the oil which can be

processed as edible oil, the seed shells can be processed to become activated carbon, and the sludge produced can be used as bio-fertilizer.

Ali et al., (2010), introduced an innovative method of processing the seed by further treating the defatted seed cake extract with microfiltration to enhance more isolation of bioactive compounds from the extract before using it to treat water. This is regarded as high technology because extracts obtained from the defatted seeds can further be purified by using ion exchange, membrane system etc. The solid by-products from these processes can used as animal feeds, the resulting permeate from membrane system can be freeze dried leading to longer shelf life for the seed. To date, most research focus on the use of the crude extract for treatment of water, while very few research have been done using the defatted seed extract and membrane processed seed extract for water treatment.

COMMON USES OF MORINGA OLEIFERA

Nutritional

Moringa leaves and seed pods are rich sources of calcium, iron, of vitamins A, B, and C and protein with good amount of amino acids, methionine and cystine (Rams et al., 1994).

Moringa leaves are edible and also immature moringa seeds are often cooked and eaten as a fresh vegetable, while mature seeds can be dried and roasted. The flowers can be cooked or oven-dried and steeped as tea. Dried leaves can be stored as future soup or sauce supplements (Davis et al, 2000).

Medicinal uses

Moringa oleifera is used in the treatment of ascites, rheumatism, venomous bites and as cardiac and circulatory stimulants. Fresh root of the young tree (as also the root bark) is used internally as stimulant, diuretic and anti-lithic and externally applied as a plaster or poultice to inflammatory swellings (Donkor et al., 1996).

Seed oil

Moringa seeds contain about 35% oil. This oil is often extracted for cooking and in rare cases, even lubrication purposes. It can be used in salads, soap making, and burns without smoke (Von Maydell et al., 1986).

Water purification

Attracting attention in recent decades is the use of the dried, crushed seeds as a coagulant (Jahn, 1984). Even very muddy water can be cleared when crushed seeds are added. Solid matter and some bacteria will coagulate and then sink to the bottom of a container. The cleaned water can then be poured off and boiled (Gupta and Chaudhuri et al., 1992).

Advantages of Moringa Oleifera coagulant:

1. Cheap and easy method for developing countries (especially at household level).
2. The processing doesn't modify the pH of the water.
3. It doesn't alter the water taste (unless a very high dose is added).

Disadvantages of Moringa Oleifera coagulant:

1. The treatment water with Moringa oleifera coagulant does not completely removal microbes which promotes secondary bacterial growth after the water coagulation.

DOSAGE OF MO SEEDS EXTRACT REQUIRED TO TREAT DRINKING WATER

As for all coagulants, amount of seeds required will vary depending on the quality of raw water. Dosages are given as equivalent to the weight of MO seed extract or number of seeds required to make up the dosing solution.

Table 2 .Showing MOC dosage required for raw water turbidity removal.

Levels of raw water turbidity/NTU	Seeds per litres of water	Seeds in grams per litre of water
<50	1 seed per 4 litres of H_20	10-50
50-150	1 seed per 2 liters of H_2O	30-100
150-250	1 seed per 1 litre of H_2O	50-200
>250	2 seeds per 1 litre of H_20	>200

2.5.2. FLOCCULATION

Flocculation is referred to as a process of forming woolly cloudlike aggregations. Flocculation involves the combination of small particles by bridging the space between particles with chemicals (Skousen et al., 1996). Essentially, coagulants aid in the formation of metal precipitate flocs, and flocculants enhance the floc by making it heavier and more stable. For this reason, flocculants are sometimes referred to as coagulant aids at water treatment operations (Tillman, et al.1996; Faust and Aly et al., 1999).

Two main groups of flocculants exist: minerals which include activated silica, clays, metal hydroxides and synthetic flocculants which include anionic, cationic, and non-ionic compounds. Activated silica has been used as a flocculant since the 1930's to strengthen flocs and reduce the potential of deterioration (Skousen et al., 1996).

It is usually produced on-site by reacting sodium silicate with an acid to form a gel. When using activated silica, the resultant floc is larger, denser, more chemically stable, and settles faster than iron and aluminium flocs (Tillman, 1996).

Synthetic flocculants consist of polymers which produce negative (anionic), positive (cationic) or both (polyampholytes and nonionic polymers). Polyampholytes are neutral but release both negative and positive ions when dissolved in water. The ions released from synthetic polymers (flocculants) adsorb to destabilized particles to form larger flocs.

According to Tillman (1996) cationic polymers are most often used for charge neutralization and are usually used in conjunction with a metallic coagulant to reduce the dose required and amount of sludge produced. Anionic polymers dissolve in water to provide more reaction sites for positively charged coagulants. A drawback to using synthetic flocculants is that over-dosage may hinder their efficiency.

2.5.3. SEDIMENTATION

Sedimentation is the phenomenon of the sediments or the gravel accumulating. During sedimentation, water is left undistributed to allow the heavy clump of particles and coagulants to settle out.

2.5.4. FILTRATION

Filtration is the process whereby fluids pass through a filter or a filtering medium. During filtration water run through a series of filters which trap and remove particles remaining in the water column. Typically, beds of sand and charcoal are used to accomplish this task during the passage water quality is improved by the removal of the suspended and dissolved solids , removal of suspended and colloidal materials , reduction of microbes and changes in its chemical constituents. The capture of the fine particles in the suspension by filtration via a porous medium occurs in two steps, transportation and attachment.

2.5.5. DISINFECTION

Disinfection is treatment to destroy harmful microorganisms. Disinfection of the clarified water prevents the growth of microorganisms both in the treatment plant and in the distribution system, thus protecting the public from water-borne diseases. Like chemical coagulants, disinfectants (chlorine in particular) combine with natural organic matter (NOM) that may be present in water to form trihalomethanes (THMs), which are carcinogenic and/or mutagenic by–products. These THM cannot be removed by conventional treatment methods and thus

water to be chlorinated should either be free from natural organics, or if NOM is present an alternative disinfectant should be used (Tokmak et al., 2004).

Alternative disinfectants such as chlorine dioxide, chloramines and ozone are also associated with the formation of disinfection by- products (DBPs) that are toxic compounds and impart objectionable taste and odour (Sadiq and Rodriguez et al., 2004).

Irradiation with ultraviolet (UV) light is a promising alternative method of disinfection but it is expensive and leaves no residue and hence another disinfectant is required to disable bacteria and viruses. In addition, UV light can react with nitrate in water to produce nitrite, the precursor for methaemoglobinaemia in infants (Mole et al., 1999).

The search for disinfectants that are cheap, maintain acceptable microbiological quality and avoid chemical risks is one of the biggest challenges facing the water treatment industry.(Bove et al., 2002).However, the research of using Moringa oleifera seed as a disinfectant for drinking water conducted by Bichi et al., 1980, revealed that the moringa seed extracts had a great potential usage as disinfectant.

CHAPHER THREE

3.0. EXPERIMENTAL METHODOLODY

Materials, equipments and reagents (chemicals) from their respective sources

Most of equipments, materials and reagents used in this study were obtained from NWSC Ggaba branch. These include; Alum (12000-14500/= per kg on Indian market price), all jar equipments,calibratedpH meter, conductimeter, portable turbidimeter(HACH) and MPN test equipment (Durham tubes , thermometers etc.) and chemicals like lactose broth ,indicators and amongst others.

Moringa seed pods were harvested from one of the garden in Bombo town council- Gogonyavillage (1 kg at 10000-8000/= on world market price).

The water samples were from a well and Lake Victoria catchment both found in Ggaba.

3.1.1. PREPARATION OF THE COAGULANT SOLUTIONS.

MORINGA OLEIFERA COAULANT (MOC)

MOC was prepared in the following steps according to Asrafuzzaman et al., (2011)

1. Naturally dried mature MO pods were harvested from Moringa garden in Gogonya village.
1. The cracks on the MO pods were Plucked to obtain the seed kernels.
2. The surrounding shells on seed kernels were remove dusing a knife.
3. The seed kernels were pounded using a local wooden mortar and pestle to form MO seeds powder.

4. The MO powder was sieved using a small sized mesh to form fine MO powder which was stored for one day under dry conditions.
5. Using sieved MO powder, three different stock solutions of MOC were prepared by mixing 50mg, 75mg and 100g of fine MO seeds powder with 10ml of clean distilled water each separately.
6. The stock solutions were mixed vigorously for about 15 minutes and each solution was filtered separately to3 different filtrates.
7. All filtrates were topped up to 1000ml with clean distilled water.
8. Finally MOC solutions were labeled as M1, M2 and M3 for various concentrations (50mg/L, 75mg/L and 100g/L) respectively and stored for further use.

ALUM COAGULANT

Alum coagulant was prepared in the following steps in accordance to Dalen et al., (2009).

1. 50mg, 75mg and 100g of solid graded Alum were weighed and then grinded into powdered form each separately.
2. Each of them was dissolved into three beakers of 1000ml using 20ml of clean distilled waters.
3. Finally each of them was topped up to 1000mlusing clean distilled water and were labeled as A1, A2 and A3 then stored for further use.

SAMPLING

Water sampling was according to NSWC standard procedures with reference to ISO 5667 Part 5 as shown in the steps below.

1. A plastic jerry cane rinsed three times with well water samples was used to collect 5 litres of water samples from a well in Ggaba village.
2. Other jerry of same size and type was rinsed three times with Lake Water samples and 5 litres of water sample was fetched from Lake Victoria catchment in Ggaba landing site where the process of water sampling was done in the mid-day when the Lake waters were unclear and moderately turbid.
3. Then finally parameters of water samples from both lake and well were pre-determined before treatment.

.2. JET TEST PROCEDURES

Jet test was in conducted in accordance to ISO 93081-1 and Association of official analytical chemists (AOAC) as shown in the steps below.

1. Using Griffin beakers of 1500ml, initially 6 beakers were labeled ranging from L1-L6, other 6 beakers from W1-W6, 1 beaker as LC and another 1 beaker as WC.
2. 1000ml of the Lake water sample was measured into each of beakers labeled from L1- L6 and LR then the same procedure was repeated on well water sample in each of beakers labeled W1 - W6 and WR.
3. In the first set, LC and WC without MOC were used as control experiments, Lake Water samples asL1, L2 andL3 were dosed with100ml (M1), 100ml (M2) and100ml (M3) of MOC respectively and the same procedure of dosing was repeated on the well water samples W1, W2, and W3 respectively.
4. Initially solutions were mixed vigorously at 70rpm for 15 minutes then mixed slowly at 25rpm for 5 minutes finally mixtures were left to settle for 30 minutes which were decanted and subjected to laboratory analysis.
5. In the second set, control experiment LR and WR without Alum coagulant was used, Lake water samples L4, L5 and L6 were dosed with 100ml (A1), 100ml (A2) and 100ml (A3) of Alum coagulant and the same procedure was also repeated using well water samplesW4, W5 and W6 respectively.
6. Solutions were mixed vigorously at 70rpm for 15 minutes then mixed slowly at 25rpm for 5 minutes finally mixtures were left to settle for 30 minutes which were decanted and subjected to laboratory analysis.

3.1.3. LABORATORY ANALYSIS

Water analysis for all physiochemical parameters was conducted in accordance ISO 93081-1 and Association of Official Analytical chemists (AOAC) per Uganda standard (US201:2008) with reference to WHO-2006 as shown below.

PH MEASUREMENT

PH was determined using MM374-HACH pH meter. Where pH meter electrodes rinsed with distilled water was inserted in the samples without it touching on the walls of the beaker, results were read off from LCD display immediately after its stabilization.

CONDUCTIVITY MEASUREMENT

Same samples used to measure pH were used for conductivity measurement with HI9032-HACH Conductimeter calibrated by immersing its electrode in the reference buffer solution

of 520μS/cm. Then conductivity probe (electrode) rinsed with distilled water was inserted into the sample without it touching on the walls of beaker, conductivity in μS/cm was read off from the LCD display on its stabilization.

TURBIDITY MEASUREMENT

Turbidity measurements on water samples was determined using2100Q-HACH turbidimeter calibrated using the 1000NTU, 100NTU, 10NTU and 0.02NTU calibration standards. Where cuvette was rinsed three times with the water samples and fourth portion of each sample was poured into the cuvette. Cuvette was firmly inserted into the optical well to the lowest reading. Then turbidity measurements were recorded in NTU by pressing and releasing the arrow button after the LCD display panel had stopped flashing.

TOTAL COLIFORM MEASUREMENT

Total coliform was determined using method of multiple tube fermentation[most probable number (MPN)] only on the untreated and treated water Samples from beakers labeled L2, L6,LC, WC, W2 and W6 following the Procedures below in accordance to ISO 93081-1 ,AOAC and Wright et al .,2004 .

Media Preparation

Two types of lactose broth viz; single strength lactose broth (SSLB) and Double strength lactose broth (DSLB) were prepared for total coliforms growth. In SSLB, 13.0gof lactose broth powder was dissolved using 1litre of clean distilled water and 5ml of the broth medium was distributed into each of 12test tubes containing inverted fermentation (Durham) tubes. The test tubes containing media were sterilized using autoclave at 121^0c for about 20minutes and allowed them to cool before their usage. DSLB was also prepared by doubling weights of each reagent used in SSLB and the medium was also distributed into another 6test tubes containing inverted tubes. The media was also autoclaved at temperatures of 121^0c for 20 minutes and cooled before storage in the oven for further use. 2.5g Of Tryptone water was then dissolved into 1litre of the distilled water and 5ml of water medium were distributed into the 18 test tubes. The medium was autoclaved at 121^0c for 20minutes and allowed to cool before their usage.

Presumptive Test

Bottles of dilution water samples were prepared by adding25ml of each water sample with 1000ml of distilled clean water. 1ml and 0.1ml from each of diluted samples was inoculated into12 tubes containing SSLB to support growth of the total coliforms. 10ml of all diluted samples was also inoculated into 6 test tubes containing DLSB for total coliform growth.

Inverted Durham tubes were placed in the all test tubes to detect the presence of gas. One setup was incubated at 37°C for 24 hrs and the other incubated at 45°C for 24 hrs for faecal coliform counts. Tubes that showed change in colour and gas formation were considered presumptive positive for coliform bacteria. From the number and distribution of positive and negative reactions, counts of the most probable number (MPN) of indicator organisms in the sample were estimated by reference to MPN statistical tables of Wright et al., (2004)

Confirmatory Test

Confirmation of samples from all presumptive positive tubes was done by establishing growth of target bacteria in the lactose broth medium incubated at 37°C for 48 hrs and morphological characteristics of colonies were noted.

Complete Test

All presumptive positive tubes cultured in both SSLB and DLSB were inoculated into different test tubes containing 5ml tryptone water medium and incubated at 37°C for 48 hours. 0.5ml of Kovac's reagent (p-dimethylaminobenzaldehyde) was added gently along the side of the tube after the 34addition of xylene to accumulate the gas. I detected the presence of indole, acid and gas by formation of a deep red coloration almost immediately at the surface or upper layer indicating a positive result. I finally analyzed the samples and the results were compared to with Wright et al., (2004) to obtain MPN at 95.0% confidence levels.

CHAPTER FOUR

RESULTS AND DISCUSSION

Table 3.showing data (results) for initial parameters of both lake and well raw water samples.

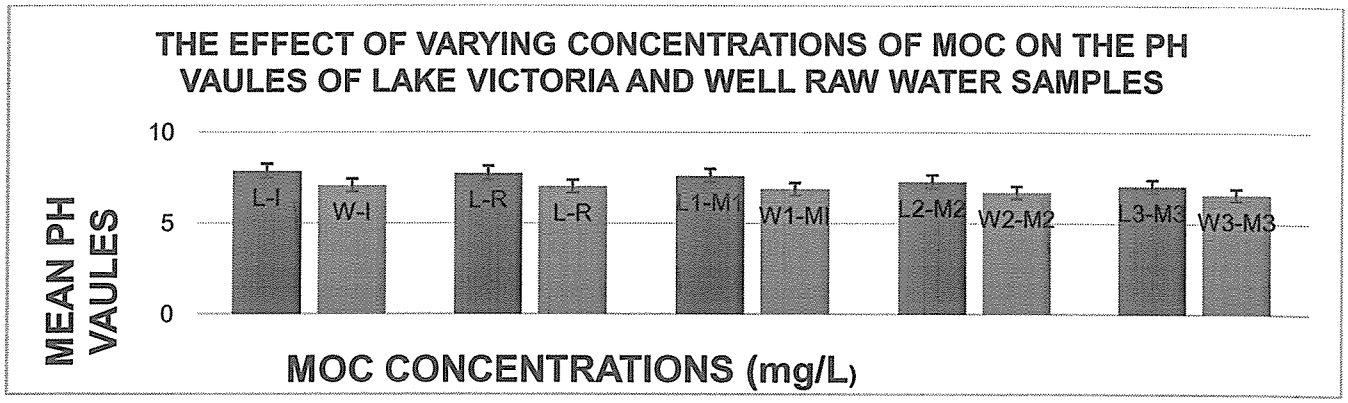
INITIAL PARAMETERS OF RAW WATER	RAW LAKE WATER SAMPLE(L-R)	RAW WELL WATER SAMPLE(W-R)
PH	7.87	7.08
CONDUCTIVITY(μS/cm)	548	352
TURBIDITY(NTU)	126.12	98.84
TOTAL COLIFORM LEVELS (MPN/100ML)	17	15

Table 4. A table of results showing tested physiochemical parameters for lake and well water samples treated with varying concentrations of MOC.

TESTED PHYSOCHEMICAL PARAMETERS	L-C WITHOUT MOC	W-C WITHOUT MOC	LAKE WATER SAMPLES TREATED WITH DIFERENT CONCENTRATIONS OF MOC (mg/L)			SAMPLES TREATED USING DIFFERENT CONCENTRATIONS OF MORINGA SEEDS COAGULANT SOLUTIONS (mg/L)		
			L1-M1	L2-M2	L3-M3	W1-M1	W2-M2	W3-M3
CONDUCTIVITY(μS/cm)	552	367	620	472	612	420	263	412
CONDUCTIVITY REDUCTION	-	-	-	13.87 %	-	-	25.28 %	-
TURBIDITY (NTU)	108.09	89.81	17.19	3.65	9.76	13.39	3.45	7.78
TURBIDITY REDUCTION	7.83%	9.14%	86.37 %	97.11 %	92.26 %	86.45 %	96.51 %	92.13 %
pH	7.75	7.02	7.61	7.29	7.06	6.88	6.70	6.58

All of the calculations and analysis of the data (results) were performed in the Microsoft excel 2013 and all were summarized in this section.

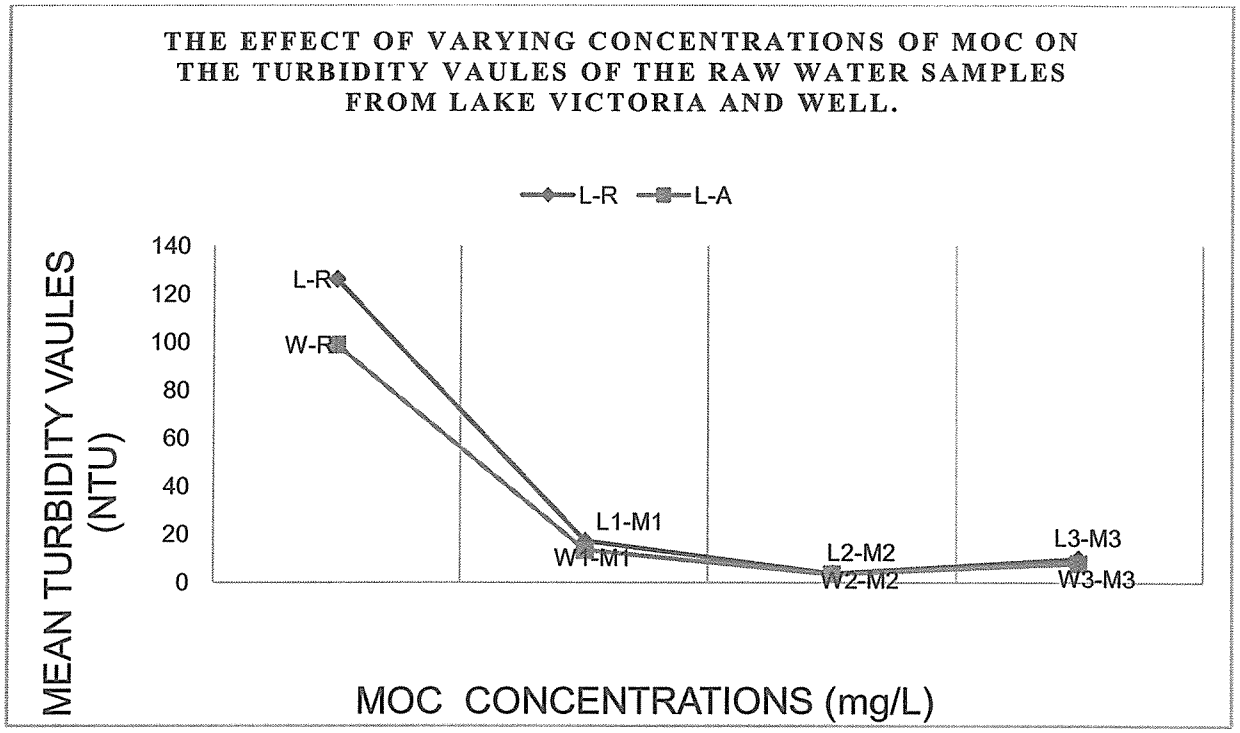
Figure 5. A bar graph showing the effect of varying concentrations of MOC on the pH values of Lake Victoria and well raw water samples.



pH

Initial pH values of raw water samples from Lake and well were 7.87 and 7.08 respectively. After treatment of the water samples with the different concentrations of MOC, a decline in the trend of pH values was observed as they changed from 7.87 to 7.75 to 7.61 to 7.29 and 7.06for water samples L-C, L1-M1, L2-M2and L3-M3 respectively. It also changed from 7.08 to 7.02 to 6.88 to 6.70 and 6.58 for well water samples W-C, W1-M1, W2-M2 and W3-M3 respectively. The pH observed above suggests that at low concentrations of MOC, MOC cationic proteins reacted with alkaline ions leaving free hydrogen ion hence slight decrease in the pH and at high concentrations MOC, basic amino acids are dominated by binding with the acidic ions from water resulting into the release of the hydroxyl group making the solution basic. In general, the pH of all water samples were within the recommended WHO-2006 standards (6.0-8.0) for drinking water hence MOC is an effective coagulant in improving pH of drinking water.

Figure 6. Showing a line graph of the effect of varying concentrations of moc on the turbidity vaules of the raw water samples from lake victoria and well.



TURBIDITY

Initial turbidity values of raw water samples from Lake and well were 1261.12NTU and 98.84NTU respectively due to phytoplankton, suspended solids, both organic and inorganic substances including crack of rock, sand, and dissolved metals. After treatment of L1, L2 and L3with M1, M2 and M3, it changed to 17.19 NTU, 3.65NTU and 9.76NTU respectively. When W1 ,W2 and W3 was treated usingM1, M2 and M3,a slight change was observed in the pH values from 98.84NTU to 13.39NTU, 3.45NTU and 7.78NTU respectively. Control experiments L-C and W-C had turbidity values of 108.09NTU and 89.81NTU respectively. The effective removal of turbidity from water samples was initially due to the MOC cationic proteins which distributed to all parts of the water and then interacted with the positively charged particles that caused dispersed turbidity (coagulation). Beyond 75mg/L, turbidity increased due to re-stabilization caused by reversal of colloidal charge due to adsorption This can be explained by the possible saturation of the polymer bridge sites in the MO protein which resulted in the restabilization of the destabilized particles due to insufficient number of particles to form more inter-particle bridges (Bratby, et al.,2007).

Generally only 75mg/L of MOC can efficiently optimize the treatment of raw water samples in accordance to WHO standards of < 5NTU. The turbidity values of the both control experiments LC and WC were above WHO turbidity standards value (<5NTU) for drinking water.

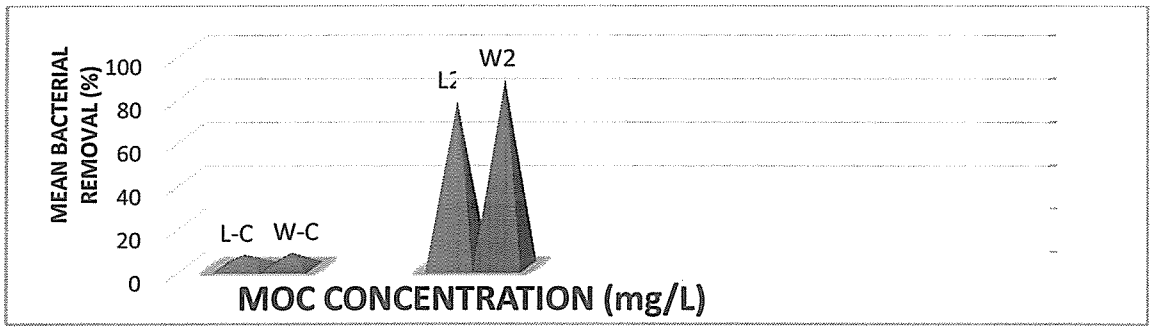
CONDUCTIVITY

Conductivity values of Lake Victoria and well water samples before their treatment with MOC were 548μS/cm and 352 μS/cm respectively because it varies considerable in different geographical regions owing to differences in the solubility of minerals. After treatment they ranged from 472μS/cm -620μS/cm and 263 μS/cm to 498 μS/cm for lake and well water samples respectively. Water treatment with MOC effectively reduced water conductivity due to increase in the cationic polyelectrolyte of MO seeds where addition of MOC to the water samples resulted into the dispersion of some mineral ions and inorganic compounds into a floc which were then precipitated and separate from the solution this caused the reduction of the electrical conductivity However, the excess use of MOC beyond the optimum dosage (75mg/L) raised conductivity value due to the presence of the unbounded ions. Conductivity values for all treated water samples ranged within for objectionable levels for consumption in accordance to WHO GDWQ-2006.

Table 5. showing the tested bacteriological parameter for untreated and treated water samples from both well and Lake Victoria using MOC.

SAMPLES	DSLB	SSLB	SSLB	MPN/100ml
	10ml	1ml	0.1ml	
L2	1	0	1	4
LR	3	2	0	16
W2	1	0	0	2
WR	3	0	0	14

Figure 7.A graph showing bacteriological tested parameters for both well and Lake Victoria water samples treated using MOC.



BACTERIAL REMOVAL

Coagulation with MOC resulted in high bacterial removal of 76.47% and 66.67% for Lake Victoria and well water samples respectively. Bacterial reduction may be due to antimicrobial agent in the seed extract as well as settling time (Jahn, 1986).

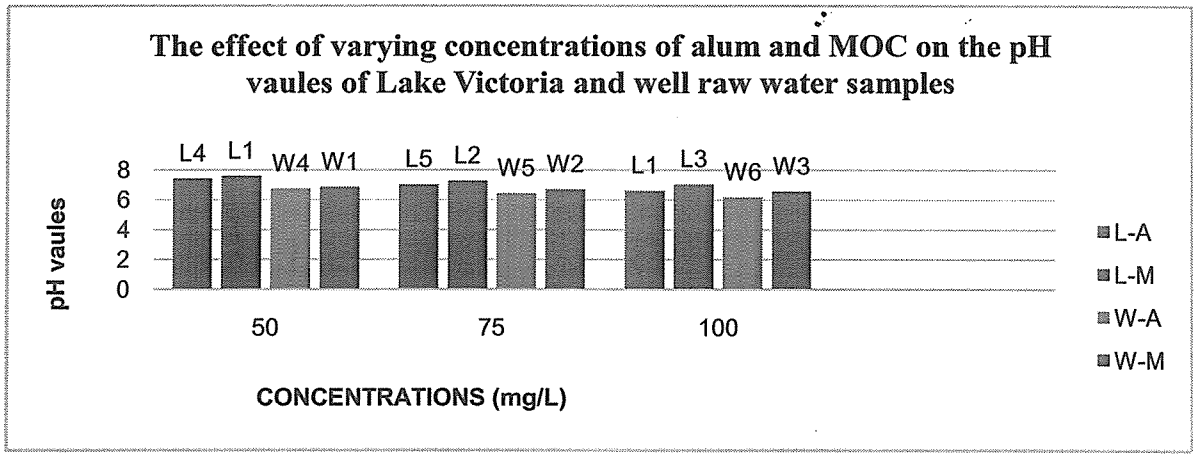
MOC protein produce a positive charge in water that acts like magnet and attract dominant negatively charged particles like microbes to form flocs. (Schwarz 2000) Antimicrobial peptides in the seed extract are thought to act by disrupting bacterial cell membranes or inhibiting essential enzymes of gram negative and gram positive. (Suarez et. al., 2003).

Furthermore, bacterial removal was due to alkaline condition generated by MOC can inhibit the growth of acidophiles and extreme alkaliphiles. However the bacterial removal was not excess due to the low MOC extraction by solvent water.

Table 6. Showing tested physiochemical parameters for lake and well water samples treated with varying concentrations of alum coagulant.

TESTED PHYSIO-CHEMICAL PARAMETERS AFTER TREATMENT	SAMPLES TREATED WITH DIFERENT CONCENTRATIONS OF ALUM COAGULANT SOLUTIONS (mg/L)			SAMPLES TREATED USING DIFFERENT CONCENTRATIONS OF MORINGA SEEDS COAGULANT SOLUTIONS (mg/L)		
	L4-A1	L5-A2	L6-A3	W4-A1	W5-A2	W6-A3
CONDUCTIVITY(µS/cm)	614	369	598	415	215	498
CONDUCTIVITY REDUCTION	-	32.66%	-	-	38.92%	-
TURBIDITY (NTU)	4.83	2.97	1.92	3.79	1.97	1.08
TURBIDITY REDUCTION	96.17%	97.65%	98.48%	96.17%	98.01%	98.92%
pH	7.43	7.04	6.63	6.74	6.44	6.19

Figure 8. showingthe effect of varying concentrations of alum and MOC on the pH vaules of Lake Victoria and well raw water samples.

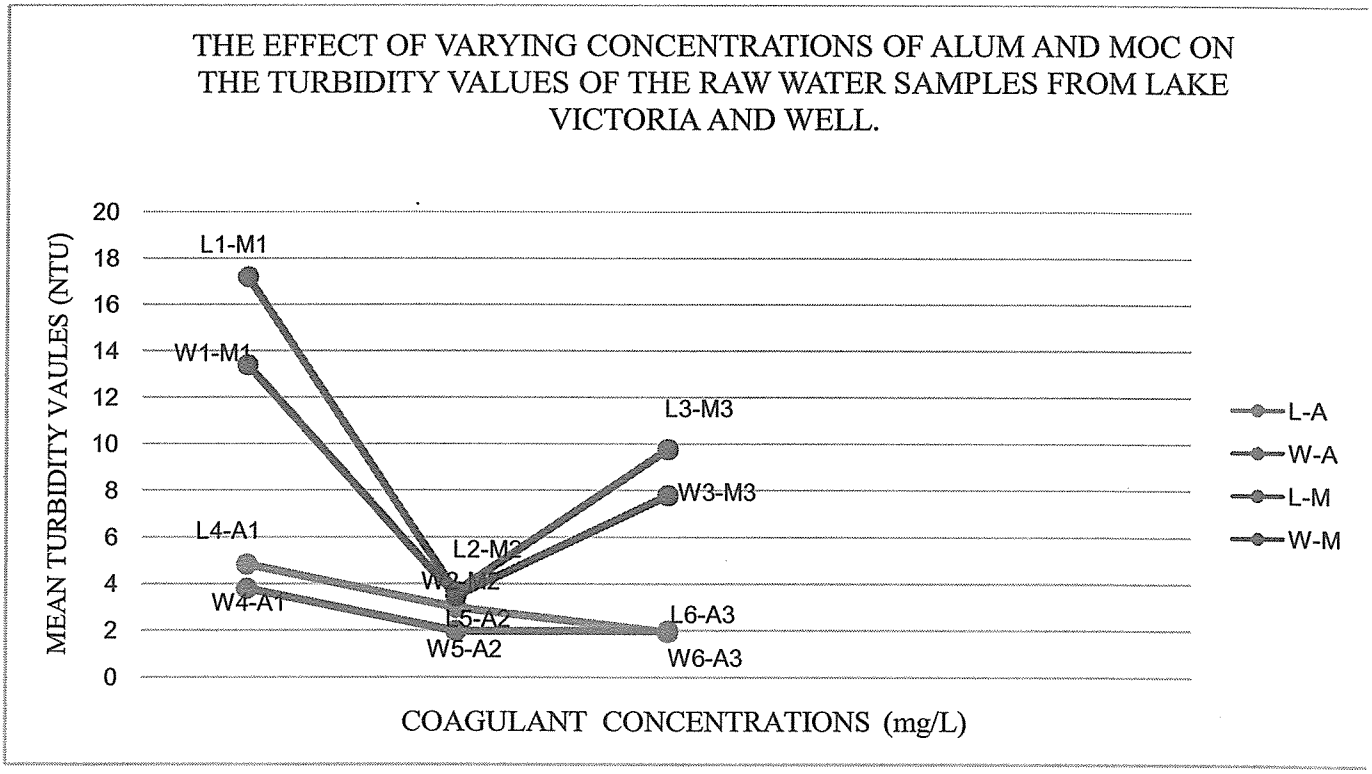


pH

Initially Lake and well raw water samples had pH values of 7.87 and 7.08 respectively. After treatment of the water samples with the varying concentrations of Alum, pH values changed from 7.87 to 7.43 to 7.04 and6.63 for water samples L4-A1, L5-A2and L6-A3 respectively. It also changed from 7.08 to 6.74 to 6.44 and6.19 water samples W4-A1, W5-A2 and W6-A3 respectively. . Alum in water produced sulphuric acid which lowered the pH levels. The increase in acidity could be also due to the trivalent cation aluminium that can act as Lewis acid and accept lone pair of electrons (Miller et al., 1984). Both sulphuric and Lewis acid reacted with the alkaline present in the water to lower pH. High dosage of alum in water treatment lead to high acidity raising health concerns about Alum related diseases as reported by Martyns et al., (1989).

The pH of all water samples treated with both coagulants were within the recommended WHO-2006 standards (6.0-8.0) for drinking water. However, Alum significantly influenced a decrease in the pH of water samples more than MOC. Generally pH of MOC was more alkaline compared to that of Alum coagulant which may require sodium hydroxide to normal pH of drinking water hence increase in their costs.

Figure 9. Showingthe effect of varying concentrations of alum and MOC on the turbidity values of the raw water samples from Lake Victoria and well.



Turbidity

After treatment of L4, L5 and L6 withA1, A2 and A3 of Alum coagulant, turbidity changed from 126.12NTU to 4.83 NTU to 2.97NTU and 1.92 NTU respectively. A relatively similar trend was also observed with increasing concentrations of Alum labeled A1, A2 and A3 which changed the pH values of well water samples W4, W5 and W6 from to 3.79 NTU, 1.97NTU and 1.08 NTU respectively.

It was observed that all concentrations of Alum established normal turbidity in treatment of raw water samples from Lake Victoria and well as recommended by WHO standards of < 5NTU compared to MOC which established normal turbidity only at optimum concentration (75mg/L).However an additional advantage of MOC over Alum is that all its mud grain after coagulation were biodegradable organic matter unlike alum where coagulation activity is strongly influenced by the neutral alkalinity of water itself.

CONDUCTIVITY

Conductivity values of Lake Victoria and well water samples before their treatment with Alum were 548µS/cm and 352 µS/cm respectively. Then they ranged from 369µS/cm - 614µS/cm and 215µS/cm -498 µS/cm for lake and well water samples respectively.

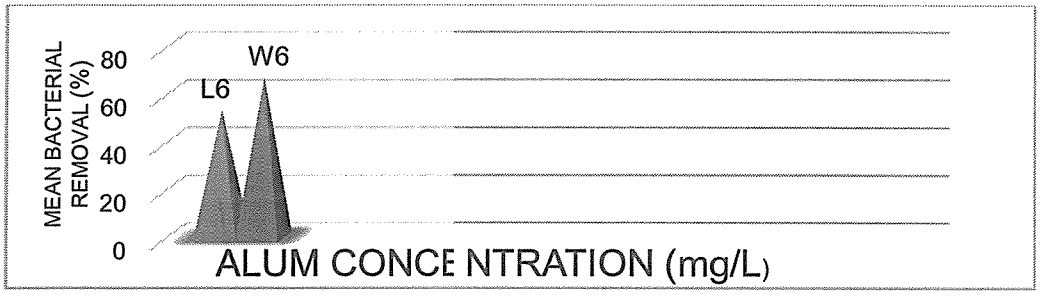
Addition of Alum coagulant increased the conductivity of both water samples due to the reaction of water with acidic or alkaline metals where water samples reacted with the salts that raised the conductivity value. Furthermore inorganic compounds dissociated in water and contributes to water's ability to conduct very large electric current.

Generally conductivity values of water samples treated with Alum coagulant were relatively in lower ranges compared to those of MOC because during coagulation MOC reacted as a positively charged natural polymer.

Table 7. showing bacteriological parameter for treated water samples from both well and Lake Victoria using alum coagulant.

SAMPLES	DSLB	SSLB	SSLB	MPN/100ml
	10ml	1ml	0.1ml	
L6	3	0	0	8
W6	2	1	1	5

Figure 10. Showing a graph of bacteriological tested parameters for both well and Lake Victoria water samples treated with alum.



BACTERIAL REMOVAL

Coagulation with Alum resulted in bacterial removal of 52.94% and 66.67% for Lake Victoria and well water samples respectively. The bacterial removal due to the reduced pH making the water slightly acidic, as well as the length of time for treated water to settle and non-availability of carbon source which got rid of all organic matter in the water resulting in the starvation microorganisms to death (Donkor, 1996).On the whole bacterial removal, they were higher in MOC treated water than that of Alum. However, after treatment of both water samples with MOC and alum separately, treated water decreased in bacterial count with emission of odour from the MO treated water. This could probably be attributed to bacterial regrowth on impurities with the organic matter present in Moringa seed providing additional nutrient support. Secondary bacterial growth might also be due to the presence of some bacterial cells which were initially sub-lethally inactivated, but resuscitated after some period of contact with the sub-lethal concentration of the chemical. Other parameters such as treatment time, temperature and water constituent may also exert a profound influence on bacterial regrowth (Madsen et al., 1987).

CHAPTER FIVE

CONCLUSION AND RECOMMENTATIONS

5.1 CONCLUSION

The following conclusions can be drawn from this study:
Moringa oleifera is an effective natural coagulant which can be used in improving the physicochemical and bacteriological parameters of water in terms of pH, turbidity and conductivity.

In coagulation, Moringa oleifera coagulant hardly affect pH of water as compared to alum which may requires pH adjustment after treatment. This is likely to reduce the high cost of the current water treatment systems.

The results obtained shown that Coagulant from seed of Moringa oleifera contains some coagulating properties with optimal doses of 75mg/l for improving quality of Lake Victoria and well water samples. These concentrations have similar effect as the conventional alum coagulant.

Both coagulants possess almost the same time-dependent potency in antimicrobial properties. Bacterial re growths were recorded after coagulation. There is therefore the need for filtration or boiling of the water if it is to be stored for a longer time.

5.2 RECOMMENDATIONS

There is a need to educate the public on how to use Moringa in water treatment through workshops and the media in all District Assemblies and regions of Uganda.
Secondary bacterial growth after coagulation with both coagulants necessitates that water for drinking purposes should be boiled or filtered before use.

Government of Uganda and private organizations should invest more in Moringa cultivation since it has the potential of reducing cost of water treatment and can help improve water quality for rural dwellers.

Future research is suggested on the following:

Efficiency of the combination of improved Moringa seeds extract, okra, sand and UV sunlight on the treatment of water.

Combination of alum and Moringa in different proportions to establish their synergistic effectiveness in treating raw water
Medicinal value of the components of the seed extract of Moringa oleifera in health benefits.

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