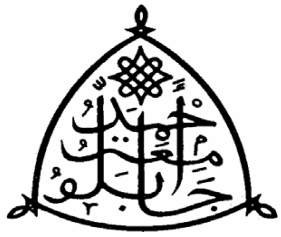


A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY, ZARIA – NIGERIA

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IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS OF SCIENCE DEGREE IN WATER RESOURCES AND ENVIRONMENTAL ENGINEERNG (M.Sc WREE)



THE USE OF SELECTED PLANT EXTRACTS IN GREY- WATER TREATMENT

BY

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A DISSERTATION PRESENTED TO THE DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL ENGINEERING AHMADU BELLO UNIVERSITY, ZARIA NIGERIA IN PARTIAL FULFILMENT OF THE AWARD OF THE DEGREE OF MASTER OF SCIENCES IN WATER RESOURCES AND ENVIRONMENTAL ENGINEERING

DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL ENGINEERING
AHMADU BELLO UNIVERSITY, ZARIA NIGERIA

MAY, 2016

DECLARATION

I, OSAYANDE Iyore Osarenren, declare that this dissertation entitled "the use of selected plant extracts in grey-water treatment was done by me in the Department of Water Resources and Environmental Engineering under the supervision of Dr. Sunday Bamidele Igboro and Dr. D.B. Adie. It has not been previously presented for the award of any degree. All sources of information which are not been originally mine are specially acknowledged by reference.

OSAYANDE Iyore Osarenren _____ _____

Signature Date

CERTIFICATION

This dissertation entitled “the use of selected plant extracts in grey-water treatment” by OSAYANDE Iyore Osarenren meet the requirements of the school of post graduate studies, Ahmadu Bello University, Zaria for the award of degree of masters of science (M.SC) in Water Resources and Environmental Engineering.

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DEDICATION

This work is dedicated to God Almighty for his unfailing love and to my lovely parents CP Amadin Osazuwa Osayande and Mrs. Blessing Osayande for their support throughout my program. Thank you for standing by me, I am forever grateful.

ACKNOWLEDGMENTS

My profound appreciation goes to the Almighty God, who has brought me this far. My sincere gratitude goes to my Supervisors, Dr. S.B. Igboro, and Dr D. B. Adie for their support, guidance and constructive criticisms during the course of this thesis which I will never forget in a long run.

I also sincerely acknowledge Prof C. A. Okuofu for his fatherly advice and support not only for the success of this work but also for my entire stay in this prestigious department. I am equally grateful to Prof Abubakar Ismail, the Head of Department, to Dr Fatima, Engr. Ajibike, Prof. J. A, Otun, Engr Sani Ismail, Engr. (Dr.) B.K. Adeogun, Engr. (Dr.) Umar Alfa Abubakar, Dr. Musa Ebenya Shaibu-Imodagbe, Dr. W.A Alayande, Prof. N.A Eharevba, Engr. Aliyu Adamu. I thank you all.

Also my sincere thanks and gratitude go to all the departmental staff both academic and non-academic staff especially the laboratory staff; Mr. P.C. Alika, Mr. Geoffrey and Mall. Yayaha, whose guidance and assistance contributed to making this work a success.

I also wish to express my profound gratitude and appreciation to my parents CP Amadin, Osazuwa Osayande and Mrs. Blessing Osayande you are the best. And to my siblings (Mr. Osagie, Mrs. Eghosa, Emmanuel and Amen) you guys are wonderful. Am also grateful to my course mates you guys are awesome. And to my heartthrob (Mr. Uyi Ehiorigie) God bless you for me. For others too numerous to mention that contributed in one way or the other towards the success of this work, I thank you all.

ABSTRACT

Grey water is the left over water from baths, showers, hand basin and washing machine; in some cases water from the kitchen sink. The use of some synthetic chemical reagents in the treatment of grey water has been reported to be cancerogenic. The present study is an investigation into the possibility of using environmental friendly substances like, *Agave sisalana* leaves extract, *Moringa oleifera* seeds extract and *parkia biglobosa* seeds extract as coagulant and antimicrobial properties. Dry leaves of *Agave sisalana*, dry seeds *Moringa oleifera* and dry seeds of *Parkia biglobosa* were obtained from the botanical garden of the Department of Biological Sciences, Ahmadu Bello University Zaria. Grey water sample with turbidity ranging from 68, 67 and 76 NTU over the period of study were collected from Queen Amina Hostel of the Ahmadu Bello University Zaria. A standard jar test apparatus was used for the coagulation test, to the determine the minimal dosage of the extracts which are 100 mg/l, 120 mg/l and 150 mg/l. 500 ml of the grey water from was dosed with increasing amounts of the extracts. Turbidity (NTU), PH, total dissolved solids (PPM) electrical conductivity (µs/cm), dissolved oxygen (ppm) BOD (ppm) and antimicrobial properties were measured using standard methods. The study shows that the extracts could act as a natural coagulant, flocculent and absorbent in grey water treatment. Separately *Moringa oleifera* was found to be more effective in coagulation than *Agave sisalana* and *Parkia biglobosa* with a turbidity removal from 76 NTU to 47 NTU and 18 NTU (85 % and 90 %) removal, and also *Moringa olerifera* separately was more effective in antimicrobial analysis with coloy reduction from 80 cfu to 40 cfu. while in combine, *Parkia biglobosa* seeds extract and *Agave sisalana* leaves extract in ratio 1:1 were more effective with turbidity removal of 35 % from 76 NTU to 62 NTU. In terms of antimicrobial analysis there was no synergistic action between them. The extracts can be used as alternative coagulants in grey water treatment. Similarly, the separate use of the extracts is more effective than in combine.

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LIST OF SYMBOLS AND ABBREVIATIONS

ABU	Ahmadu Bello University, Zaria
APHA	American Public Health Association
BOD	Biological Oxygen Demand
cfu	Coliform
DO	Dissolved Oxygen
^{o}C	Degree centigrade
EC	electrical conductivity
g/kg	grams per kilogram
g/l	grams per liter
ml	Milli liter
mm	millimeter
m/hr	meter per hour
mg/L	Milligrams per liter
mg/g	Milligrams per grams
m^2	square meter
NTU	Nephelometric turbidity units

pH	Power of Hydrogen
%	Percentage
ppm	Parts per million
TDS	Total Dissolved Solids
rpm	Rotation per minute
µS/cm	Micro-siemens per centimeter
t_c	T – calculated
t_t	T – tabulated

CHAPTER ONE

INTRODUCTION

1.1 Preamble

Grey water got its name from its cloudy appearance and from its state as being between fresh potable water known as white water" in a household context. Grey water is the left over water from baths, showers, hand basins and washing machine only some definitions of grey water include water from the kitchen sink. Any water containing human waste (feces) is considered as black water. Grey water reuse can be reuse for subsurface irrigation and for toilet flushing (Mcconnachie, 1993).

Water is life. The importance of water to man's existence cannot be overemphasized. Adequate supply of water is central to life and civilization. Of the five basic human needs (water, food, health, education, peace) water is a common factor to the other four (FRN, 2004). Safe water is a precondition for health and development and a basic human right, yet it is still denied to hundreds of millions of people throughout the developing world. Water-related diseases caused by insufficient safe water supplies coupled with poor sanitation and hygiene causing 3.4 million deaths a year, mostly among children. Despite continuing efforts by governments, civil society and the international community, billions of people still do not have access to improved water sources (UNICEF, 2008).

The fact that 70 % of the human body weight and 98 % of neonatal body weight are accounted for by water underscores the importance of water to man's survival (Okuofu, 2010). Moreover, water covers about 70 % of the total earth surface. This obviously explains why many ancient civilizations in history have thrived around water bodies.

Water bodies that played this vital role include the Euphrates, Tigris, Thames, and Nile just to mention but a few (Okuofu, 2010). The importance of water cuts across food production as well as recreation. The sufficiency of water for these uses depends largely on proper harnessing and management of the little available.

The use of water also extends to disposal of waste from domestic and municipal sources. This is often where the problem arises especially when the waste is pre-treated to conform to specified standards and the water may be re-used for other purposes such as irrigation and even for drinking as obtainable in some localities. This may result in physical, chemical or biological (including microbiological) problems with respect to quality of water (Okuofu, 2010).

As pressures on freshwater resources grow around the world and as new sources of supply become increasingly scarce, expensive, or politically controversial, efforts are underway to identify new ways of meeting water needs. Of special note are efforts to reduce water demand by increasing the efficiency of water use and to expand the usefulness of alternative sources of water previously considered unusable, Among these potential new sources of supply is “grey water” (Allen *et al.*, 2010).

By appropriately matching water quality to water need, the reuse of grey water can replace the use of potable water in non-potable applications like toilet flushing and landscaping. In most modern wastewater systems, treated wastewater is then disposed off into the ocean or other water bodies, voiding the reuse potential of this treated wastewater. In other places, once used wastewater may be disposed of directly into the

environment. This system wastes water, energy, and money by not matching the quality of water to its use (Allen *et al.*, 2010).

1.2 Statement of Problem

The use of some synthetic chemical reagents in the treatment of grey water has been associated with health problems, for example chlorine which reacts with natural organic materials during pre and post chlorination to form by products, some of which have been reported to be carcinogenic (Herbert, 2007).

The adoption of a sustainable technology is a major factor that determines the success of the treatment of grey water. The use of conventional technologies is not only capital intensive, but also requires sophisticated equipment, and requires skilled operators, with the use of natural treatment additives and processes, and these problems can be greatly reduced or totally eliminated.

1.3 Justification of Study

Grey water which is gotten from bathrooms, washing machines and kitchen sinks, contains organic and inorganic substances. The use of chemical reagent like (Chlorine, Ozone etc.) can cause serious health hazards e.g. cancer. However, the present study is an investigation into the possibility of using environmental friendly substances like, *Agave sisalana* leaves extract, *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract as coagulants and to test for the present of antimicrobial properties. These extracts are natural sources of reagents that are affordable, with less health hazards and are easy to handle.

1.4 Aim and Objective

1.4.1 Aim

The aim of this research is to use *Agave sisalana* leaves extract, *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract to treat grey water for the purpose of irrigation and toilet flushing.

1.4.2 Objectives

1. To characterize the antimicrobial properties of *Agave sisalana* leaves extract, *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract in grey water treatment.
2. To evaluate *Agave Sisalana* leaves extract, *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract as grey water treatment coagulant, individual and in combination.
3. To attest the feasibility of *Agave sisalana* leaves extract in the treatment of grey water.

1.5 Scope of the Study

This research is a laboratory based study. Its scope includes: the coagulation studies and antimicrobial anayisis of *Agave sisalana* leaves extract, *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract.

CHAPTER TWO

LITERATURE REVIEW

2.1 Background

Sisal with the botanical name *Agave sisalana* is a species of Agave native to southern Mexico but widely cultivated and naturalized in many other countries. It yields a stiff fiber used in making various products. The term sisal refers either to the plants common name or the fiber, depending on the context. It is sometimes referred to as "sisal hemp" because of centuries 'hemp' was a major source of fiber, and all other fiber sources were named after it. (Sara *et al.,* 2006).

The sisal fiber is traditionally used for rope and twine, and has many uses, including paper, cloth, wall covering carpets and dartboards (Sara *et al.,* 2006).

2.1.1 Plant Description of *Agave Sisalana*

Sisal plants, *Agave sisalana*, consist of a rosette sword – shaped leaves which are about 1.5 – 2 m and 4.9 – 12 m tall. Young leaves have teeth along their margins, but lose them as they mature. The sisal plant has 7 – 10 years life span. It typically produces 200 – 250 commercially usable leaves. Each leaf contains an average of around 1000 fibers. The fibers account for only about 4 % of the plant weight sisal is considered a plant of the tropics and subtropics, because its produce mostly at temperature above 25 degrees Celsius with sunshine. (David *et al.,* 2006).Fig 2.1 shows the young *Agave sisalana* plant.



Fig 2.1: *Agave Sisalana* Leaves. Source: (David *et al.*, 2006).

2.1.2 Cultivation of *Agave sisalana*

Sisal was used by the Aztecs and the Mayans to make crude fabrics and paper. In the 19th century, sisal cultivation spread to Florida, the Caribbean Islands, and Brazil (Paraiba and Bahia), as well as to countries in Africa, notably Tanzania and Kenya and Asia (Mark *et al.*, 2009).

The first commercial Planting in Brazil was made in the late 1930s and the first sisal fiber exports from there were made in 1948. It was not until the 1960s that Brazilian production accelerated and the first of many spinning mills was established. Today Brazil is the major world producer of sisal. (Mark *et al.*, 2009) Figure 2.2 shows a full blow mature *Agave Sisalana* plant which is 12 m tall.



Figure 2.2: *Agave sisalana* plant, source :(Mark *et al*., 2009)

2.1.3 Environmental Impacts of *Agave Sisalana* Plant

Sisal farming initially causes environmental degradation, because sisal plantations replaced native forest, but is still considered less damaging than many types of farming. No chemical fertilizers are used in sisal production but herbicides are occasionally used, even this impact can be eliminated, since most weeding is done by hand. The effluent from the decortications process, which is the process of extracting fiber form the sisal plant, can cause serious pollution when allowed to flow into the water courses. In Tanzania there are plants to use the waste as bio –fuel. (Kadolph and Ann, 2002).Table 2.1 is showing the scientific classification of *Agave Sisalana* plant.

Within the plant kingdom, *Agave sisalana* can be identified according to the following classifications.

Table 2.1 Scientific Classification of *Agave Sisalana* Plant

Kingdom	Plantae
Class	Angiosperms
Order	Asparagales
Family	Asparagaceae
Sub-family	Agavoideae
Genus	Agave
Species	*Agave sisalana*

Source :(Mark *et al*., 2009)

2.1.4 Uses of *Agave sisalana*

Traditionally, sisal has been the leading material for agricultural twine (binder twine and baler twine) because of its strength, durability, ability to stretch, affinity for certain dyestuffs and resistance to deterioration in saltwater. The importance of this traditional uses is diminishing with competition from polypropylene and the development of other hay making techniques, apart from ropes, twines and general cordage. Sisal is used in low-cost and specialty paper, dartboards, buffing cloth, filters, geo- textiles, mattresses, carpets, handicrafts, wire rope cores and macramé. Sisal has been utilized as an event to replace asbestos and fiber glass in composite materials in various uses including the automobile industry. The lower-grade fiber is processed by the paper industry because of its high content of cellulose and hemicelluloses. The medium-grade fiber is used in the

cordage industry for making ropes, baler and binder twine. Ropes and twines are widely employed for marine, agricultural and general industrial uses. . (Kadolph andAnn, 2002).

The higher-grade fiber after treatment is converted into yarns and used by the carpet industry. Other products developed from sisal fiber include spa products, cat scratching posts, lumbar support belts, rugs, slippers, cloths, and disc buffers. Sisal wall covering meets the abrasion and tearing a resistance standard of the American society for testing and materials and of the national fire protection association. (Lacerda *et al*., 2006).

As extraction of fiber uses only a small percentage of the plant, some attempts to improve economic viability have focused on utilizing the waste material for production of biogas, for stock feed, or the extraction of pharmaceutical materials. (Lacerda *et al*., 2006).

Sisal is valuable forage for honey bees because of its long flowering period. It is particularly attractive to them during pollen shortage. The honey produced is however dark and has a strong and unpleasant flavor. Because sisal is an agave, it can be distilled to make tequila like liquor. Sisal waste has also been used as fertilizer (Lacerda *et al.*, 2006).

i. Traditionally, sisal has been the leading materials for agricultural twine (binder twine and baler twine) because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in salt water.

ii. Sisal is used in low cost and specialty paper, dartboards, buffing cloth, filters, geo-textiles, mattresses', carpets, handcraft, wire rope coves and macramé.

iii. Sisal has been utilized as an environmentally friendly strengthening agent to replace asbestos and fiberglass in composite maters in various uses including the automobile industry.

iv. The lower-grade of sisal is being used by the paper industry, because of its high content of cellulose and hemicelluloses.

v. The higher-grade of sisal is converted into yarns and used by the carpet industry.

vi. Other product developed from sisal fiber include spa product, cat scratching post, lumber support belts, rugs, slippers, cloths and disc buffers.

vii. The waste material are-used for biogas, for stock feed and for pharmaceutical materials.

2.1.5 **Antimicrobial Properties of *Agave sisalana***

Agave sisalana plant is rich in secondary metabolites such as tannins, terpenoids, alkaloids and flavouoids which have been found in vitro to have antimicrobial properties in vitro extracts of many plants are known to exhibit antimicrobial activity. The antimicrobial screening of the plant extracts was determined using agar well diffusion method as described by (Irobi *et al*., 1994). The microorganisms were sub-cultured into prepared normal saline and incubated at 37 ^{o}C for 30 min. the concentration of each suspension was obtained to form a turbidity that matched with the scale of 0.5 of Mac Far land's standard (1.5 x 10^{8} cells /ml). The cells suspensions of E. faecalis were seeded in muller hiutonagar C. albicans, p. aernginosa and B. atrophaeus were seeded in nutrient agar and S.dysenteriae in sallmonella shingle agar. Wells were created into the centre of the plates of the seeded organisms using sterile cork-borer of 6 mm in diameter. 40 mg/ml of the extracts prepared in distilled water were introduced into the wells and allowed to stand for one hour at room temperature for diffusion. All plates were incubated at 37 ^{o}C for 24 hours. The zones of inhibition were measured and recorded.

The presence of these components in this species shows that it may have some medicinal potential. This is probably due to the fact that each of the components identified has record of one therapeutic usage or another. For instance, plants rich in saponins are known to be immune boosting and have anti-inflammatory properties (Hammauel *et al*., 2011).

Similarly, plants with tannins have antibacterial potentials due to their basic character which allows them to react with proteins to form state water soluble compounds thereby killing the bacteria by directly damaging its cell membrane (Elmarie and Johan, 2001). The antibacterial activities of alkaloids and flavonoids have been reported by (Ajoku *et al*., 2005) and (Ade-Ajayi *et al*., 2011). The results indicated that *Agave sisalana* has antimicrobial properties.

2.1.6 **Extraction of *Agave sisalana* Leaves**

For extraction of the fiber, two methods are employed via the retting process and the mechanical process. The fiber yield in retting process is about 5.5 % and in the mechanical process is about 3.4 % based on the weight of the green leaves.

2.1.7 **Extraction of Juice from *Agave sisalana* Leaves**

The chopped leaves were processed through a compressor cum in a dewatering unit and fresh juice was collected from the outlet. The juice was then followed by centrifugation at 2000 rpm for 15 min clear supernatant liquid was collected at the end and 16 ml of toluene was added to the supernatant, it was then stored at 4 ^{o}C for 24 hour .(Shipra and Varshney ,2011).

2.1.8 **Nutritional Value of *Agave sisalana* Leaves**

Agave is useful as a sugar alternative because with a 90 % fructose, it has low glycenic index. Steroid hormone precursors are obtained from the leaves pique prepared from

Agave species was a food item studied intensively for a nutrition potential among traditional and luminous peoples, and is an example of how local food-based strategies can be used to ensure micronutrient nutrition. Traditional food strategies could be used not only for alleviating malnutrition, but also for developing locally relevant programs for stemming the nutrition transition and preventing chronic disease particularly among indigenous and traditional peoples who retain knowledge of using food species in their local ecosystems. (Shipra and Varsney, 2011)

2.1.9 **Toxicology of *Agave sisalana***

To verify the toxicity and related mechanism of *Agave sisalana* perrine to golden apple snail, the toxic effects of aqueous, n-butauol and ethanol extracts of *Agave sisalana* were tested via the snail-immersed method. The effects of n-butanol (59 mg/l, 96 mg/l) and ethanol (180 mg/l, 325 mg/l) extracts on cholinesterase (CHE), superoxide dismutase (SOD) and denosine tripuospuatase (ATP) activities in hepatic tissue of golden apple snails were also investigated. Based on the result aqueous, n – butanol and ethanol extracts of A. sisalana had toxic effects on golden apple snail. Their semi – lethal concentrations (LC 50) on golden apple snail for 72 hours, toxicity exposure were 35. 3 mg/l, 93.3 mg/l and 298.6 mg/l respectively. The corresponding 95 % confidence interval ranges were 32.9 – 37.7 mg/l, 87.6 – 99.7 mg/l and 272.9 – 318.7 mg/l, respectively. (Ade-Ajayi *et al*., 2011). When treated with n-butanol and ethanol extracts for 12 hours, SOD activating in snail hepatic tissues showed no obvious change at low concentration. SOD activity, however, increased significantly high concentration. After treatment for 48 hours, SOD activity at high concentrations n-butanol extract was significantly higher than that of the control. However, SOD activity did not show any obvious change in both low and high concentrations of ethanol extract. All *A. sisalana* extracts somehow increased

CHE activity, with n-butanol extract exhibiting higher affect on CHE activity. When treated with 96 mg/l n-butanol extract for 48 hours, CHE activity significantly exceeded that of the control ($p< 0.05$). Overall, n-butanol extracts treatment enhanced ATP activity at low concentrations and suppressed it at high concentrations respectively; no obvious pattern change was noted under ethanol extract treatment. However *Agave sisalana* was found to be toxic to golden apple snail. (Ajoku *et al*., 2005).

2.1.10**: Composition of Agave**

The leaves contain several steroidal sapogenins, Hecogenin, tigogenin, neotigogenin, neotigogenune, Δ 9 (11) – dehydrohecogenin, sisalagenin, rockogenin, 5-9-pregnan -3β 20β-diol, 12-epirockogenin and chlorogenin. They contain β-sitosterol and two tri hydroxyl sapogenins via hainangenin and hongguang genin Hecogenin occurs in the plant in the form of its glycoside, heconin sisal waste and the juice expressed from the leaf pulp by decortications of fresh leaves are the commercial sources of hecogenin (Shipra and varshey, 2011).

2.2 ***Parkia Biglobosa***

Locust bean with the botanical name "*Parkia biglobosa* is locally known as "dorawa" in northern Nigerian and Irugba abata, Igbo, or aridan – abata in western Nigeria, it is also known as dawadawa or nitta in Igbo or eastern Nigeria while it is called rarco by the kanouri in Nigeria and chad.

It is a product of a deciduous tree that grows as tall as twenty meters, with large fruit pods; the fruit pods contain a row of black seeds. The seeds are obtained from the pod simply by washing away the surrounding meal, to obtain the kernel, it is usually to boil the seeds for twenty four hours to soften the tester or roast them. Thereafter, it is pounded

and is washed several times. The product is a blackish item with a pungent smell. It is used as seasonings for food.

2.2.1 **Description:** *Parkia biglobosa* is a leguminous tree, with a dense spread crown, scaly and creviced grey – brown bark, slash brown the leaves are bipinnate up to 40 cm, with an orbicular gland on the petiole, up to 40 pairs of pinnate having up to 65 pairs of leaflets each. Leaflets is oblong and linear with dimensions 0.8 – 3.0 cm x 0.2 – 0.8 cm, flowers are red or orange clustered in heads up to 7 cm in diameter borne on hanging peduncle up to 35cm long. Pods are linear with sizes 12 x 30 x 1.5 – 2.5 cm, glabrous and brown. (Burkill, 2000).Fig 2.3 shows *Parkia biglobosa* Tree



Fig: 2.3 *Parkia biglobosa* Tree, Source: (Komami, 2012).

2.2.2 **Uses of *Parkia biglobosa.***

As a result of increased industrial and agricultural process across the globe, there has been significant increase in industrial and agricultural wastes which often have negative impact on the environment. Much research efforts increases in times are geared towards possible ways of recycling these wastes for re-uses to keep the environment clean and

safe. The transportation construction and environmental industries have the greatest potential to reuse because they use large quantities of earthen materials annually (Burkill, 2000).

Parkia biglobosa tree is a multipurpose, which is equally valued as the Shea butter tree. The leaves are sometimes eaten as vegetable, usually after boiling is then mixed with other food such as cereal flow. Young flowers buds are usually used to mix salads, the roasted seeds are used as coffee substitute known as "Sudan coffee" orcafe negre", the mealy pulp from the fruit is eaten or mixed with water to make a sweet refreshing drink. The boiled pods are used as dye for pottery black. The bark is rich in tannins and can be use to moderate quality especially in colour, which is often reddish, uneven and darkens when exposed to light in tanning hides. (Sina and Traore, 2002). It is also used in traditional human medicine to treat infections and diseases. While in veterinary medicine, the root is used to treat corcidiosis in poultry. The green pods are crushed and added to rivers to kill fish, although the nutritional value of the fish is not adversely affected. ((Sina and Traore, 2002). It is also used for soil improvement; its leaves are used as manure. It is also important in agriculture, being a good source of neater and suitable for placement of hives. It serves as wind breaker in front of buildings and long a venue/motor ways. (Garvin and Sheshan,1977). Scientist has also proved its antibiotic in-vitro from the crude extracts of the tree. (Marquez, 2005), and (Smith *et al*., 2007).

2.2.3 **Antimicrobial Property of *Parkia biglobosa***

There are evidence that *Parkia biglobosa* is used in the prevention of disease caused by germs which is known as coli which causes bloody diarrhea *Staphylococcus aureus*. Antibacterial evaluation of the methanoic extracts and aqueous fractious of the leaf, stem

bark and root of *Parkia biglobosa*. The agar me diffused method was used. The extract and their fraction were tested against two gram of positive organism – *Staphylococcus aureus* ATCC 25923 and bacillus subtitles' NCTC 83261376 and two gram of negative organisms *Escherichia coli* ATCC 27853. Result confirmed broad spectrum of activity as the entire organism used where inhibited by the extracts and their aqueous fractions at concentration between 2.5 – 20 mg. Zones of clearing against *S. aureus* were more pronounced, distinct and wider than those against other organisms tested, it was closely followed by *P. avruginosa*. Result of the Minimum Inhibitory Concentration (MIC) test using the aqueous fractions showed the Micrunged from 1.562 – 25 mg/ml. This confirms that high activity of the aqueous fractions of the methanoic extract of the stem, bark (WS) against *S. aureus* ATCC 25923 and *P. aerogiuosa* ATCC 2785. The WS showed higher activity than the aqueous fraction of the ethanoic extracts of the root (WR). When the extracts were screened for secondary metabolities; ntannins, flavuoids and sciponins were detected among other. These secondary metabolites are not likely responsible for the observed activity of the plant parts. Results obtained from this study justify the medicinal uses of *Parkia biglobosa* tree. The quest for solutions to the global problem of antibiotic resistance in pathogenic bacteria has often focused on the characterization of new antimicrobial compounds from medicinal plant (Sibanda and Okon, 2007).

2.2.4 ***Parkia biglobosa*** **and Quality of Treated Water**

For grey water treatment application, *Parkia biglobosa* plant is used because it has show similar composition with *Moringa oleifera*. It is used remove suspended material and generates reduced sludge volume in comparison to alum. Although *Parkia biglobosa* has not been found in the treatment of water of any type, but base on the facts that it shared

almost the same quality with *Moringa oleifera* plant, it was then consider that what *Moringa oleifera* plant can do, *Parkia biglobosa* will do the same (Micheal, 2012). When used in the removal of suspended matter, *Parkia biglobosa* maintained a wide range of pH value. (Oluduro and Aderiye 2007), used *Moringa oleifera* seed extract to treat surface and ground water samples and it was observed that a slight decrease in pH occurred after treatment this implies that if *Moringa oleifera* can do this then *Parkia biglobosa* can do it as well.

2.2.5 **Composition of *Parkia biglobosa***

Parkia biglobosa seeds were found to be rich in lipid, protein, carbohydrate, soluble sugars and ascorbic acid (Alabi *et al*., 2005).

Preparation and Extraction of *Parkia biglobosa* seed

The seeds were air dried for five days on the laboratory bench and then grounded to fine powder using mortar and pestle and kitchen blender. 250 g were extracted with methanol using sox let apparatus (oboh *et al*., 2007).

2.3 ***Moringa Oleifera***

2.3.1 **Description:** As high as 9 m: *Moringa oleifera* has a soft white wood and corky, gummy bark. Root has the taste of house radish. Each compound leaf contains 3 – 9 m then leaflets dispersed on a compound (3 times pinnacles) stalk. Flowers and fragrant, producing long, pendulous 9 – ribbed pods 3 – angled winged seeds. Fig 2.4 shows *Moringa oleifera* Tree.

The fig shows that the trees are slender with drooping branches that grows to approximately 10 meters in height. To maintain the pod and leaves within the arms reach, the tree is normally cut to one meter.



Figure 2.4: *Moringa oleifera* Tree, Source: (Komami, 2012).

2.3.2 Seed Extract Coagulation – Flocculation

Coagulation – flocculation with extracts from natural and renewable vegetation has been widely practiced since time memorial, and appears to be an effective and accepted physic – chemical treatment for household water in some parts of the world. In particular, extracts from the seeds of moringa species, the trees of which are widely present in Africa, the middle East and the Indian subcontinent, have the potential to be an effective, simple and low-cost coagulant – flocculent of turbid surface water that can be implemented for household water treatment (Jahn and Dirar, 1979), (Jabu, 1982) and(Jahu 1988). The effectiveness of another traditional seed, or nut extracts, from the Nirmali plant or strychnos potatorum (also called the clearing nut) to coagulate flocculate

or precipitate microbes and turbidity in water was also been documented (Tripathi *et al*., 1976).

The efficacy of *Moringa oleifera* seed is about 50 %and 95 % in reducing total bacteria and coliforms respectively in the surface water after 24 hours of treatment (Oluduro and Aderiye, 2007) despite the potential usefulness of *Moringa oleifera*, strychuos potatorum and other seed extracts for treatment of turbid water, there has been little effort to characterize the active agents in these seed extracts or evaluate the efficacy as coagulants in reducing microbes from waters having different turbidities. The chemical composition of the coagulant in strychuos potatorum has been identified as a polysaccharide consisting of 1:7 mixtures of galactomannan and galactan. The in vitro protein digestibility of raw dry heat-treated and autoclaved seeds according were 61.2 % 77.4 % and 80.2 % respectively(Oluduro and Aderiye, 2007). These findings suggest that such seed extracts may function as a particulate, colloidal and soluble polymeric coagulants as well as a coagulant aids.

Studies according to (John, 1986) (, Eivlert *et al*., 1981) and (Bina, 1991) all showed bacterial re-growth problems when *Moringa oleifera* was used as a disinfectant. There is also the likelihood of high levels of bacterial concentrations being present in sludge from water coagulated with *Moringa oleifera* seed extracts some may still be viable and pathogenic (Muyibi and Okvofu, 1995).

2.3.3 **Nutritional Values of *Moringa oleifera***

Moringa oleifera leaves are the most nutritious part of the plant, being a significant source of Vitamins B, vitamins C, pro vitamin A as betacarolene, Vitamin K, manganese, and protein, among other essential nutrients. When compared with common foods particularly high in certain nutrients per 100 g fresh weight, cooked *moringa* leaves are

considerable sources of these same nutrients. Some of the calcium in moringa leaves is bond as crystals of calcium oxalate though at levels $1/25^{th}$ to $1/45^{th}$ of that found in spinach which is a negligible amount. The seeds, sometimes removed from more mature pods and eaten like peas or roasted like nuts, contain high levels of vitamin c and moderate amounts of vitamin B and dietary minerals. Mature seed yield 38 – 40 % edible oil called Ben oil from its high concentration of behenic acid. The refined oil is clear and odorless and resists rancidity. The seed cake remaining after oil extraction may be used as a fertilizer or as a flocculent to purify water. Moringa seed oil also has potential for use as a biofuel. The roots are shredded and used as a condiment with sharp flavor qualities deriving from significant content of polyphenols. (Torondel, *et al*., 2014).

2.3.4 **Uses of *Moringa oleifera***

It is used for hand washing and water purification.

The bark sap, roots, leaves, seeds and flowers are used in traditional medicine, including how it might affect blood lipid profiles, although it is not effective as a drug for diagnosing, treating or presenting any human diseases.

2.3.5 **Potential Adverse Effects**

Various adverse effects may occur from consuming Moringa bark, roots or flowers as these components contain chemicals that appear to be toxic when eaten. But the seed is 100 % edible and free from all chemical components. (Olson, 2010).

2.3.6 **Antimicrobial Effect of *Moringa oleifera* seed**

Two approaches were used for the evaluation of the antimicrobial activities of the plant extracts as described by (Okigbo *et al*., 2003) Antimicrobial activity of the extracts was determined by Agar-me diffusion method using the test organisms, *E. coli* and *S. aureus* an agar media was prepared and a sterile cork borer of about 6 mm in diameter was use to

bore holes on the agar media. The already characterized test was swabbed on the solid agar media. Aqueous liquid of 0.2 ml of the extract was introduced in the holes made on the agar media containing each isolate of organisms at different concentrations of (1, 0.5, 0.25, 0.125, 0.0 625 mg/ml) of the two (2) extracts (*Moringa oleifera* and J. Curcas). A control hole where the solvent used for the extraction was added and the plates were incubated at 37 ^{o}C for 24 hours in the incubator. The ability of the various extracts to inhibit growth of the clinically significant bacteria was measured and recorded as diameter of the zone of inhibition in cm. The result of this investigation revealed that the leaf extracts of *Moringa oleifera* and jaropha curcas possesse appreciable antimicrobial activity against staphylococcus aureus, and escheriehia coli and staphylococcus aureus at various concentrations the Minimum Iinhibition Concentration of both leaf extracts on the test organism ranged between 0.250 mg/ml and 0.125 mg/ml.

Quantitative physiochemical screening in percentage of the dried leaf extracts of *M. olefera* and J. curcaus revealed the presence of some phytochemical constituents (Flavonoids, alkaloids, tannin and saponins), (Rehilla *et al*., 1994) observed that there is need for local herbs to be evaluated for photochemistry to determine the potential of indigenous source of medicine. The observed antimicrobial properties could be due to the presence of these bioactive compounds and further substantial's the use of *Moringa oleifera* and jatropha curcas leaf extracts in medicine. The extracts in correct doses can successfully be used in vivo to inhibit and eventually kill the test bacteria used in this study. (Okorondu *et al*., 2015).

2.3.7 **Extraction of *Moringa oleifera* Seed**

It is known that *Moringa oleifera* contains a natural coagulant in the seeds. The method using salt water to extract the active coagulation component from *Moringa oleifera* seed

was developed and compared with the conventional method using water. In this research the active coagulation component was purified from a Neal solution crude extract of *Moringa oleifera* seed. The active component was isolated and purified from the crude extract through a sequence of steps that included salting-out by dialysis, removal of lipids and carbohydrate by homogenization with acetone, and anion exchange specific coagulation activity of the active material increased up to 34 times more than the crude extract after the ion exchange. Its active component was not the same as that of water extract. The molecular weight was about 3000 g. The lowly method and the phenol – sulfuric acid method indicated that the active component was neither protein nor polysaccharides. The optimum pH of the purified active component for coagulation of turbidity was pH 8 and above, different from the conventional water extracts, the active component can be used for water with low turbidity without an increase in the dissolved organic (Baptista and Coldebella, 2015).

2.3.8 **Nutritional Value of *Moringa oleifera* Seed**

Moringa oleifera seed is used for culinary and for water purification. The seeds of *Moringa oleifera* plants are among the most nutritious and useful botanical product. These versatile seeds can be used in variety of ways including as medicinal, as nutritional supplement and for industrial and agricultural purposes. Moringa seeds are edible in both fresh and dried forms and, along with the seed pods that contain them, can be prepared in numerous ways as both food and medicine. (Okorondu *et al*., 2015).

2.3.9 ***Moringa oleifera* Seeds and Toxicity**

(Berger *et al* .,1984) carried out a study to determine the potential risks associated with the use of the seeds in water treatment. In that study it was concluded that *Moringa oleifera* seeds as water purifiers may not constitute a serious health hazard. To date, all

the studies have concluded that there is no evidence to suggest any acute or chronic effects on humans, particularly at the low doses required for water treatment (Dishua, 2000).

2.3.10 **Composition of *Moringa Oleifera* seed**

The constituents of *Moringa oleifera* seeds are the same but their proportions vary depending on the location the plant is grown. A study by (Anwar and Rashid, 2007) has shown that the seed from *Moringa oleifera* plant contains oil, moisture, fiber ash and protein in varying proportions. In the study it was reported that *Moringa oleifera* seed obtained from the North West frontier province of Pakistan contained 34.80 % oil, 31.65 % protein, 7.54 % fiber, 8.90 % moisture and 6.53 % ash contents. In another study by (Oluduro and Aderiye, 2007), the *Moringa oleifera* seed powder was shown to contain 37.8 % protein, 36.2 % fat, 3.67 % crude fiber and 9.48 % ash. In the study it was additionally reported that the seeds are also rich with about 129.6, 103.5, 701, 34.6 and 5.4 mg/L of magnesium, potassium, sodium, calcium and iron respectively. The seeds have been reported by (Folkard and Sutherland, 2002) to contain water soluble, positively charged proteins (Molecular weight 13 g and iso electric pH 10-11) that act as an effective coagulant for water and waste water treatment.

2.3.11 **Treatment of Greywater Using *Moringa Oleifera* Seeds**

Moringa oleifera seeds treat water on two levels, acting both as a coagulant and an antimicrobial agent. It is generally accepted that Moringa works as a coagulant due to positively charged, water-soluble proteins, which bind with negatively charged particles (silt, clay, bacteria, toxins, etc) allowing the resulting “flocs” to settle to the bottom or be

removed by filtration. The antimicrobial aspects of Moringa continue to be researched. Findings support recombinant proteins both removing microorganisms by coagulation as well as acting directly as growth inhibitors of the microorganisms. While there is ongoing research being conducted on the nature and characteristics of these components, it is accepted that treatments with Moringa solutions (Folkard *et al*., 1996)

2.4 **Grey Water**

Grey water is gotten from the bathroom sinks, showers, tubs, and washing machines. It is not gotten from water that has come in contact with feces, neither from the toilet or from washing diapers, grey water may contain traces of dirt, food, grease, hair and certain house hold products.

Grey water (also spelled as gray water) or silage in wastewater is generated in households or office buildings, from streams without fecal contamination. Sources of grey water include e.g. sinks, showers, bath, washing machines or dish washers. As grey water contains fewer pathogens than domestic wastewater, it is generally safer to handle and easier to treat and reuse onsite for toilet flushing landscape or crop irrigation, and other non-potable uses. However, the use of non-toxic and low-sodium soap and personal care products is recommend in protecting vegetation when reusing grey water for irrigation purposes. The application of grey water reuse in urban water systems provides substantial benefits for both the water supply subsystem by reducing the demand for fresh clean water as well as the wastewater subsystem by reducing the amount of waste water required to be conveyed and treated (Behzadian and Kapelan, 2015).

Grey water, by definition, does not include the discharge of toilet of faculty contaminated wastewater of any kind, which is designated sewage or black water to indicate it contains human waste. However, under certain conditions traces of feces, and therefore pathogens,

might enter the grey water stream via effluent from the shower or washing machine (Behzadian and Kapelan, 2015). Table 2.2 shows the compositions of grey water.

2.4.1 **Composition of Grey Water**

Table 2.2 Composition of grey water

Grey water Source	Possible Contents
Automatic clothes washer	Suspended solids (dirt, lint), organic material, oil and grease, sodium, nitrates and phosphates (from detergent), increased salinity and pH, bleach
Automatic dishwasher	Organic material and suspended solids (from food), bacteria, increased salinity and pH, fat, oil and grease, detergent
Bathtub and shower	Bacteria, hair, organic material and suspended solids (skin, particles, lint), oil and grease, soap and detergent residue
Sinks, including kitchen	Bacteria, organic matter and suspended solids (food particles), fat, oil and grease, soap and detergent residue

Source: (Aifa *et al*., 2014).

2.4.2 **Reuse of Grey Water**

Most grey water can reuse for irrigation purpose, grey water is assume to have some black water-type components which Include pathogen, it should be applied below the surface (e.g. via drip line on top of the soil, under mulch, or in mulch – filled trenches) and not sprayed, as there is a danger of inhaling the water as an aerosol. (Igboro, 2015)

In any grey water system, it is important to avoid toxic materials such as bleaches bath salts, artificial dyes, chlorine-based cleansers, strong acids/alkali, solvents, and products containing boron, which is toxic to plants at high levels. Most cleaning agents contain

sodium salts, which can causes excessive soil alkalinity that inhibit seed germination and destroy the structure of the soils by dispersing. Clay soils watered with grey water can be amended with gypsum (calcium sulfate) to reduce the pH. Grey water containing ammonia is safe for plants. In 2010 studies showed that grey water irrigation use, found no major health effects on plants. (Behzadian and Kapelan, 2015).

Some grey water may be applied directly from the sink to the garden or container field, receiving further treatment from soil life and plant roots. Indoor recycled grey water from showers and bathtubs are used for flushing toilets in most European and Australian jurisdictions and in United States they have adopted the international plumbing code. Such a system could provide an estimated 30 % reduction in water use from average household. The danger of biological contaminant is avoided by using.

- A clean tank, to eliminate floating and sinking items
- An intelligent control mechanism that flushes the collected water if it has been stored longs enough to be hazardous. This completely avoids the problems of filtration and chemical treatment. The uniform plumbing code, adopted in some U.S jurisdictions prohibits grey water use indoors.

Grey water recycling without treatment is used in certain areas where potable water is not required (e.g. garden and land irrigation, toilet flushing). Rain water is already fairy clean to begin with, as long as it has not been polluted with non-degradable chemicals (thus using natural cleaning product instead). It is not recommended to use grey water that has undergo filtration for more than 24 hours because of bacteria builds up.(Igboro, 2015)

2.4.3 **Benefits of Reuse**

Demand on conventional water supplies and pressure on sewage treatment systems is reduced by the use of reuse grey water. Reuse grey water also reduces the volume of sewage effluent entering water courses which can be ecologically beneficial. In time of drought especially in urban areas. Grey water reuse in genders or toilet systems helps to achieve some of the goals of ecologically sustainable development.

The potential ecological benefits of grey water recycling include

- Reduced freshwater extraction from rivers and aquifers
- Less impact from septic tank and treatment plant infrastructure
- Reduced energy use and chemical pollution from treatment
- Groundwater recharge
- Reclamation of nutrients

Greater quality of surface and ground water will be preserved by the natural purification in the top layers of soils than generating water treatment process (Muyibi and Bugaje, 2005).

2.4.4 **Problems Associated With Grey water Treatment**

The potential health and environmental implications associated with the use of chemical include: the influence of pH value on grey water, increased in insoluble residues and increase in volume and metallic content of sludge. (Muyibi and Bugaje, 2005) some of the problems include.

i. The cost of a conventional chemical coagulants used in grey water treatment have been increasing at an alarming rate Thus, making the cost of grey water treatment expensive.

ii. The use of chemical coagulants produces voluminous, non biodegradable sludge after treatment thus possessing disposal problems which justifies doubts raised by earlier workers about the advisability of introducing aluminum into the environment.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

1. *Agave sisalana* leaves: Good quality of *Agave sisalana* leaves were obtained from the Botanical garden of the department of Biological Sciences Ahmadu Bello University Zaria, (Nigeria).Fig 3.1 shows *Agave Sisalana* leaves presented in fig 3.1.



Fig 3.1*: **Agave Sisalana*** **leaves**

2. *Moringa oleifera* seeds: The seed/pods were allowed to dry naturally on the tree. Dry *Moringa oleifera* seed/pods of good quality were obtained from Botanical garden of Department of Biological Sciences Ahmadu Bello University, Zaria (Nigeria).Fig 3.2 shows *moringa oleifera* pods presented in fig 3.2



Fig 3.2 *Moringa Oleifera* Pods

3. *Parkia biglobosa* seeds: Dry *Parkia biglobosa* seed/pods of good quality were obtained for botanical garden of Department of Biological Science Ahmadu Bello University, Zaria (Nigeria).Fig 3.3 shows *Pakia biglobosa* pods presented in fig 3.3.



Fig 3.3 *Parkia biglobosa* pods

4. Grey Water Sampling: The grey water sample used for this study was collected from Queen Amina Hostel of the Ahmadu Bello University, Zaria through the drainage outlet, by filling a 10 liter jerry can with the aid of a funnel; it was conveyed to the Environmental Engineering laboratory of Department of Water

Recourses Engineering Ahmadu Bello University Zaria for analysis. It was then passed through a sand filter which is considered as the filtered sample. Fig 3.4 shows the drainage outlet of grey water from Queen Amina Hostel.



Figure 3.4: Grey Water Drainage

5. Nutrients agar.

3.1.1 **Equipment**

The equipment used in conducting this study is listed as follows.

`Table 3.1 shows equipment used in the study

S/N	Name Of equipment	Model	Manufacturer
1	A four-paddle stirrer	-	Paterson Candy international limited England
2	Weighing balance	PI60N	Gallenkamp England
3	Stop watch		Blackberry Corporation Hungary
4	Magnetic stirrer	S/NO5/SS620	Gallenkamp England
5	Whatman filter paper	NO 1	Whatman International Limited England
6	Funnel		-
7	Muslin cloth (0.15mm)	-	-
8	Domestic sieve (0.8mm)	-	-
9	Graduated laboratory glass	-	Pyrex England
10	Turbidity meter	HACH, 2100P	Hach chemical limited USA
11	Kitchen blender	MJ1731	Nakai, Japa
12	Mortar and Pestle	-	_
13	Spatula	-	-
14	pH meter	H1991000	Hanna instruments USA
15	EC/TDS meter	H198311	Hanna instruments USA
16	Autoclave	-	Surgitech, India
17	Incubator	-	Surgitech, India

3.2 **Reagents**

The reagent used in conducting this study is listed as follows.

Table 3.2 shows the reagent used for the study.

S/N	Reagent	Model	Manufacturer
1	Magnesium Sulphate	S/9240	BDH chemicals England
2	Alkaline Iodide	S/9240	BDH chemicals England
3	Sodium Thiosuphate	S/9240	BDH chemicals England
4	Starch Solution	S/9240	BDH chemicals England
5	Sulphuric Acid	S/9240	Fison Plc England

3.2 **Methods**

3.2.1 **Determination of Grey Water Quality Parameters**

. All the analyses were carried out using standard methods for analysis of water and waste water described in (APHA,1995). All analysis was carried out at the Environmental Engineering laboratory of the Department of Water Resources and Environmental Engineering. While pH, turbidity, electrical conductivity and total dissolves solid were measure using the respective equipment listed in 3.1.

Physico – Chemical Analysis

In order to evaluate the treatment efficiency of *Agave Sisalana leaves*, *Moringa Oleifera* seeds and *Parkia Biglobosa* seeds extracts on the respective substrates (filtered grey water) the following parameters were analyzed

Turbidity: Turbidity is the measure of presence of fine negatively charge particulate

matter suspended in water (cloudiness), usually reported as nephelometric turbidity units (NTU). It is the measure of the extent to which light either absorbed or scattered by suspended solid in water.

***Total Dissolved Solids**:* This was measured in order to estimate all the dissolved solid matter thereby characterize the filtered grey water sample. The measurement of the total solids was carried out according to the standard method for the examination of water and wastewater previously described in (APHA, 1995).

***pH**:* This gives the intensity of acidic or basic character of the extracts. It was measured to determine the influence on the acidity/alkalinity of the grey water sample. Samples were analyzed at ambient temperature with a pH meter model (Hanna, 1991000). The meter was calibrated and analyses were carried out. The pH analysis was carried out throughout the period of study.

***Electrical conductivity**:* It measures the salinity of all the ions dissolved in grey water including negatively charged ions and positively charged ions. The measurement of the electrical conductivity was carried out according to the standard method for the examination of water and wastewater previously described in (APHA, 1995).

Biochemical Oxygen Demand (BOD): The BOD test measures the molecular oxygen consumed during a specific incubation period for the biochemical degradation of organic matters and the oxygen used to oxidize the inorganic matters present in the grey water sample. The BOD test was carried out according to standard method of examination of water and waste water (APHA 1995)

3.2.2 **Preparation of Extracts**

For the purpose of this study the extracts were prepared using the following steps.

A. Preparation of Agave Sisalana Leaves Extract.

- To obtain the leaves, a sharp knife was used to remove it from the sources.
- The leaves were thoroughly washed under running water (tap).
- The leaves were left to dry for 3-5 days and they were ground to fine powder using kitchen blender.(model no mj1731)(Nakai, Japa)
- The powder was sieved using a domestic sieve (0.8 mm).

3.0g of the powder was added to 100ml of distilled water in a 250 ml beaker(pyrex England) and the set up was stirred on a magnetic stirrer at high speed(10 rmp) for 15 min to obtain a suspension. The suspension was first filtered through a muslin cloth with pore hole of 0.15 mm, then through a Whatman No1 filter paper to give a stock solution of 3000mg/l. The stock was then measured for the required dosage of 100 mg/l, 120 mg/land 150 mg/l. The filtrate which contains the bio coagulant will be referred to as "fresh plain extract" When this extract is kept under room temperature condition for more than one day (i.e beyond the day it was prepared) it is referred to as "plain extract.



Figure 3.5: *Agave sisalana* leaves

B. **Preparations of *Moringa oleifera* Seeds Extract**

- To obtain dry shelled kernel of *Moringa oleifera* seeds, the winged seed covers were removed by gentle pounding it with mortar and pestle.
- The seeds were grounded to fine powder using a kitchen blender.(model no mj1731)(Nakai, Japa)
- The powder was sieved using a domestic sieve (0.8 mm).

3.0 g of the powder was added to 100ml of distilled water in a 250 ml beaker(pyrex England) and the set up was stirred on a magnetic stirrer at high speed(10 rmp) for 15 min to obtain a suspension. The suspension was first filtered through a muslin cloth with pore hole of 0.15 mm, then through a Whatman No1 filter, to give a stock solution of 3000 mg/l. The stock was then measured for the required dosage of 100 mg/l, 12 0mg/land 150 mg/l. The filtrate which contains the bio coagulant will be referred to as "fresh plain extract" When this extract is kept under room temperature condition for more than one day (i.e beyond the day it was prepared) it is be referred to as "plain extract.

The seeds and powder of *Moringa oleifera* are presented in plate 3.1 and 3.2 respectively

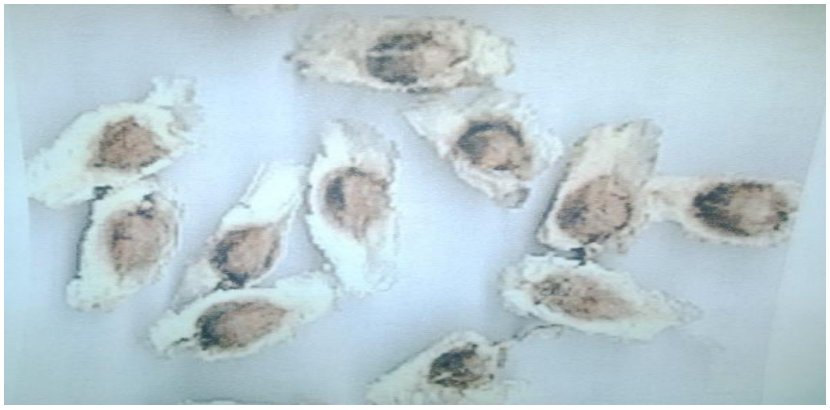


Plate 3.1: *Moringa oleifera* seed



Plate 3.2: *Moringa oleifera* powder

C. **Preparation of *Parkia biglobosa* Seeds Extract**

- To obtain dry shelled kernel of *Parkia biglobosa*, the seed covers were removed by gentle pounding it with mortar and pestle.
- The seeds was grounded to fine powder using a kitchen blender.(model no mj1731)(Nakai, Japa)
- The powder was sieved using a domestic sieve(0.8 mm)

3.0 g of the powder was added to 100ml of distilled water in a 250 ml beaker(pyrex) and the set up was stirred on a magnetic stirrer at high speed(10 rmp) for 15 min to obtain a suspension. The suspension was first filtered through a muslin cloth with pore hole of 0.15 mm, then through a Whatman No1 filter paper, to give a stock solution of 3000 mg/l. The stock was then measured for the required dosage of 100 mg/l, 120 mg/land 150 mg/l. The filtrate which contains the bio coagulant will be referred to as "fresh plain extract" When this extract is kept under room temperature condition for more than one day (i.e beyond the day it was prepared) it is referred to as "plain extract.

The seeds and powder of *Parkia biglobosa* are presented in plate 3.3 and 3.4 respectively



Plate 3.3: *Parkia biglobosa* seeds



Plate 3.4: *Parkia biglobosa* powder

3.2.3 Treatment of Grey Water

A. **Coagulation Treatment.**

The initial turbidity of the grey water was first measured using a tubidimeter (HACH model 2100P), and then standard jar test apparatus was used for coagulation test to determine the minimal dosage of the extracts 100mg/l, 120mg/l and150mg/l, 500ml of

grey water from Queen Amina Hostel was dosed with increasing amounts of the extracts (10 .0ml, 12.0m land 15.0ml). Experiment was stirred for 1minute at rapid mixing (10rpm) followed by slow mixing for 20 minutes (5rpm) and the experiment were turned off to allow settling of the floc for an hour. After settling 20ml of the sample was taken from the supernatant of each beaker using a pipette, and placed in a small bottle for turbidity measurement.

Others parameters such as pH, total dissolved solids, electrical conductivity, Dissolved oxygen and biological oxygen demand, were carried out on the supernatant to determine the effect of the extracts on filtered` grey water from Queen Amina Hostel drainage.

In combination of the extracts the extracts were in ratio 1:1, using the same method of preparation.

B. **Antimicrobial Treatment**

The "Agar plate count" method was adopted for the bacteriological examination of *Agave sisalana, Moringa oleifera* and *Parkia biglobosa* using nutrient agar.

The antimicrobial aqueous extracts of *Agave sisalana* leaves extract, *Morinage oleifera* seeds extract *and Parkia biglobosa* seeds extract were assessed. The grey water sample from Queen Amina Hostel was used for inoculation after serially dilution. The 10^{-4} was inoculated with incremental dose (10.0 ml, 12.0 ml, and 15.0 ml) of the extracts (Banso, 2008), (Folteard, 1994). Numbers of colonies were counted after incubation for 24 hours.

3.2.4 **Treated Grey Water Quality Analysis**

The treated grey water was analyses for physico-chemical analysis using the standard methods stated in section 3.2.1.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Preamble

The results obtained from this study are classified into two parts and presented in figures and tables.

The two parts are:

a. Coagulation of turbid grey water with *Agave sisalana* leaves extract, *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract individual and in combination.
b. Antimicrobial activities of *Agave sisalana* leaves extract, *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract singly and combination.

Table 4.1 shows the average grey water characteristic of the sample from Queen Amina Hostel drainage during the period of three weeks (6^{th}-20^{th} July 2015). The turbidity of the grey water sample measured was between 68 and 76 NTU with pH between 7.87 and 7.48. The conductivity was from 745 μs/cm to 935 μs/cm, the total dissolved solids varied from 31 ppm to 37 ppm the dissolved oxygen concentration varies from 10 ppm to 12 ppm and the Biological oxygen demand from 50 ppm, 23 ppm to 149 ppm, and the BOD value increases at week 3 due to the increase in the population of the students in Queen Amina Hostel, BOD was at its peak. The highest values were use as the control values.

Table 4.1 Characteristics of Queen Amina Hostel Grey water at Zaria.

Source of grey-water	**Queen Amina Hostel**		
Weeks	1	2	3
Depletion of parameters			
Turbidity (NTU)	68	67	76
Electrical conductivity (μs/cm)	745	845	935
pH	7.87	8.07	7.48
Dissolved oxygen concentration (ppm)	10	10	12
Total dissolved solids (ppm)	31	34	37
Biological Oxygen demand (ppm)	50	23	149

Source: field work 6-20th July 2015

4.2.1 **Physico-Chemical Test Result.**

The results of the physico-chemical test are presented in figure, Turbidity, pH, Electrical conductivity, Total dissolved solids, Dissolved oxygen concentration and Biological oxygen demand.

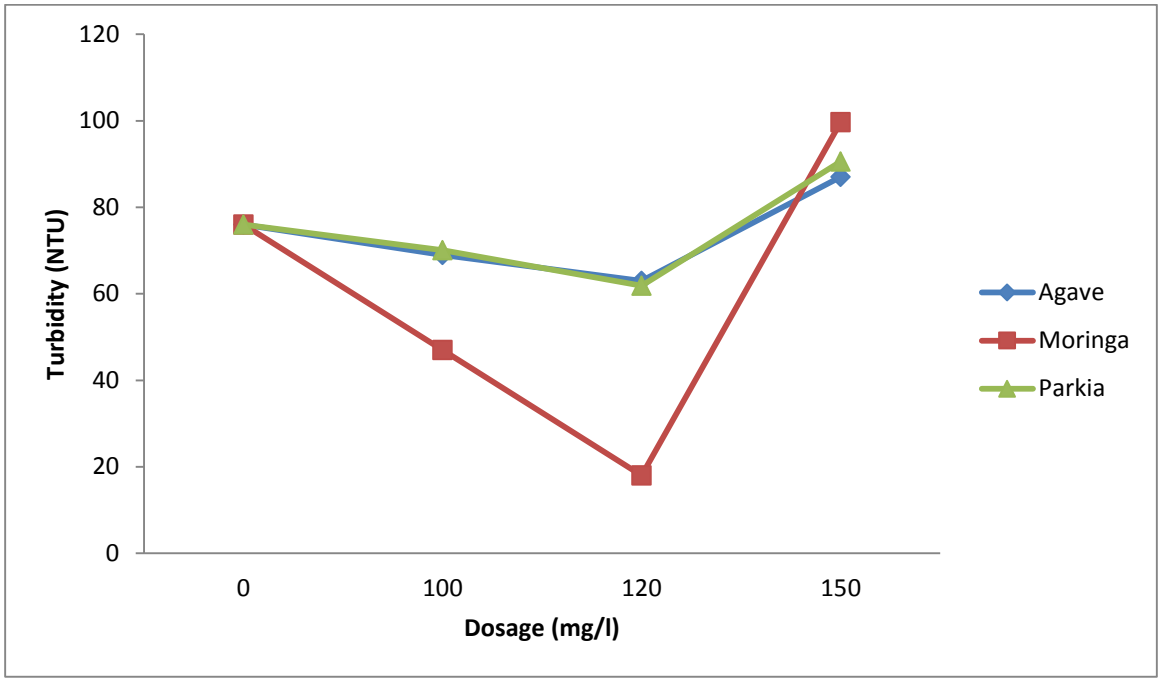


Figure 4.1: **Turbidity characteristics of treated grey water using separate extracts.**

Figure: 4.1 showed the turbidity of the filtered grey water to be 76 NTU, while treatment with 100 mg/l dose of *moringa oleifera* seeds extract recorded 47 NTU leading to 75 % turbidity removals. While treatment with 120mg/l dose from 76 NTU to 18 NTU which lead to 90 % turbidity removal, but an increase in turbidity was observer in 150mg/l dose from 76 NTU to 99.7 NTU which is as a result of colour change.

Treatments with 100 mg/l dose of *Agave sisalana* leaves extract from 76 NTU to 69 NTU indicate 20 % turbidity removal. While treatment with 120 mg/l dose from 76 NTU to 63 NTU which leads to 30 % turbidity removal, but an increase in turbidity was also observe at 150 mg/l dose from 76 NTU to 87 NTU which is also as result of colour change.

Treatments with 100 mg/l dose of *Parkia biglobosa* seeds extract from 76 NTU to 70.1 NTU indicate 10 % turbidity removal. While the treatment with 120 mg/l dose from 76

NTU to 61.9 NTU which leads to 38 % turbidity removal, but an increase in turbidity was also observe at 150 mg/l dose from 76 NTU to 90.6 NTU due to colour change.

The result have confirmed the effectiveness of *Moringa oleifera* seed extracts in coagulation over *Agave sisalana* leaves extracts and *Parkia biglobosa* seed extracts. Despite the crude protein in *Moringa oleifera* seed. As cited by (Oluduro and Aderyi, 2006) and (Komami, 2012).

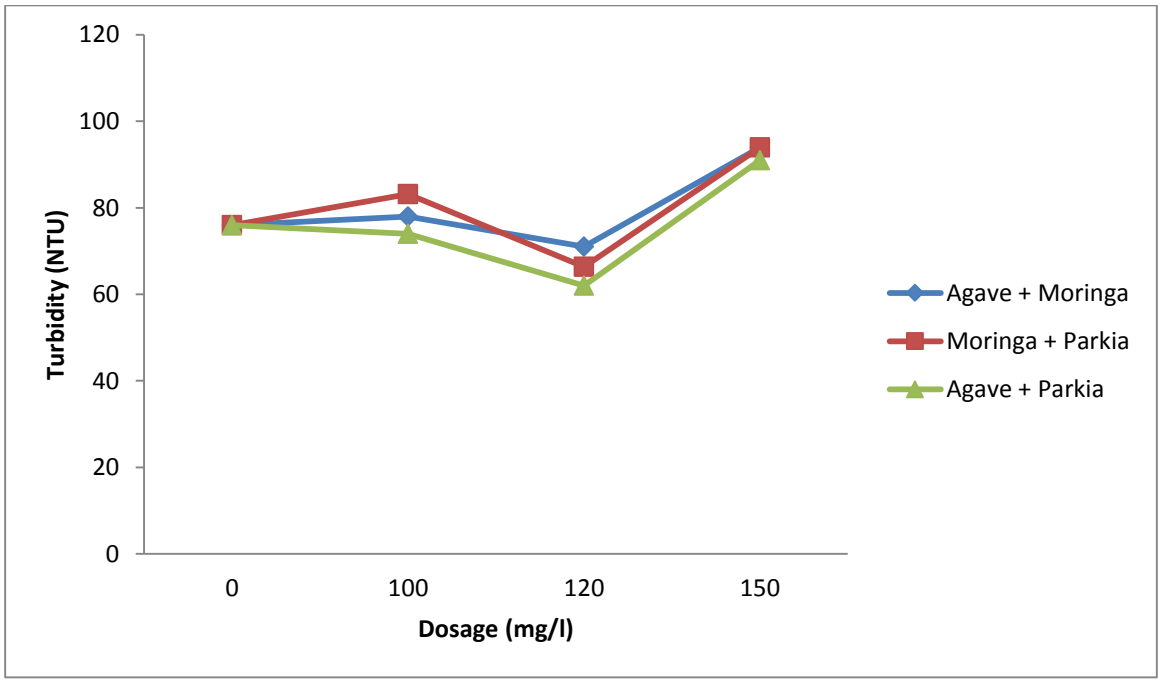


Figure 4.2: Turbidity of treated grey water with combined extracts.

Figure: 4.2 also shows the combined use of both extracts in 1: 1 of *Moringa oleifera* seeds and *Agave sisalana* leaves, the turbidity removal of 15 % was achieved, from 76 NTU to 71 NTU at 120 mg/l dose, but at dosage 100 mg/l from 76 NTU to 78 NTU and 150 mg/l dosage from76 NTU to 94 NTU increased in turbidity was observed.

Also in combination use of both extracts in 1:1 of, *Moringa oleifera* seeds and *Parkia biglobosa* seeds,

Showed turbidity removal of 25 % with treatment with 120 mg/l dose from76 NTU to 66.4 NTU, but an increase in turbidity was observed at 100 mg/l from 76 NTU to 83.2 NTU and 150 mg/l dosage from 76 NTU to 94 NTU.

While for the combined use of both extracts of *Parkia biglobosa* seeds and *Agave sisalana* leaves, it shows turbidity removal of 35 % with treatment with 120 mg/l dose from 76 NTU to 62 NTU, but an increase in turbidity was observed at 100 mg/l from 76 NTU to 74 NTU and 150 mg/l dosage from 76 NTU to 91 NTU.

This phenomenon between this extracts in regard to their increases in turbidity in combination is unknown. As cited by (Djasro, 2010)

pH

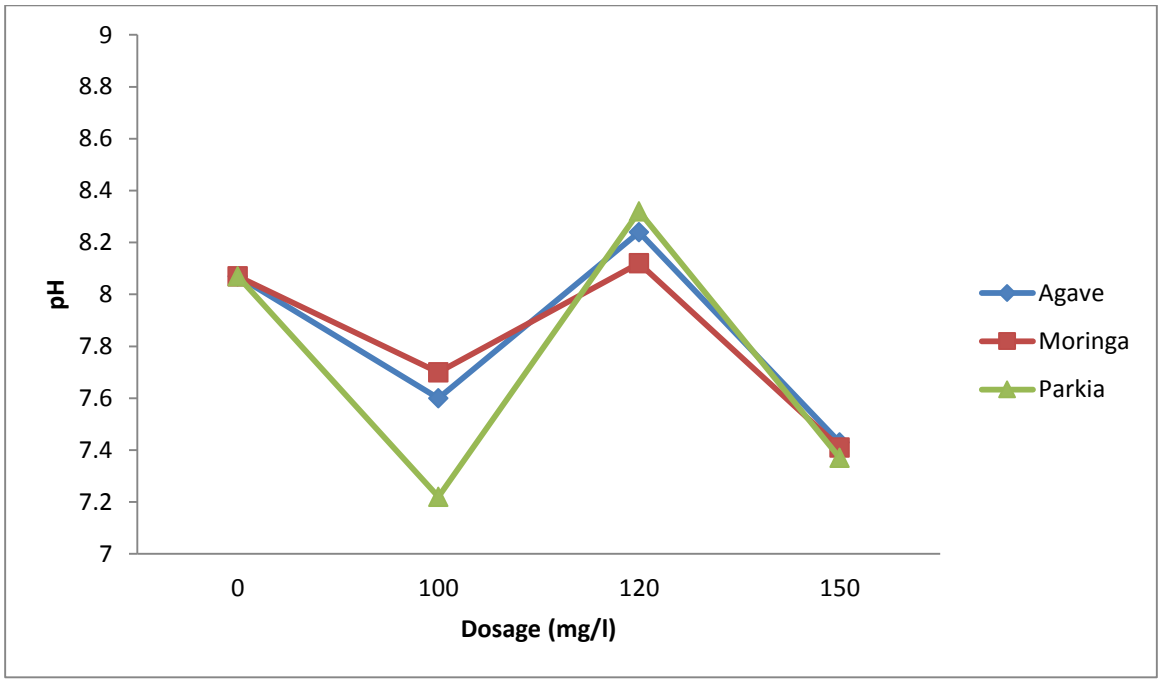


Figure 4.3: pH characteristics of treated grey water using extracts.

Figure: 4.3 Shows pH decreasing from 8.07 to 7.6 and 7.43 at dosage 100 mg/l, and 150 mg/l but an increase in pH was observed from 8.07 to 8.24 at dose 120 mg/l when *Agave sisalana* leaves extract was used as treatment.

Decrease in pH from 8.07 to 7.7 and 7.41 at dosage 100 mg/l and 150 mg/l but an increase was observed from 8.07 to 8.12 at dose 120mg/l when *Moringa oleifera* seeds extract was use for treatment.

Decrease in pH from 8.07 to 7.22 and 7.37 at dosage 100 mg/l and 150mg/l but an increase in pH was observed from 8.07 to 8.32 at dose 120 mg/l when *Parkia biglobosa* seeds extract was used for treatment.

This is between the standard limit by World Health Organization (WHO, 2006). Increase in pH was observed at 120 mg/l dose in all the extracts which is ranging from 8.07 to 8.12, 8.24 and 8.32 respectively. This is as a result of low affinity of H+ in the grey water leading to the present of more OH- which can cause an increase pH. As cited by (Djsaro, 2010)

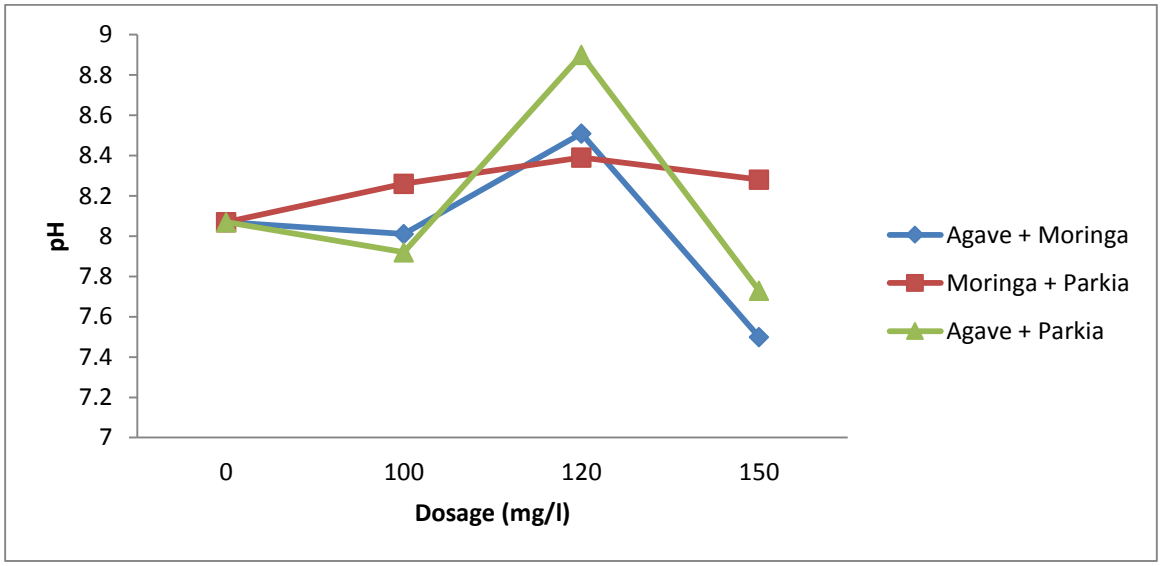


Figure 4.4: pH of treated grey water with combined extracts.

Figure: 4.4 also shows the combined use of in 1:1 of *Agave sisalana* leaves and *Moringa oleifera* seeds extracts

pH decreasing from 8.07 to 8.01 at dose 100 mg/l and from 8.07 to 7.5 at dose 150 mg/l but increased in pH at 120 mg/l dose.

Also combination use of both extracts in 1:1 of *Moringa oleifera* seeds and *Parkia biglobosa* seeds

pH increase from 8.07 to 8.26, 8.28 and 8.39 at 100 mg/l, 120 mg/l and 150 mg/l.

While for both extracts in 1:1 of *Agave sisalana* leaves with *Parkia biglobosa* seeds

pH decrease from 8.07 to 7.92 and 7.73 at 100 mg/l and 150 mg/l dosage, but an increase pH from 8.07 to 8.90 at 120 mg/l dose.

In combined increased in pH was as a result of colour change.

It was also observed that 120 mg/l dose pH increases and at the same 120 mg/l dose turbidity decreases. As cited by (Altaher and Alghamdi, 2011) the highest removal efficiency in turbidity was found at higher pH.

Electrical Conductivity

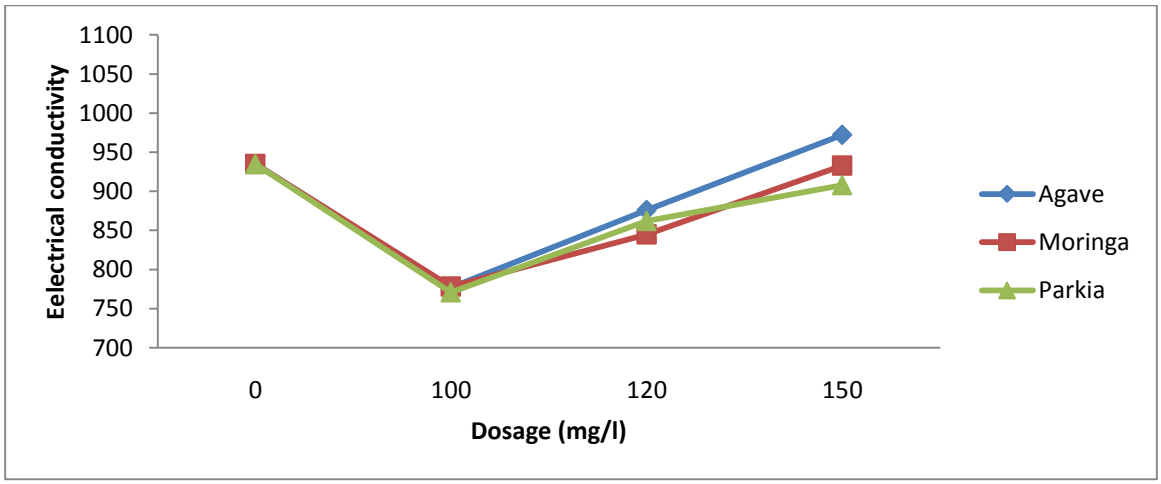


Figure 4.5: Electrical conductivity of treated grey water using separate extracts.

Figure: 4.5 result shows a decrease in EC from 935 µs/cm to 777 µs/cm and 876 µs/cm at dosage 100 mg/l and 120 mg/l, but an increase in EC was observe at dose 150 mg/l from 935 µs/cm to 972 µs/cm when *Agave sisalana* leaves extract was use for treatment.

Also when *Morniga oleifare* seeds extract was used a decrease in EC from 935 µs/cm to 778 µs/cm, 842 µs/cm and 933 µs/cm at dosages 100 mg/l, 120 mg/l and 150 mg/l was observed.

While using *Parkia biglobosa* seeds extract a decreases in EC was observed from 935 µs/cm to 771 µs/cm, 862 µs/cm and 908 µs/cm at dosages 100 mg/l, 120 mg/l and 150 mg/l.

It is known that turbidity affect EC, increase in turbidity result to increase in EC.As cited by (Saulawa, 2010).

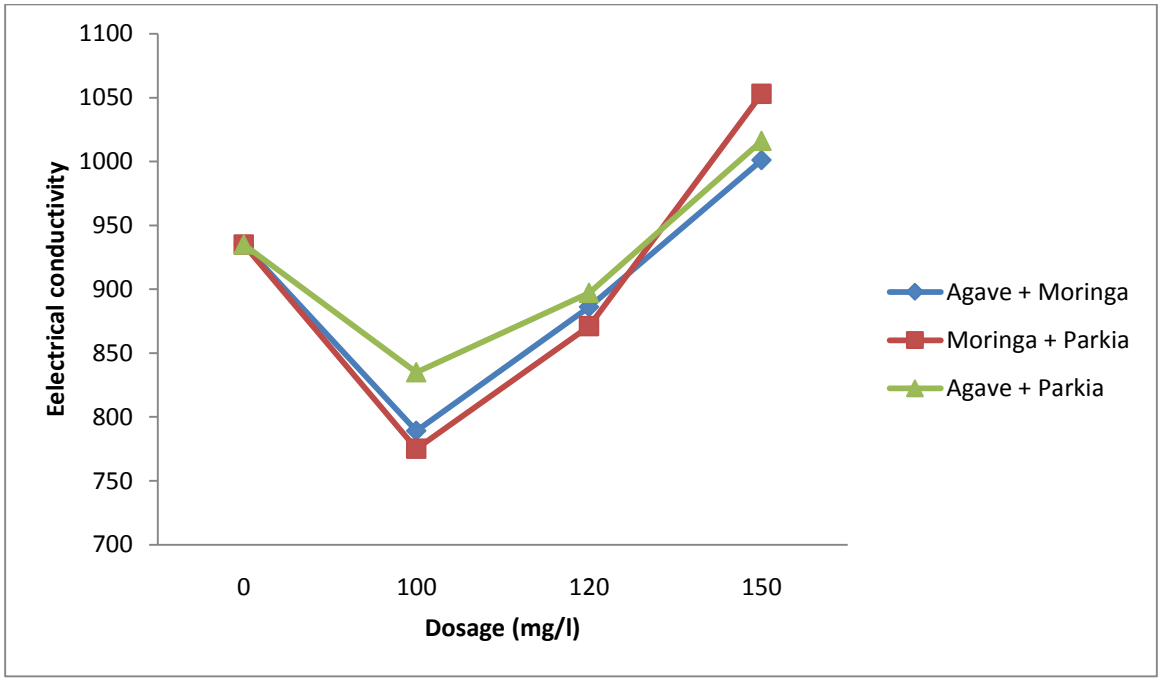


Figure 4.6: Electrical conductivity of treated grey water with combined extracts.

Figure: 4.6 also show the combined use in 1:1 of *Agave sisalana* leaves extract and *Moringa oleifera* seeds extract. The result shows decrease from 935 µs/cm to 789 µs/cm

and 886 µs/cm at dosage 100 mg/l and 120 mg/l, but an increase in EC was observed at 150 mg/l dose from 935 µs/cm to 1001 µs/cm.

Also in combination use of both extracts in 1:1of *Moringa Oleifera* Seeds and Parkia B*iglobosa* Seeds,

This result shows a decrease in EC from 935 µs/cm to 775 µs/cm and 871 µs/cm at dosages 100 mg/l and 120 mg/l, but an increase in EC from 935 µs/cm to 1053 µs/cm at 150 mg/l dose.

While for both extracts in 1:1 of *Agave sisalana* leaves and *Parkia biglobosa* seeds shows a decrease in EC from 935 µs/cm to 835 µs/cm and 897 µs/cm at dosage 100 mg/l and 120 mg/l, but an increase in EC from 935 µs/cm to 1016 µs/cm at 150 mg/l dose was observed. Generally it is known that introduction of new ions increases electrical conductivity. As cited by (Ghebremichael, 2007).

Total Dissolved Solids

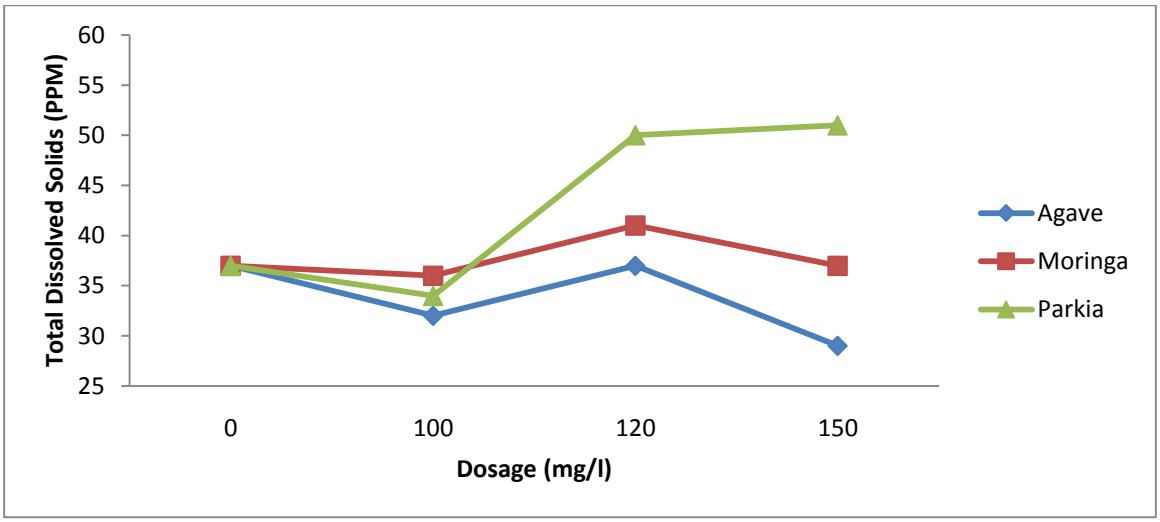


Figure 4.7: Total dissolved solids of treated grey water using separate extracts.

Figure: 4.7 shows the total dissolves solids of *Agave sisalana* leaves extract, *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract.

Decrease in TDS from 37 ppm to 32 ppm and 29 ppm at dosages 100 mg/l and 150 mg/l was observed, but at 120 mg/l dose there was no change, when *Agave sisalana* was used as treatment.

Using *Moringa oleifera* seeds extract as treatment decreases in TDS from 37 ppm to 36 ppm at 100 mg/l dose, but an increase in TDS was observed from 37 ppm to 41 ppm at dose 120 mg/l, no change occur at 150 mg/l.

Also when *Parkia biglobosa* seeds extract was used as treatment, decrease in TDS was observed at dose 100 mg/l from 37 ppm to 34 ppm, but an increase in TDS from 37 ppm to 50 ppm and 37 ppm to 51 ppm was observed at dosage 120 mg/l and 150 mg/l.

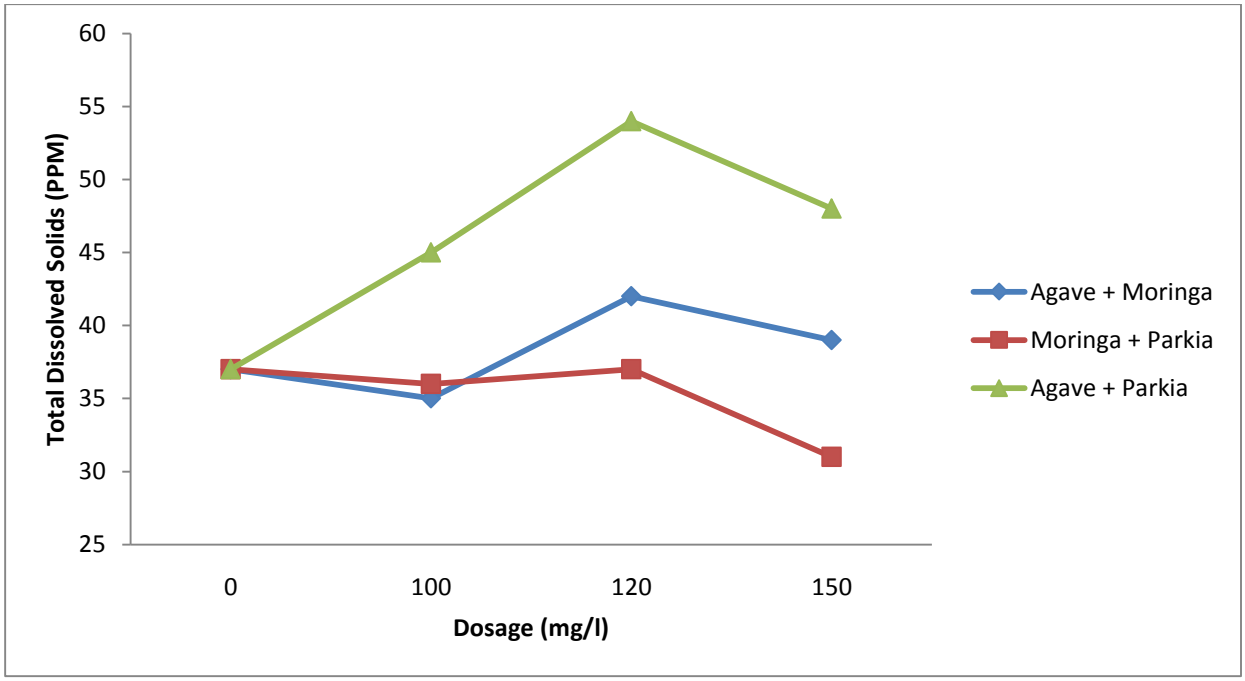


Figure 4.8: Total dissolved solids of treated grey water with combined extracts.

Also presented in figure 4.8 is the combined use of extracts from *Agave sisalana* leaves and *Moringa oleifera* seeds, *Moringa oleifera* seeds and *Parkia biglobosa* seeds and *Parkia biglobosa* seeds and *Agave sisalana* leaves in 1:1.

This result shows a decrease in TDS from 37 ppm to 35 ppm at dosage 100 mg/l, and an increase in TDS from 37 ppm to 42 ppm and 39 ppm at dosage 120 mg/l and 150 mg/l when *Agave sisalana* leaves and *Morinag oleifera* seeds extracts was use as treatment.

Also when *Moringa oleifera* seeds and *Parkia biglobosa* seeds extracts was used as treatment, decrease in TDS from 37 ppm to 36 ppm and from 37 ppm to 31 ppm was observer at dosage 100 mg/l and 150 mg/l, but at dose 120 mg/l no change occurred.

While for both extracts *Agave sisalana* leaves and *Parkia biglobosa* seeds increase in TDS from 37 ppm to 45 ppm, 54 ppm and 48 ppm was observed at dosages 100 mg/l, 120 mg/l and 150 mg/l.

This result shows their natural absorbent for coagulant, flocculants in the treatment of grey water. As cited by (Aifa *et al*., 2014).

Dissolved Oxygen

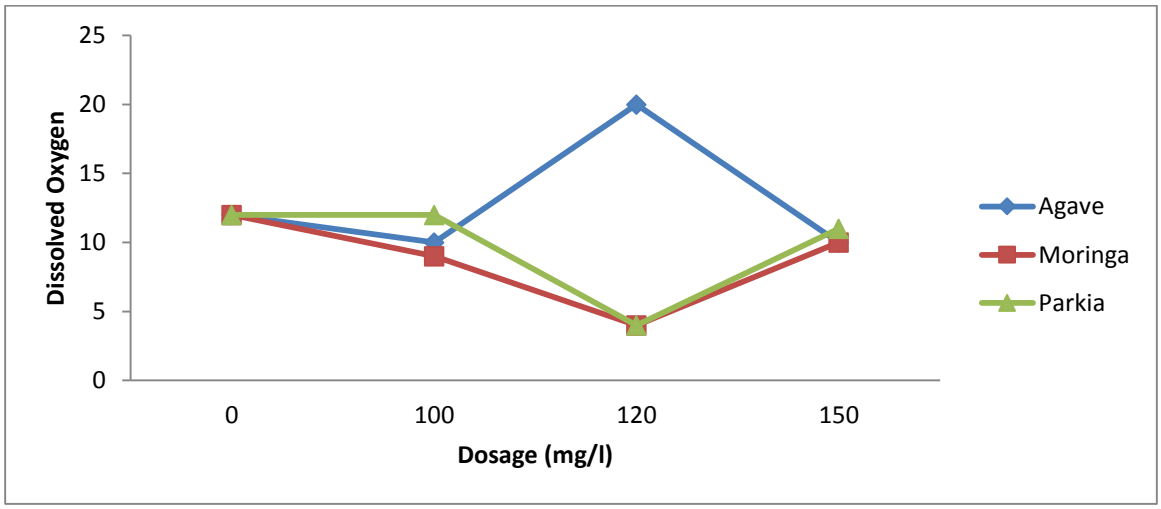


Figure 4.9: Dissolved oxygen content of treated grey water using separate extracts.

Figure: 4.9 presents the dissolved oxygen levels in grey water after treatment with the extracts at different dosage.

This result shows a decrease in DO from 12 ppm to 10 ppm at 100 mg/l dose and also at 150 mg/l dose from 12 ppm to 10 ppm, while an increase in DO was observer at dose 120 mg/l from 12 ppm to 20 ppm using *Agave sisalana* leaves extract as treatment.

Using *Moringa oleifera* seeds extract as treatment, decrease in DO was observed from 12 ppm to 9 ppm, 4 ppm and 10 ppm at dosage 100 mg/l, 120 mg/l and 150 mgl/.

Also using *Parkia biglobosa* seeds extract as treatment, decrease in DO was observer from 12 ppm to 4 ppm and 11 ppm at dosage 120 mg/l and 150 mg/l, while at dose 100 mg/l no change occur.

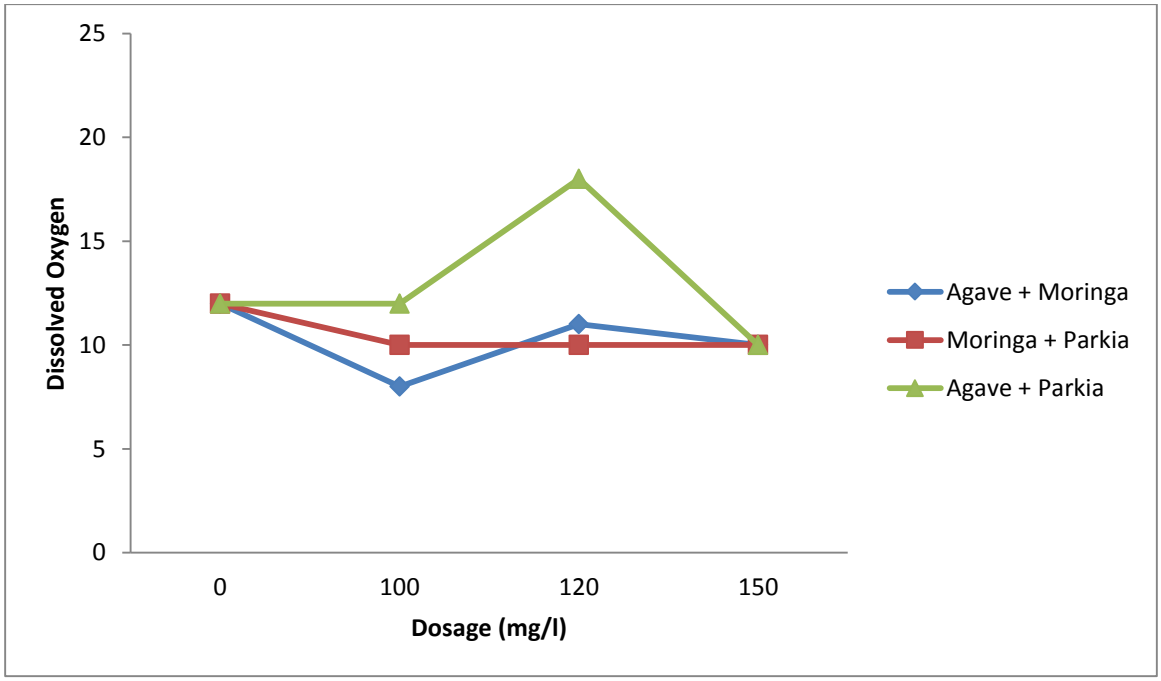


Figure 4.10: Dissolved oxygen content of treated grey water with combined extracts.

Also presented in figure 4.10 is the combined use of the extracts from A*gave sisalana* leaves and *Moringa oleifera* seeds, *Moringa oleifera* seeds and *Parkia biglobosa* seeds and *Agave sisalana* leaves and *Parkia biglobosa* seeds in 1:1.

This result shows as decrease in DO from 12 ppm to 8 ppm, 11 ppm and 10 ppm at dosage 100 mg/l, 120 mg/l and 150 mg/l while using *Agave sisalana* leaves extract and *Moringa oleifer*a seeds extract as treatment.

Using *Moringa oleifera* seeds and *Parkia biglobosa* seeds extracts as treatment, decrease in DO was observer from 12 ppm to 10 ppm, 10 ppm and 10 ppm at dosage 100 mg/l, 120 mg/l and 150 mg/l.

Also while using *Agave sisalana* leaves and *Parkia biglobosa* seeds extracts as treatment a decrease in DO from 12 ppm to 10 ppm at dose 150 mg/l was observed, while an increase in DO was observed from 12 ppm to 18 ppm at dose 120 mg/l, but no change occur at dose 100 mg/l.

Biological Oxygen Demand

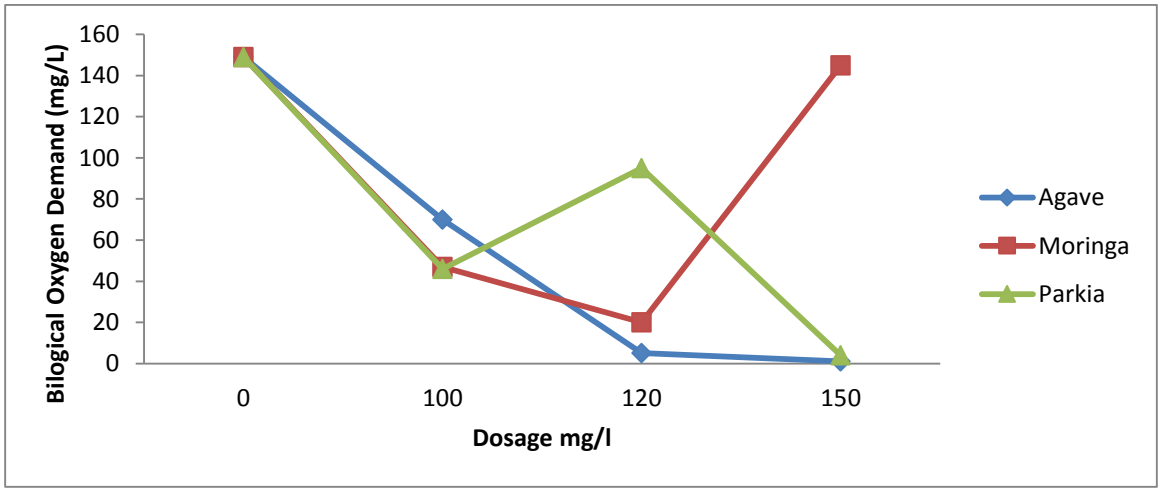


Figure 4.11: Biological oxygen demand of treated grey water using separate extracts.

Figure: 4.11 presents the biological oxygen demand of filtered treated grey water using Agave *sisalana* leaves extract, *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract as treatment samples were incubated in complete darkness at 20 ^{o}C for 5 days.

This result shows a decrease in BOD from 149 ppm to 70 ppm, 5 ppm and 1 ppm at dosage 100 mg/l, 120 mg/l and 150 mg/l when *Agave sisalana* leaves extract was used as treatment resulting to 50 %, 95 % and 99 % BOD removal.

When *Moringa oleifera* seeds extract was used, for treatment a decrease in BOD was observe from 149 ppm to 47 ppm, 20 ppm and145 ppm at dosages 100 mg/l, 120 mg/l and 150 mg/l resulting to BOD removal of 65 %, 80 % and 30 %.

Also, when *Parkia biglobosa* seeds extract was used for treatment a decrease in BOD was observed from 149ppm to 46 ppm, 95 ppm and 4 ppm at dosage 100 mg/l, 120 mg/l and 150 mg/l, with BOD removal of 64 %, 45 % and 96 %.

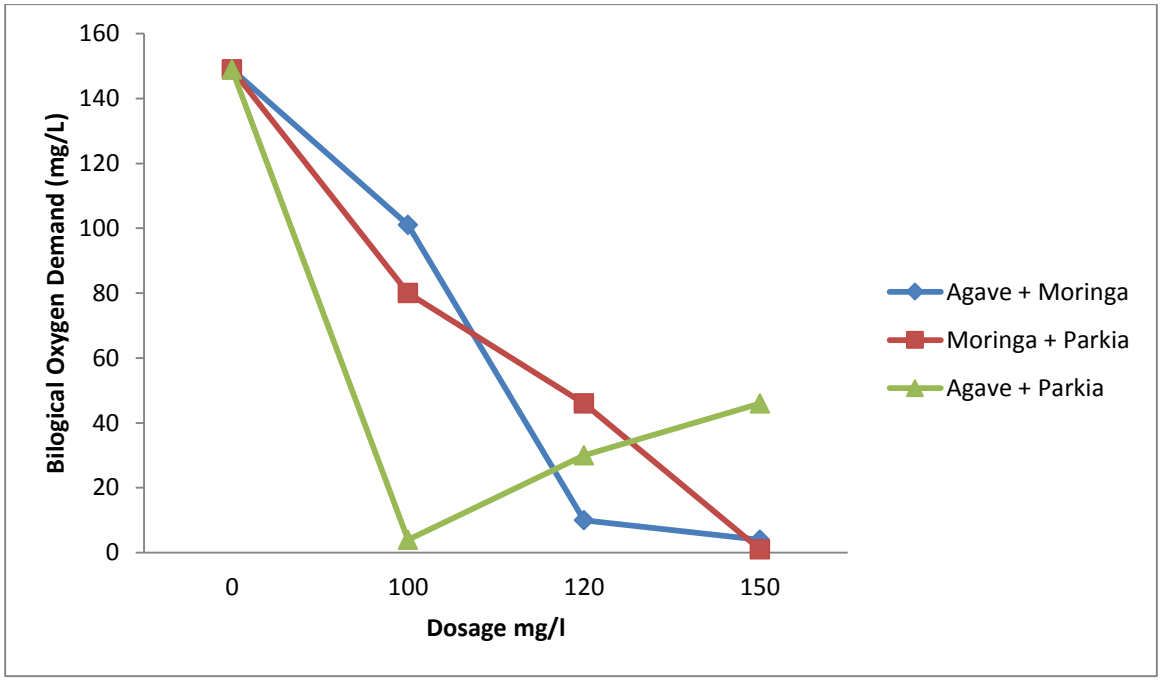


Figure 4.12: Biological oxygen demand of treated grey water with combined extracts

Also presented in Figure 4.12 is the combined use of extracts from *Agave sisalana* leaves and *Moringa oleifera* seeds, *Moringa oleifera* seeds and *Parkia biglobosa* seeds and *Agave sisalana* leaves and *Parkia biglobosa* seeds in 1:1. The result shows a decrease in BOD from 149 ppm to 101 ppm, 10 ppm and 4 ppm at dosages 100 mg/l, 120 mg/l and

150 mg/l resulting to 50 %, 90 % and 96 %. BOD removal when *Agave sisalana* leaves and *Moringa oleifera* seeds extracts was used for treatment.

When *Moringa oleifera* seeds and Parkia biglobosa seeds extracts was used for treatment a decrease in BOD from 149 ppm to 80 ppm, 46 ppm and 1 ppm at dosages 100 mg/l, 120 mg/l and 150 mg/l was observed resulting to BOD removal of 70 %, 85 % and 99 % While for both *Agave sisalana* leaves and *Parkia biglobosa* seeds extracts a decrease in BOD from 149 ppm to 4 ppm, 30 ppm and 46 ppm at dosages 100 mg/l, 120 mg/l and 150 mg/l was observed BOD removals were 96 % 70 % and 64 %.

4.3 **Antimicrobial Analysis**

The results of antimicrobial susceptibility test using *Agave* sisalana leaves extract *Moringa oleifera* seeds extract and *Parkia biglobosa* seeds extract for treatment are presented and discussed below.

The three extracts exhibit antimicrobial activities which are related to physio-chemical analysis of some secondary metabolites which include saponins, glycosides, terpenoids, alkaloids, Flavonoids and tanning (Pinheiro). Tannins have been reported to prevent the development of micro-organisms by precipitating microbial protein and making nutritional protein unavailable for them (Clark, 1981; Gozalel and Mather 1982).

4.3.1 **Antimicrobial Analysis Result**

Table 4.1 to 4.4 present the result of statical analysis using T test to characterize the antimicrobial properties of *Agave Sisalana* leaves extract, *Moringa olerifera* seeds extract and *Parkia biglobosa* seeds extract.

Table 4.2**: Optimum dosage of Agave, Moringa and parkia extracts**

Dosage	No. of colony after treatment with extracts		
	Agave	Moringa	Parkia
100	85	53	90
120	70	50	80
150	50	40	55

Table 4.3: **Optimum dosage Agave of and other extracts**

Dosage	No. of colony after treatment with extracts	
	Agave + Moringa	Agave + Parkia
100	50	60
120	30	40
150	55	60

Table 4.4: **Optimum dosage of Moringa and other extracts**

Dosage	No. of colony after treatment with extracts	
	Agave + Moringa	Moringa + Parkia
100	50	40
120	30	35
150	55	49

Table 4.5: **Optimum dosage of Parkia and other extracts**

Dosage	No. of colony after treatment with extracts	
	Moringa + Parkia	Agave + Parkia
100	40	60
120	35	40
150	49	60

The results of the T test analysis are show below:

Decision Rule

Accept H_o if $t_c < t_t$ (less than)

Reject H_o if $t_c > t_t$ (more than) $t_t = 0.05$ df 2 ($\alpha = 5\%$)

1. $t_c = 2.230 = t_t = 2.920$

   Dosage: Agave

   $t_c = 4.111$ $t_t = 2.920$

   Dosage: Moringa

2. $t_c = 1.942$ $t_t = 2.920$

   Dosage: Parkia

3. $t_c = 1.639$ $t_t = 2.920$

   Dosage: Agave + Moringa in 1:1

4. $t_c = 1.192$ $t_t = 2.920$

   Dosage: Agave + Parkia in 1:1

5. $t_c = 0.264$ $t_t = 2.920$

Dosage: Agave + Moringa in 1:1

6. $t_c = 0.824$ $t_t = 2.920$

   Dosage: Agave + Parkia in 1:1

7. $t_c = 2.421$ $t_t = 2.920$

   Dosage: Moringa + Parkia in 1:1

8. $t_c = 1.588$ $t_t = 2.920$

   Dosage: Agave + Parkia

Significant difference of 2 was obtained in all where t_c is more than t_t which means there is high present of antimicrobial properties in the extract, *Moringa olerifera* seeds extracts t_c is more than the t_t which means it has high present of antimicrobial properties while the remaining extracts t_c is less than t_t which mean they have less antimicrobial properties. *Moringa oleifera* seeds extract is shows to more effective than other extracts at the end of the T test analysis.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusions

Based on the present study, the following conclusions are made.

i. The use of *Agave sisalana* leaves extract in the treatment of grey water is feasible with turbidity removal from 76 NTU to 63 NTU at 120 mg/l dose and colony reduction from 80 cfu to 50 cfu at 150 mg/l.

ii. *Moringa olerifera seeds* separately were found to be more effective in antimicrobial analysis with colony reduction from 80 cfu to 40 cfu.

iii. The combined use of *Agave sisalana* leaves extract and *parkia biglobosa* seeds extract revealed good coagulation properties with turbidity removal of 35 % from 76 NTU to 62 NTU at 120 mg/l.

iv. *Agave sisalana* leaves, *Moringa oleifera* seeds and *Parkia biglobosa* seeds extracts separately can be used as alternative coagulant in grey water treatment due to the following results, turbidity removal for *Agave sisalana* leaves extract was from 76 NTU to 63 NTU at dosage 120 mg/l, pH from 8.07 to 7.43, EC from 935 µs/cm to 777 µs/cm, TDS from 37 ppm to 29 ppm, DO from 12 ppm to 10 ppm and BOD from 149 ppm to 1 ppm leading to 99 % BOD removal. *Moringa oleifera* seeds extract turbidity removal was from 76 NTU to 18 NTU at dosage 120 mg/l, pH from 8.07 to 7.41,EC from 935 µs/cm to 778 µs/cm, TDS no change occur, DO from 12 ppm to 4 ppm and BOD from 149 ppm to 20 ppm leading to 80% BOD removal and *Parkia biglobosa* seeds extract turbidity removal was from 76 NTU to 61.9 NTU at

dosage 120 mg/l, pH from 8.07 to 7.22,EC from 935 µs/cm to 771 µs/cm, TDS from 37 ppm to 34 ppm, DO from 12 ppm to 4 ppm and BOD from 149 ppm to 4 ppm leading to 96 % BOD removal.

v. The optimal dose for turbidity removal for this experiment was at 120 mg/l.

vi. The combine use of the extracts shows no synergetic actions in antimicrobial analysis.

vii. Large scale cultivation and production of *Agave sisalana*, *Moringa oleifera* and *Parkia biglobosa* for grey water treatment will provide job opportunities to a fraction of unemployed youth in Nigerian.

5.2 **Recommendations**

On the basis of the results of this study, the following recommendations are made.

i. Further studies on combined use of *Agave sisalana* leaves extract and *parkia biglobosa* seeds extract in grey water treatment with provision of activated carbon filter for colour removal should be carried out.

ii. Further investigation on the physico-chemical interaction of *Agave sisalana* leaves extract and *moringa oleifera* seeds extract should be carried out.

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Appendix 1-6

Turbidity						
	Agave	Moringa	Parkia	Agave + Moringa	Moringa + Parkia	Agave + Parkia
0	76	76	76	76	76	76
100	69	47	70.1	78	83.2	74
120	63	18	61.9	71	66.4	62
150	87	99.7	90.6	94	94	91

pH						
	Agave	Moringa	Parkia	Agave + Moringa	Moringa + Parkia	Agave + Parkia
0	8.07	8.07	8.07	8.07	8.07	8.07
100	7.6	7.7	7.22	8.01	8.26	7.92
120	8.24	8.12	8.32	8.51	8.39	8.9
150	7.43	7.41	7.37	7.5	8.28	7.73

Electrical Conductivity						
	Agave	Moringa	Parkia	Agave + Moringa	Moringa + Parkia	Agave + Parkia
0	935	935	935	935	935	935
100	777	778	771	789	775	835
120	876	845	862	886	871	897
150	972	933	908	1001	1053	1016

Total Dissolved Solids (PPM)						
	Agave	Moringa	Parkia	Agave + Moringa	Moringa + Parkia	Agave + Parkia
0	37	37	37	37	37	37
100	32	36	34	35	36	45
120	37	41	50	42	37	54
150	29	37	51	39	31	48

Dissolved Oxygen						
	Agave	Moringa	Parkia	Agave + Moringa	Moringa + Parkia	Agave + Parkia
0	12	12	12	12	12	12
100	10	9	12	8	10	12
120	20	4	4	11	10	18
150	10	10	11	10	10	10

Biological Oxygen Demand (mg/L)						
	Agave	Moringa	Parkia	Agave + Moringa	Moringa + Parkia	Agave + Parkia
0	149	149	149	149	149	149
100	70	47	46	101	80	4
120	5	20	95	10	46	30
150	1	145	4	4	1	46

Appendix 7

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Dosage & Agave	3	-.999	.021
Pair 2	Dosage & Moringa	3	-.983	.119
Pair 3	Dosage & Pakia	3	-.992	.081
Pair 4	Agave & Agave + Moringa	3	-.269	.827
Pair 5	Agave & Agave + Pakia	3	-.082	.948
Pair 6	Moringa & Agave + Moringa	3	-.472	.687
Pair 7	Moringa & Agave + Pakia	3	-.835	.371
Pair 8	Parkia & Moringa + Pakia	3	-.801	.408
Pair 9	Parkia & Agave + Pakia	3	-.240	.846

Appendix 8

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Dosage – Agave	55.00000	42.72002	24.66441
Pair 2	Dosage – Moringa	75.66667	31.87998	18.40592
Pair 3	Dosage – Pakia	48.33333	43.10839	24.88864
Pair 4	Agave - Agave + Moringa	23.33333	24.66441	14.24001
Pair 5	Agave - Agave + Pakia	15.00000	21.79449	12.58306
Pair 6	Moringa - Agave + Moringa	2.66667	17.50238	10.10500
Pair 7	Moringa - Agave + Pakia	6.33333	13.31666	7.68838
Pair 8	Parkia - Moringa + Pakia	33.66667	24.09011	13.90843
Pair 9	Parkia - Agave + Pakia	21.66667	23.62908	13.64225

Appendix 9

Paired Samples Test

		Paired Differences	
		95% Confidence Interval of the Difference	
		Lower	Upper
Pair 1	Dosage – Agave	-51.12241	161.12241
Pair 2	Dosage – Moringa	-3.52760	154.86094
Pair 3	Dosage – Pakia	-58.75385	155.42051
Pair 4	Agave - Agave + Moringa	-37.93647	84.60314
Pair 5	Agave - Agave + Pakia	-39.14053	69.14053
Pair 6	Moringa - Agave + Moringa	-40.81166	46.14499
Pair 7	Moringa - Agave + Pakia	-26.74707	39.41374
Pair 8	Parkia - Moringa + Pakia	-26.17648	93.50981
Pair 9	Parkia - Agave + Pakia	-37.03122	80.36455

Appendix 10

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	Dosage – Agave	2.230	2	.156
Pair 2	Dosage – Moringa	4.111	2	.054
Pair 3	Dosage – Pakia	1.942	2	.192
Pair 4	Agave - Agave + Moringa	1.639	2	.243
Pair 5	Agave - Agave + Pakia	1.192	2	.355
Pair 6	Moringa - Agave + Moringa	.264	2	.817
Pair 7	Moringa - Agave + Pakia	.824	2	.497
Pair 8	Parkia - Moringa + Pakia	2.421	2	.137
Pair 9	Parkia - Agave + Pakia	1.588	2	.253