USE OF *MORINGA OLEIFERA* AND *MAGNIFERA INDICA* IN RIVER WATER TREATMENT

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CERTIFICATION PAGE

This is to certify that this project titled **"USE OF *Moringa oleifera* AND *Magnifera indica* IN WATER TREATMENT"** was carried out by NWOSU JUDE SOMTOCHUKWU, with Registration Number 2017224046 in the Department of Civil Engineering, Nnamdi Azikiwe University, Awka.

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APPROVAL PAGE

This is to certify that this project work titled **"USE OF *Moringa oleifera* AND *Magnifera indica* IN WATER TREATMENT"** is an authentic academic work undertaken by NWOSU JUDE SOMTOCHUKWU with Registration Number 2017224046 in the Department of Civil Engineering, Faculty of Engineering, Nnamdi Azikiwe University, Awka, Anambra State.

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DEDICATION

This work is dedicated to God Almighty, who guided me all through my stay in school. And also to my parents Mr and Mrs Pius Nwosu who struggled and made sure that I'm able to acquire this level of knowledge. I am forever grateful.

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All gratitude and adoration goes to the Almighty God for His provision and protection all through my stay in school.

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ABSTRACT

This study lays emphasis on the use of *Moringa oleifera* and *Magnifera indica* (Mango) as a natural coagulant for water treatment. This is so because *Moringa oleifera* and *Magnifera indica* seed powder have gained popularity as natural coagulants in water treatment processes due to their effectiveness and eco-friendliness. The demand for fresh water has continued to increase at a rapid pace due to the growing population, increasing urbanization and the constant economic growth. Fresh water scarcity can be overcome to an extent by using fresh water sources for drinking purposes and treated wastewater for various domestic purposes. Conventional treatment techniques are extremely expensive for developing countries like Nigeria. Therefore, an urgent need for cost effective methods of treatment and recycling of wastewater are highly desirable. The water sample was gotten from Ezu River and was used for the laboratory analysis. The Jar test was used to determine the optimum coagulant dosage of *Moringa oleifera* and *Magnifera indica* (Mango). *Moringa oleifera* and *Magnifera indica* (Mango) are capable of absorbing various metals and other pollutants present in industrial waste waters. This project also reports an investigation regarding activation of *Moringa oleifera* and *Magnifera indica* (Mango) for this purpose. This experimental method found *Moringa oleifera* and *Magnifera indica* (Mango) powder coagulant optimum dosage to be 0.5g and 0.3g. However, *Moringa oleifera* seed powder is more effective than *Magnifera indica* seed powder.

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NTU - Nephrometric turbidity Unit

g - gramme

L - Litre

Conc - Concentration

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Water is an important necessity in life. Living things need water for their survival. Water is used for different purposes, which include drinking, food preparation, irrigation and manufacturing. In as much, water covers more than 70% of the Earth's surface, less than 1% of that resource is available as fresh water – and this is not evenly distributed throughout the world. Billions people worldwide, mostly in developing countries, lack safe drinking water. Apart from water scarcity, there are many other challenges encountered towards providing a safe, adequate and reliable water supply in different parts of the world. There are different methods being used in portable water treatment based on its toxicity in order to protect the aquatic systems (Kukić et al., 2018) such as coagulation, adsorption, dissolved air flotation, membrane technology, biological systems, filtration and so on (Kukić et al., 2018; Tetteh and Rathila 2019; Tetteh and Rathila 2020).

River water drawn for human consumption and general household use can be highly turbid particularly in the rainy season. River silt is collected by suspension and run off from fields and other surfaces which carry solid material, bacteria and other micro-organisms into the river. It is of paramount importance to remove as much of this suspended matter as possible prior to consumption. This can generally only be achieved by the addition of coagulants to the raw water within a controlled treatment sequence.

Coagulation has being one of the common method of portable water treatment known to man. Coagulation is considered one of the simple methods to remove suspended solids and impurities in water efficiently. Successful coagulation can be attained by using either chemical-based (inorganic and synthetic organic) coagulants or natural coagulants (de Paula et al., 2018). Natural coagulants have been recognized for their traditional local water purification (Choy et al., 2014). Today, environmental engineers' primary concern is how to make use of more natural resources around our environment as coagulant, reduce the cost of coagulants and flocculants and improve the characteristics of the generated sludge for safe use .Given its simplicity and cost-effectiveness, the commonly utilized coagulation and flocculation process is a crucial stage in water and wastewater treatment.

Coagulation is normally used either as a pre-treatment phase or as a post-treatment step, depending on the nature of the sample being treated (e.g., various types of water or wastewater) and the overall treatment plan used. Coagulation, is the mechanism by which a given colloidal suspension or solution is destabilized.

The natural coagulants that will be used in water purification in this study are *Moringa oleifera* and *Magnifera indica* seeds which have been used for water treatment because of its effectiveness and eco-friendliness.

Coagulation originated from a Latin word "coagula" which means to gather together in order to gain mass, that is to make it denser. This process is aimed towards removing colloids, as well as suspended impurities in water, including organic and inorganic substances which are principal contributors to turbidity and colour.

Coagulation is a physical–chemical process to remove turbidity of drinking water and wastewater. Conventionally, chemical-based coagulants such as alum (AlCl3), ferric chloride (FeCl3), polyaluminium chloride and synthetic polymers (polyacrylamide) are used to remove the turbidity of water (Alwi et al. 2013; Choy et al. 2014). Coagulation has been a vital mechanism in physio-chemical wastewater treatment processes, which involves the addition of chemicals. Most of these chemicals are commonly known as coagulants (polymeric, natural, organic and inorganic) responsible for destabilizing and agglomerating the contaminants (Beyene et al., 2016; Teh et al., 2014). Generally, aluminum and iron-based coagulants are employed in pre-treatment processes in water and wastewater treatment facilities to efficiently reduce the organic load prior to subsequent treatment processes (Kukić et al., 2018; Teh et al., 2014). However, these types of coagulants are associated with the formation of large volumes of sludge associated with complex metals. Generation of excessive non-biodegradable sludge is the major issue of using chemical coagulants for wastewater treatment (Carvalho et al. 2016). As a result, this poses great threat to agriculture, human health (memory loss, intestinal constipation, abdomen colic, spasms) and aquatic life if not treated before being disposed into the environment (Beyene et al., 2016; Teh et al., 2014). An alternative greener and sustainable approach is use of natural coagulants for turbidity removal. Natural coagulants from plant based materials or renewable sources are attracting a lot of attention due to their various advantages over chemical counterpart. They are biodegradable, non-toxic, non-corrosive and cheaper than chemical coagulants. Since they produce lesser sludge with high nutritional value (Choy et al. 2014), the sludge handling and treatment cost is minimal. Despite these advantages, natural coagulants are not commercialized so far (except few such as *Moringa oleifera* seeds) (Choy et al. 2014). Challenges in harvesting and processing of natural coagulants from plants might be the major factors limiting their commercialization (Carvalho et al. 2016).

Meanwhile, advanced changes of the coagulation process by the use of cost effective, biodegradable or natural coagulants is worth investigating, since there is limited information and studies on natural coagulants used for wastewater treatment. This study tends to appreciate the importance of moringa and mango seed powder in portable water treatment.

1.2 AIM

The aim of this research is to study on the effectiveness of *Magnifera indica* seed powder and *Moringa oleifera* seed powder as a potential coagulant to reduce turbidity of water sample gotten from Ezu River (boundary between Anambra and Enugu State).

1.3 OBJECTIVE

1. Extraction of crude protein from *Moringa oleifera* seed powder.
2. Determination of properties of water sample gotten from Ezu river.
3. Determination of turbidity removal efficiency using *Magnifera indica.*
4. Determination of turbidity removal efficiency using *Moringa oleifera* crooked etract.
5. Determination of turbidity removal efficiency using hybrid coagulation.

1.4 SCOPE OF STUDY

Notwithstanding the various methods for wastewater treatment, coagulation and flocculation process is the most preferable. This treatment is commonly being practiced as it is cost effective, simple and best regarded as low-energy consuming process. This established physical and chemical process removes colloidal, suspended and soluble particles efficiently by prompting aggregation of macro and micro particles into larger size proceeded by sedimentation. In conventional treatment processes, various types of coagulants are often used depending on chemical traits of the contaminants present in the wastewater. Despite that, such treatment leads to disposal problems as the sludge obtained after the treatment using aluminium salts risks accumulation in the environment. The alternative solution to these problems is replacement of metal and synthetic coagulants with natural coagulants which are safer in the environment.

1.5 LIMITATIONS OF STUDY

Plant extracts derived from seeds, leaves, root and fruits have been used in water purification process ever since ancient times. Natural coagulants exhibit various benefits which include reduction in production of sludge, lower cost, restrain variations in the pH of treated water, iniquity and provide greater biodegradability. Researchers on biological originated coagulants that have been studied include okra, *Moringa oleifera* and mango seed.

1.6 STATEMENT OF PROBLEM

Coagulation is the primary treatment process for treating wastewater. It is a common process in treating both industrial wastewater and surface water. Dissolved and colloidal substances are removed in coagulation by overcoming inter-particle repulsive energy barrier (Prakash, Sockan and Jayakaran 2014, Shankar, et al. 2014). However, high procurement cost, detrimental effect on human beings and environment are the major disadvantage of chemical coagulation. Also, large area requirement, high maintenance and long retention time are the major drawbacks associated with biological treatment (Alwi, et al. 2013). Therefore, natural coagulants are an alternative and if adopted, will reduce the health risks of using chemical coagulants.

1.7 JUSTIFICATION OF PROBLEM

The natural coagulants are cost effective and thus reduce usage of chemicals and environmental pollution (Subramani, et al. 2018).

Moringa seeds and leaves contain natural coagulants that have been used for centuries to purify water and treat various ailments. The use of *Moringa* as a natural coagulant has gained popularity in recent years due to its effectiveness, low cost and environmental sustainability.

Mango seeds contain a range of bioactive compounds, including tannins and flavonoids, that have been found to have coagulation properties. Studies have shown that mango seed extract can effectively remove suspended particles, turbidity and organic matter from water. The coagulation mechanism of mango seed is thought to be similar to that of *Moringa* where the positively charged compounds in the seed extract neutralize the negatively charged particles in the water, causing them to clump together and settle.

In addition to its coagulation properties, *Moringa* has also been found to have antimicrobial properties, which can help reduce the presence of harmful bacteria in water. This makes it a promising option for use in developing countries where access to clean water is limited and waterborne diseases are prevalent.

Overall, the use of *Moringa* and mango seed as a natural coagulant is supported by scientific research and its effectiveness, low cost and environmental sustainability make it a promising option for water treatment in various settings.

CHAPTER TWO

LITERATURE REVIEW

RESEARCH ON THE EFFECTIVENESS OF MANGO AND MORINGA SEED POWDER AS NATURAL COAGULANT IN PORTABLE WATER TREATMENT.

2.1 WATER QUALITY CONTENTS

Like we all know, water is colourless, tasteless and odourless liquid amongst other qualities.(Ababio 1990). It is a strong solvent and as a result dissolves many minerals it comes in contact with. This is why there is no such thing as 'pure water' in nature.

2.2 IMPURITIES IN WATER

The impurities in natural water can be grouped under the following groups (Quasim, Motley & Zhu 2008).

1. Dissolved Organic and Inorganic Particle – these include:

(a) Cation and Anions, such as Ca2+, Mg2+ , Na+ , K+, CI-, SO4 2-, F- etc

i. Natural Organic matters that contain substances like hydroxyl and carboxyl groups which give hydrophilic properties.

ii. Colloids – They are very small to be seen with unaided eyes. They have diameter range that can be greater than 1mm and less than 10-3 mm. Examples includes microorganism like bacteria fungi, protozoa, parasitic worms etc.

(b) Suspended Particles – they include floating substances like leaves, debris, silt sand etc.

2.3 WATER QUALITY CHARACTERISTICS

A lot of water quality parameters are used to describe properties of water that is indicative of treated and quality water. G.N. Gray in his work "Water Technology" grouped the parameters as:

- Physical Parameters: These include – turbidity, colour, odour, taste, temperature, total dissolved solids (TDS), dry solid content, conductivity etc.
- Chemical Parameters: To include cations, anions, molecules alkalinity, acidity, hardness, radioactivity, agressivity dissolved oxygen, penols etc.

- Microbiological Parameters: Water has long served as a medium of transmission of diseases. The most important of the water borne diseases are those of the intestinal tracts including typhoid fever, dysentery, cholera and some parasitic worms all caused by microorganisms content in water.

Water is one of the major factors for economic development worldwide as it is generally used in different productive sectors including industry, agricultural production, livestock and urban supply. The fast-paced industrialization, economic growth and population growth in developing countries has implicated in unpredicted water requirement in cities. Water treatment is a crucial process in sanitation system.

Water is important not only for survival but also contributes immensely to the quality of our lives. Since the dawn of time, human beings have always needed water to improve their lives. Various reports have mentioned the direct and indirect toxic effects of metals in the form of tumors, cancers, and allergies. Hence, health problems caused by alum have been recently reported. In order to replace alum as coagulants, the natural coagulants like in the combination of *Moringa oleifera*, mango seeds and so on are used in water treatment via coagulation-flocculation processes. The investigation conducted found that moringa and mango seed can be a good coagulant which can absorb Biological Oxygen Demand. The Dehydration method is found to be more efficient for moringa seed.

The Worldwide water demand increases day by day due to rapid population, and on the other hand there is continuous decline in ground and surface water levels due to over exploitation. Efforts are being made to find the alternatives for water supply and one prominent solution is treatment and re-use of wastewater. The wastewater is a combination of kitchen waste water, washing and rinsing, bathing water which generates lot of wastewater which contains very high concentration of organic substances such as proteins, carbohydrates and lipids. Besides that, mango seed and moringa seed also have adsorbent potentiality. It is very useful for purification and refining processes.

2.4 TURBIDITY

Turbidity is a measure of the light-transmitting properties of water. It is also a measure of the cloudiness of water and the cloudier the water, the greater the turbidity. It is a unity of measurement quantifying the degree to which light traveling through a water column is scattered by the suspended particles in wastewater discharges and natural waters.

The measurement of turbidity is based on comparison of the intensity of light scattered by a sample to the light scattered by a reference suspension under the same conditions. Formation suspensions are used as the primary reference standard. The results of turbidity measurements are reported as Nephelometric Turbidity Units (NTU).

2.5 NUTRITIONAL VALUE OF MANGO AND MORINGA SEEDS POWDER.

Moringa and mango seed powders are both used as dietary supplements and are known for their nutritional benefits.

Moringa seed powder is a good source of protein, fibre and healthy fats. It is also rich in vitamins and minerals including vitamin C and E, potassium, calcium and iron. Moringa seed powder is also high in antioxidants which can help protect the body against oxidative stress and inflammation.

Mango seed powder is lower in protein and fibre compared to moringa seed powder, but it is still a good source of healthy fats, it is particularly high in monounsaturated and polyunsaturated fats which are beneficial for health. Mango seed powder also contains vitamins and minerals including vitamin E, potassium and magnesium.

Both moringa and mango seed powders are also rich in phytochemicals which are plant based compounds that have been linked to various health benefits, including reduced inflammation improved immune function and protection against chronic diseases.

It's worth nothing that while moringa and mango seed powders can be a good source of nutrition, they should not be used as a replacement for a balanced diet. Additionally, it's important to choose high quality, reputable brands of seed powders and to follow the recommended dosages. As with any dietary supplement, it's best to consult with a healthcare professional before adding these powders to your diet.

2.6 ANTIBACTERIAL AND PHYTOCHEMICAL ANALYSIS OF MANGO SEEDS AND MORINGA SEEDS.

Mango seeds and Moringa are both known to have potential antibacterial properties and contain various phytochemicals.

Mango seeds have been traditionally used in various parts of the world to treat various ailments such as diarrhea, dysentery, and other bacterial infections. Studies have shown that mango seed extracts contain various phytochemicals such as tannins, phenolic compounds, flavonoids, and alkaloids, which have been found to possess antibacterial properties. For example, a study published in the Journal of Medicinal Plants Research in 2013 found that mango seed extracts had significant antibacterial activity against common bacterial pathogens such as Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa.

Moringa, also known as the "miracle tree," has been traditionally used for its medicinal properties in many parts of the world. Moringa leaves, seeds, and root extracts contain various phytochemicals such as alkaloids, flavonoids, and phenolic compounds, which have been found to possess antibacterial properties. A study published in the International Journal of Applied Microbiology and Biotechnology in 2017 found that Moringa leaf extracts had significant antibacterial activity against common bacterial pathogens such as Staphylococcus aureus and Escherichia coli.

Both mango seed and Moringa contain various phytochemicals that have been found to possess antibacterial properties. Further studies are needed to determine the specific antibacterial compounds responsible for the observed effects and to evaluate their potential as natural antibacterial agents.

2.7 CHEMICAL PROPERTIES OF MORINGA AND MANGO SEEDS.

Moringa and mango seeds contain various chemical compounds such as carbohydrates, proteins, lipids, and minerals. They also contain phytochemicals such as phenolic compounds, flavonoids, and alkaloids.

Carbohydrates: Both seeds contain carbohydrates such as glucose, fructose, and sucrose. These sugars provide energy to the body.

Proteins: Both seeds are a rich source of proteins, containing all the essential amino acids required by the body. These proteins are important for building and repairing tissues in the body.

Lipids: Both seeds contain lipids such as fatty acids, sterols, and triglycerides. These lipids are important for energy storage and membrane structure.

Minerals: Both seeds are a good source of minerals such as iron, calcium, and phosphorus. These minerals are important for various physiological processes in the body.

Phytochemicals: Both seeds contain various phytochemicals such as phenolic compounds, flavonoids, and alkaloids. These compounds have been found to possess antioxidant, anti-inflammatory, and antibacterial properties, and may have potential therapeutic effects.

In addition to the above-mentioned compounds, Both seeds also contain a unique compound called "nitrile glycoside". This compound has been found to have anti-inflammatory and analgesic effects, and may have potential therapeutic applications.

Both seeds contain a variety of chemical compounds that have potential health benefits. Further research is needed to fully understand the chemical properties of Moringa seeds and their potential therapeutic applications.

2.8 WHAT IS COAGULANT?

These are inorganic or organic substance that initiates or aids a settling process during water treatment. Coagulants, together with other chemicals, are added in water to aggregate dissolved contaminants and tiny particles into larger particles so that filtration, clarification, or any other solid removal process may be used to remove them. Inorganic coagulants, except the sodium aluminate (which is basic), decrease alkalinity levels in water. This helps to reduce risks of corrosion attack in pipes transporting wastewater.

Coagulants are used in colored, low pH or alkaline and low turbidity water. The optimum pH it generates helps in water purification. The coagulate dose used in purification produces a hydrolysis process that generates a pH suitable for coagulation. The metal hydroxide formed is what adsorbs the impurities (humus) to form compounds that become flocs. These flocs can later be filtered out since they are suspended solid bodies and when heavy they settle at the base.

The importance of a coagulant is to destabilize the acidity of the fluid and cause flocs formation and also to Purify the fluid by removing unwanted active metallic or non-metallic elements. An inappropriate coagulant dose might lead to corrosion due to acidity, hence one must follow guidelines by the governing authority. (Corrosionpedia, 2018).

2.9 WHAT IS COAGULATION?

Coagulation flocculation involves the addition of compounds that promote the settling of fines particles into larger floc so that they can be more easily separated from the water. Coagulation is a chemical process that involves neutralization of charge. (Jiang and Jia-Qian 2015; Chekli et al., 2017). Coagulation is an effective, simple and widely practiced water treatment method. However, the usage of chemical coagulant pose detrimental effect on living organism and human health as well as producing large amount of toxic sludge. This study describes the utilization of banana peel as a natural coagulant for the treatment of household wastewater. The natural coagulant extracted from banana peel was prepared by using simple extraction method. The effectiveness of the natural coagulant was evaluated based on the reduction of turbidity during the treatment process.

2.10 ESSENCE OF COAGULATION

Most of these constituents may cause several problems such as inhabiting disinfections, leaving the untreated water cloudy and causing problem in the distribution system. It is also known that these suspended solids in aqueous solution exhibit Brownian movement, which keeps them in constant motion, inhabiting settling.

This is accomplished in the coagulation process when tiny particles are brought closer into denser particles which will settle more quickly, thus the high surface area to mass ratio in the colloidal suspension is reduced or destabilized (Shaw, 1989). For effective coagulation, an ion that has opposite charge to that of the colloidal particle is usually added. Since colloidal particles are usually negatively charged the ions added as coagulants must be cations.

The coagulating power of an ion is dependent on its valence and magnitude of charge. When a coagulant is added to water, these results into a series of complicated reactions, firstly, the ions of the coagulant are hydrated, also anions present in the water such as hydroxide and sulphate ions attach themselves to the aluminium ions, leading to a large positively charged molecule with aluminium ions centred. As this continues, elation reaction takes place and this involves bridging of two or more of these larger molecules to produce large, positively charged ions.

2.11 FACTORS AFFECTING COAGULATION

Coagulation is affected by the type of coagulant used, its dose and mass; pH and initial turbidity of the water that is being treated; and properties of the pollutants present. (Ramavandi and Bahman 2014). The effectiveness of the coagulation process is also affected by pretreatments like oxidation. (Ayekoe et al. 2017).

2.12 FLOCCULANTS

These are chemicals that are used to increase flocculating by causing colloids and other suspended particles in liquids to aggregate, forming flocs. Flocculants are used in water treatment process to improve the sedimentation of small particles. For this reason, flocculants are sometimes called coagulants aid at water treatment operation. Many flocculants are multivalent cations such as aluminum, iron, calcium or magnesium. These positively charge molecules interact with negatively charged particles and molecules to reduce the barriers to aggregation.

2.13 CHEMICAL COAGULATION

Chemical coagulation is the process of destabilizing the colloidal impurities in water or wastewater by using chemically produced substances. The process of formation of flocs on charge neutralization is known as flocculation (Hamawand, 2015). Aluminum sulfate (Quintero-Jaramillo et al., 2016), potassium aluminum sulfate, Iron (III) chloride hexahydrate, ferric sulfate (Karamany, 2010), etc. can be used as coagulants for water and wastewater treatment. Alum is the most commonly used chemical coagulant. Alum is easily available and is a less expensive alternative for the wastewater treatment. Madhavi et al. 2014 used alum for treating wastewater from the metal fabrication industry. Alum, at a concentration of 450mg/L, removed 99% of color from the wastewater at a pH of 8.0 (Madhavi et al., 2014). The effectiveness of alum can be increased by using it with other coagulants.

2.13.1 DISADVANTAGES OF CHEMICAL COAGULANTS: HEALTH AND ENVIRONMENTAL IMPACTS

Chemical coagulation is done by using synthetic chemical coagulants. This practice has the potential of leaving a bad impact on the environment and the public health. Chemical coagulants are non- biodegradable and remain in the water even after the coagulation process is completed. There is a possibility that the treated supernatant contains the traces of metals present in the chemical coagulants due to the presence of residual aluminum in the supernatant.

Major issues with the use of aluminium based coagulants are that they tend to increase concentration of residual aluminium in the supernatant (WHO Guidelines, 2010). This aluminum may either seep into the groundwater or may have a surface runo (WHO Guidelines, 2010). Conventional, water and wastewater treatment plants do not remove aluminium and water with elevated aluminium content is supplied to the end consumers. If aluminium entered the public distribution system, it could lead to precipitation of hydrous aluminium in the water, which is to be supplied to the consumers. Residual aluminium in the treated water is found to negatively impact the health of consumers.

2.14 NATURAL COAGULANTS FOR WASTEWATER TREATMENT

The potential environmental and human health hazards associated with the use of chemical coagulants has necessitated the need for the use of natural coagulants for industrial wastewater treatment. Natural coagulants are gaining a lot of attention these days as they are an effective alternative to the chemical coagulants. Natural coagulants are a sustainable approach. Plant-based materials have been investigated for treating industrial effuents from different industries. Plant-based substances like *Moringa Oleifera* (Chonde and Raut, 2017; Sivakumar, 2013), chitosan and chitin, Abelmoschus esculentus, Opun a cus-indica, Synchorous Potatorum, Prosopis laevigata Seed Gum, Hibiscus rosa-sinensis (Awang and Aziz, 2012) etc. can be used as coagulants. Generally, the natural coagulants are directly used as a powder or a stock solution. In some cases, the deoiled powder is also used. The plant-based products (such as seeds, etc.) are first extracted from the plant, cleaned to remove any impurities that may interfere with coagulation, and then dried. The powder is then formed (with or without the oil extraction, as per need) by grinding . This powder may be directly used, or a stock solution can be prepared from it. In some cases, proteins may be extracted from the specific plant parts and used as a coagulant. This may require extensive extraction and purification steps (Kansal and Kumari, 2014). Kumar et al. 2017 and Tariq et al., 2015 reported that the microbial polysaccharides, starches, gelatin galactomannans, cellulose derivatives, chitosan, glues, and alginate can be used for wastewater treatment. Mohamed et al. 2014 used Moringa oleifera and Strychnos potatorum seeds as a natural coagulant for car wash wastewater. The turbidity and COD reduction efficiency of coagulants was studied. Using Moringa oleifera, 94% turbidity, 60% COD, 81% phosphorus removal were obtained, whereas using Strychnos potatorum, 97% turbidity, 54% COD, and 82% phosphorus removal were obtained. These results were compared with synthetic coagulants, and natural coagulants were suggested for coagulation process as they provide better treatment, are cost-effective and are safe for environment. Kani et al. 2016 used banana pith juice for textile wastewater treatment. At pH 4, 97.5% turbidity and 50.1% total solids were removed from the wastewater. There was a significant improvement in the electrical conductivity. It was concluded that there is a significant improvement in the physicochemical characteristics of wastewater and heavy metal chromium was successfully controlled by natural coagulants.

2.14.1 ADVANTAGES OF NATURAL COAGULANTS

Wastewater treatment using natural coagulants is an eco-friendly option. Natural coagulants are non-toxic, biodegradable, and environment friendly (Verma et al., 2012; Muralimohan et al., 2014). Unlike synthetic coagulants, treated water contains no residual aluminium. Prodanović et al. 2013 used common bean extract for the treatment of dis llery wastewater treatment. The study claimed that anaerobic sludge contained no aluminium salt.

Need for natural coagulants, Chemical coagulant used has raised controversial issues due to its toxic nature for living organisms and can be categorized into three types: hydrolyzing metallic salts, pre-hydrolyzing metallic salts, and synthetic cationic polymers(Freitas et al., 2018; Verma et al., 2012). Due to the low cost, easy handling, storage, and high availability, chemical coagulants are more prevalent in wastewater treatment processes.

Despite the availability, low cost etc.; chemical coagulants are far behind in green chemistry due to high residual concentrations of aluminum found in treated wastewater(Freitas et al., 2018). According to Freitas et al., 2018; Excessive concentrations of chemical coagulants such as aluminum reduce the pH of water tends and also, they can be accumulated to food chains (Kurniawan et al., 2020). Improper disposal of toxic sludge pollutes the groundwater and soil. Accumulation of toxic sludge, such as aluminum, iron etc., in natural water bodies causes adverse effects on aquatic organisms and plant species (Kurniawan et al., 2020). Hence there is a need for the efficient utilization of natural coagulants for water and wastewater treatment.

2.15 APPLICATIONS, ADVANTAGES AND DISADVANTAGES OF MORINGA AND MANGO SEEDS AS A COAGULANT.

Applications of moringa and mango seeds as a coagulant

- To identify a sustainable, simple, locally available.
- Ecofriendly water treatment technology which is more suitable for the earth to protect it from pollution caused by
- Chemical coagulant.
- Evaluate the optimum dosages of banana powder for a different level to remove turbidity.

- Removal efficiency is very high in banana powder.

2.15.1: ADVANTAGES OF MORINGA SEED AS A COAGULANT.

Moringa has been shown to be an effective natural coagulant in water treatment. The use of Moringa in water treatment has several advantages:

1. Low cost: Moringa is an inexpensive and easily available resource in many parts of the world, making it a cost-effective alternative to traditional water treatment methods.

2. Non-toxic: Moringa is a natural product and is non-toxic, making it a safe alternative to chemical coagulants which can be harmful to human health and the environment.

3. Effective in turbid water: Moringa has been found to be highly effective in treating turbid water, which is a common problem in many parts of the world. Moringa coagulates the suspended particles and sediments in the water, making it clear and safe for consumption.

4. Scalable: The use of Moringa as a natural coagulant is scalable, meaning it can be used in small-scale household water treatment systems as well as large-scale municipal water treatment facilities.

5. Sustainable: Moringa is a sustainable resource as it can be easily grown and harvested locally, reducing the need for transportation and minimizing the carbon footprint.

2.15.2 DISADVANTAGES OF MORINGA SEED AS A COAGULANT.

Moringa seeds have been used for centuries as a natural coagulant to treat water and remove impurities. However, there are some disadvantages to using Moringa as a coagulant:

1. Cost: Moringa seeds can be expensive, especially if they need to be sourced from far away or imported. This can make it difficult to use Moringa as a cost-effective solution for water treatment.

2. Shelf-Life: Moringa seeds have a relatively short shelf-life, which means they need to be used quickly after being harvested, dried and processed. This can be a challenge in areas where the supply chain for Moringa seeds is not well-established.

3. Variable Quality: The quality of Moringa seeds can vary depending on the source and the processing method. This can lead to inconsistent results in water treatment, making it difficult to rely on Moringa as a consistent coagulant.

4. Time-Consuming: The process of extracting the active coagulating agent from Moringa seeds can be time-consuming and labor-intensive. This can make it difficult to use Moringa as a practical solution for large-scale water treatment projects.

5. Limited Effectiveness: While Moringa seeds can effectively remove some impurities from water, they may not be effective against all types of contaminants. In some cases, additional treatment methods may be necessary to completely purify the water.

2.16.1 ADVANTAGE OF MANGO SEED AS COAGULANT

Mango seeds have been found to be an effective natural coagulant for water treatment, with several advantages over other coagulants:

1. Abundant and Sustainable: Mango seeds are abundant in many parts of the world, making them a sustainable and readily available source of coagulant. This can make them a cost-effective solution for communities that lack access to traditional chemical coagulants.

2. High Coagulation Efficiency: Mango seeds contain a high concentration of active coagulant compounds, such as tannins and phenolic compounds, which make them highly effective at removing impurities from water. Studies have shown that mango seed powder can remove up to 99% of suspended solids from water.

3. Easy to Prepare: Mango seed powder can be easily prepared by drying and grinding the seeds, making it a simple and accessible technology for communities with limited resources.

4. Safe and Non-Toxic: Mango seeds are non-toxic and safe for human consumption, making them a suitable option for water treatment in rural areas where treated water may be used for drinking and cooking.

5. Versatile: Mango seed powder can be used to treat a wide range of water sources, including surface water, groundwater, and wastewater. It is also effective at removing a variety of contaminants, including turbidity, heavy metals, and bacteria.

2.16.2 DISADVANTAGE OF MANGO SEED AS COAGULANT

While mango seeds have many advantages as a natural coagulant for water treatment, there are also some disadvantages to consider:

1. Seasonal Availability: Mango seeds are only available during the mango harvest season, which can limit their availability as a coagulant throughout the year. This can make it difficult to rely on mango seeds as a consistent source of coagulant for large-scale water treatment projects.

2. Variability in Quality: The quality of mango seeds can vary depending on the variety of mango, the ripeness of the fruit, and the processing methods used. This can lead to inconsistent results in water treatment, making it difficult to rely on mango seeds as a consistent coagulant.

3. Seed Processing Requirements: Mango seeds require processing before they can be used as a coagulant. This involves washing, drying, and grinding the seeds, which can be labor-intensive and time-consuming. This can add to the cost of using mango seeds as a coagulant.

4. pH Sensitivity: The coagulation efficiency of mango seeds is pH-sensitive, with optimal results obtained at a pH range of 5-8. This can limit their effectiveness in water treatment applications where the pH of the water is outside of this range.

5. Limited Effectiveness on Some Contaminants: While mango seeds are effective at removing many types of contaminants from water, they may not be effective against all types

of impurities. In some cases, additional treatment methods may be necessary to completely purify the water.

2.17 MECHANISM OF COAGULATION BY NATURAL COAGULANTS

Coagulation occurs between the coagulant added, the impurities, and the alkalinity of the water, resulting in the formation of insoluble flocs. Flocs are the agglomerations of particulate suspended matter in the raw water, reaction products of the added chemicals, colloidal and dissolved matter from the water adsorbed by these reaction products. Unprocessed water from the reservoir contains organic and inorganic impurities, such as silt, rotten substance, alga, bacterium, etc. Hence coagulation is the essential step in water purification. In addition, coagulants make suspensions in water to gather and reduce the turbidity of water. The successful coagulation of natural coagulants (Ang et al., 2020) stands on these three pillars: characteristics of coagulant used, characteristics of water to be treated, characteristics of mixing process (Ang et al., 2020; Kumar et al., 2017).. Coagulants' molecular weight (Ang et al., 2020; Gautam and Saini, 2020), types of equipment and reagents used, chemical and physical properties of the pollutants such as zeta potential (Ang et al., 2020), color, the concentration of the colloidal particles, the presence or absence of impurities (trace elements and dissolved salts (ions and chemicals) also affect the coagulation process (Ang et al., 2020; Kumar et al., 2017; Muruganandam et al., 2017). If the natural coagulant contain positive surface charge, its coagulation activity against negatively charged suspended particles will be higher and vice versa for negatively charged natural coagulants with positively charged suspended particles. Functional groups also contribute to surface charge (Ang et al., 2020). Molecular weight of natural coagulant is very important in particle bridging. If the molecular weight of natural coagulant is higher, it can form strong bridges with the particles and it leads to the formation of strong flocs and improve settling (Ang et al., 2020). Mixing is another critical step in the coagulation process. Fast mixing increases the interactions between coagulants and suspended particles and forms micro flocs. Slow mixing leads to the aggregation of micro flocs into large flocs (Kurniawan et al., 2020). Coagulation also affects the other steps of the treatment process. An efficient and effective coagulation process favors the microbiological quality (Kumar et al., 2017) of the end product and increases the lifetime of filters (Kumar et al., 2017), reducing the total cost of treated water. Natural coagulants are composed of carbohydrates, protein, and lipids. The primary building blocks are the polymer of polysaccharides and amino acids. According to the previous research, the main mechanisms governing coagulation activity are charge neutralization and polymer bridging. Polymer bridging is preceded by polymer adsorption. The patches of positive and negative regions on the particle's surface cause the additional attraction between particles. Ionizable polymer (polyelectrolytes) is used as a coagulant in the charge neutralization mechanism. It stabilizes the negatively charged colloidal particles. Polycation is used to stabilize the particles, gaining near to zero zeta potential. The optimum dosage of polyelectrolyte needed will be determined by the charge density of the polyelectrolyte (Amran et al.,2018).

CHAPTER THREE

3.0. MATERIALS AND METHODS

This chapter highlights the methods as well as the procedures used in the evaluation of mango seed and moringa seed powder as natural coagulant for portable water treatment and other water test.

3.1 SAMPLE COLLECTION AND PREPARATION

Water sample was gotten from Ezu river (boundary between Anambra and Enugu State) and used throughout the experiment as the testing specimen. The sample was taken to the laboratory immediately and initial analysis done so as to get the initial Turbidity without allowing the sample to settle. After which the total suspended soilds, total dissolved solids and total solids practical took place. Also test for PH degree, Colour, Potassium, Nitrate were also conducted.

3.2. APPARATUS

1. Five Beakers
2. Volumetric pipette
3. 1 Litre measuring cylinder
4. Electronic weighing balance
5. Turbidity Meter
6. Electro-magnetic stirrer
7. Stop watch
8. Voltage regulator
9. Standby power generator
10. PH meter
11. Filter paper
12. Conical flask

13. Heater

14. Burette and clip

15. Retort stand

16. Funnel

17. Petri-dish

3.3 MATERIALS

Materials to be used for the research are gotten from natural plants we see around us which are:

- *Magnifera Indica* (Mango seed)
- *Moringa Oleifera* (Moringa seed)

3.3.1 *Magnifera indica* (MANGO SEED)

Every mango has a seed inside, it's protected by that thick, husk like thing set aside when preparing the fruit for eating. One has to start with a ripe mango otherwise the seed within the husk may not be matured enough for the research it will be used for. Mango seed is known to be a good natural coagulant as it is a cathonic coagulant. Generally, to ensure an efficient coagulant process, a coagulant must have positive surface charge. The positive charge would bind towards the negative charged particles that acted as pollutants in the wastewater. Mangifera Indica (Mango Seed) is plucked from a tree growing it, washed and the outer flesh is sliced off manually to get the seed which is used for the coagulation process using stainless steel knife. The seed is kept opened to atmosphere to air dry about 24 hours for drying as shown in plate 3.1 . The dried seed is cut opened to obtain the dried kernel as shown in plate 3.2. The dried kernel was mechanically grounded to fine powder using grinder available in the lab and sieved to make it fine powder appropriate size of about 300 μm as shown in plate 3.3.

Plate 3.1: Mango seed with closed shell

Plate 3.2: Mango seed with open shell

Plate 3.3: Mango seed powder

3.3.2 *Moringa oleifera* (MORINGA SEED)

It is a fast growing, drought resistant tree of the family Moringaceae, native to the Indian subcontinent. It is often called the drumstick tree, miracle tree, ben oil tree or the horseradish tree. It has been used for centuries due to its medicinal properties and health benefits. It also has antifungal, antiviral, antidepressant and anti inflammatory properties. Moringa Olifera pod shells were removed manually; kernels were grounded in a domestic blender and sieved through 300-μm stainless steel sieve.

OIL EXTRACTION BY ETHANOL

Oil can be removed by mixing the seed powder in ethanol. This was mixed with a magnetic stirrer for 30–45 min, and subsequently, separation of the residue from the supernatant was done by centrifuging for 10 min at 4000 rpm. The supernatant was decanted and the residual solid was dried (seed cake) at room temperature for 24hr (Gidde et al. 2012). This practical was carried out at the Pharmaceutical laboratory located at Agulu in Anambra state.

Plate 3.4: Moringa shelled seed

Plate 3.5: Moringa seedlings

Plate 3.6: Moringa seed powder

3.4 HYBRID COAGULANT

Hybrid coagulants have recently received attention in water and wastewater treatment technologies mainly due to their cost-efficiency and exceptional performance. As such, this study highlights the recent advanced applications of hybrid coagulants in wastewater treatment. The materials used for hybrid coagulants, such as those hybridised in chemical bond, structurally-hybridised, and functionally-hybridised under certain combination techniques (e.g., organic/inorganic, organic/organic, inorganic/inorganic, organic/natural polymer, inorganic/natural polymer, organic/biopolymer, & inorganic/biopolymer), were evaluated and compared based on their applications on different type of wastewaters, experimental conditions, and treatment efficiency. The performance of inorganic/inorganic hybrid coagulation demonstrated high removal of turbidity (98.5%), chemical oxygen demand (COD) (73.3%), heavy metals (99.2%), and colour (98%) - seemingly better than organic removal efficiency. The optimum operational conditions for inorganic/organic coagulants at varied pH levels (6–12) lowered the cost for chemicals used for pH adjustment in treating industrial wastewater. Referring to the review outcomes, hybrid coagulation applications are indeed efficient for treatment of highly concentrated industrial wastewater, such as oily wastewater.

Hybrid components are novel materials with high potential to treat wastewater sample due to their superior efficiency and lower cost in comparison to inorganic coagulants and organic flocculants, respectively (Dawood and Li, 2014; Maćczak et al., 2020; Wang et al., 2008).

The addition of functional chemical component(s) to an original chemical that yields a hybrid material can enhance the aggregation process during the coagulation-flocculation phase in treating wastewater (Tzoupanos and Zouboulis, 2011). Hybrid materials outperform separate components, primarily due to the synergistic impact of the hybrid elements that are more stable than standard inorganic coagulants during storage (Owodunni and Ismail, 2021; Zhao et al., 2013; Zhu et al., 2012). Numerous effective composite coagulant applications in wastewater treatment have resulted in higher treatment efficacy (Owodunni and Ismail, 2021; Tolkou and Zouboulis, 2020a). The use of hybrid materials has been proven to reduce operational time, which is beneficial to enterprises that release massive volumes of polluted wastewater (Lee et al., 2010). Apart from addressing the shortcoming of weak flocs, hybrid materials have resulted in increased flake size, better growth rate, and higher flakes recoverability (Owodunni and Ismail, 2021). Therefore, the cost-efficient hybrid materials that offer exceptional performance can be put into use for both commercial and industrial purposes.

Hybrid materials, which are combinations of more than one material to yield novel materials with new chemical bonds, are categorised into three types; structurally-hybridised materials (composites), materials hybridised in chemical bond, and functionally-hybridised materials (Alemán et al., 2007) (see Fig. 1).

Structurally-hybridised materials are material combinations produced at the macroscopic level using the rule of mixing (Alemán et al., 2007; Nanko, 2009). In the mixing rule, the

3.5 EFFECT OF OPERATING PARAMETERS ON HYBRID COAGULATION PROCESS

The coagulation process has been extensively employed because it is an effective, efficient, and easy way to treat water and wastewater. The selection procedure, as well as the coagulant dose applied to the wastewater, is critical. Thus, the number of researchers who have investigated hybrid materials (inorganic-inorganic, organic-natural, & inorganic-organic) has increased in recent years (Bobadilla et al., 2019).

Some factors that influence the efficacy of the coagulation process includes:

- Choice of coagulant
- Dosage of coagulant
- PH of water sample
- Initial turbidity of water sample
- Properties of pollutant present

3.6 PRECAUTIONS

The following precaution were taken so as to obtain accurate results

1. The sample was collected on the very day of the experiments so as not to allow it settle before the commencement of the tests.

2. A minimum of five readings were taken and the average obtained for a particular reading.

3. Other rules and principles in the use of various metres used were strictly followed.

3.7 PROCEDURE

The objective of the test is to determine the effectiveness of mango seed and moringa seed powder as a natural coagulant for portable water treatment. Therefore, selection and optimum dosage of coagulants are determined experimentally by the jar test. The jar test must be performed on any water that is to be treated and must be repeated with each significant change in the quality of the water. The jar test was performed using a series of glass beakers of uniformed sizes and shapes. Five jar beakers were used with a stirring device that mixes the contents of the jar uniformly. Each of the five beakers was properly washed and cleaned to ensure zero impurities in them, and afterwards filled to the 1000ml mark with the wastewater. Different dosages of mango seeds and moringa seeds powder were added ranging from 0.1g, 0.3g, 0.5g, 0.7g and 1.0g. After which each of the beaker containing the water sample, coagulant and a magnetic stirrer was placed on the electro-magnetic stirrer with hot plate and was connected to a power supply. The mixture was rapidly mixed using the electro-magnetic stirrer, stirred for three 3 minutes fast, followed by 27 minutes of slow mixing. This is to keep flocs particles to suspend uniformly. The mixture was left for one hour to allow settling and some portions of the settling water was extracted at different time intervals to determine the Turbidity by using the Turbidity meter measured in Nephelometric Turbidity Unit (NTU).

The turbidity reduction was calculated for each sample by using the Formula as in **Eq. 1**

Turbidity Removal (NTU) = Initial turbidity (NTU) – Final turbidity (NTU)............**Eq. 1**

Eq. 2 Turbidity removal percentage co-efficient

TR(%) = Initial turbidity(NTU) – Final turbidity(NTU)/Initial turbidity(NTU) x 100

3.8 TABLE OF CALCULATION VALUE

This table tends to show how the values are being recorded after the practical has being carried out. It includes the time, coagulant dosage, initial turbidity, final turbidity, turbidity removal and turbidity removal percentage co-efficiency. These values are put in place into the table of value after due calculations has being done from the value gotten while the practical was carried out.

TABLE 3.1 SAMPLE OF TABLE OF VALUE

Time (mins)	Coagulant dosage (g)	Initial turbidity (NTU)	Final turbidity (NTU)	Turbidity removal (NTU)	Turbidity Removal percentage Co-efficiency (%)
10	0.1 0.3 0.5 0.7 1.0				

20					
30					
40					
50					

CHAPTER FOUR

4.0 RESULT ANALYSIS AND DISCUSSION

At this stage, series of practical were conducted and the results stated as follows.

4.1 JAR TEST RESULT

The graphical representation of the result was used in this chapter to make influence. The tables for the results are shown below.

4.2 DETERMINATION OF OPTIMUM DOSAGE

The optimum dosage has to correspond to the column with the least turbidity value (Matti et al, 2004). And also the optimum dosage has the highest settling rate, that is, more particles were removed within the stated time. So, looking and comparing the values gotten by the use of different concentrations of mango seeds and moringa seeds as shown in table 4.1, 0.1g of mango and moringa coagulant gave a turbidity value of 115/100NTU, 108/89NTU, 98/87NTU, 91/70NTU, 94/60NTU and 91/50NTU after every ten minutes' intervals for 60minutes respectively for both of the coagulants. And by increasing the concentration to 0.3g, lower values were obtained for that of mango seed powder which wasn't the same as that of the moringa seed. But further increase to 0.5g moringa seed powder gave the best result while mango seed powder tends to give higher turbidity values showing that the optimum dosage of mango seed powder coagulant required for the coagulation of Ezu river water sample is 0.3g while that of moringa seed powder is 0.5g.

TABLE 4.1 RESULTS OF THE TURBIDITY REMOVAL AND TURBIDITY REMOVAL CO-EFFICIENCY (%) FOR DIFFERENT COAGULANT DOSAGE USING MANGO SEED POWDER.

Time (mins)	Coagulant dosage (g)	Initial turbidity(NTU)	Final turbidity (NTU)	Turbidity removal (NTU)	Turbidity removal co-efficiency (%)
10	0.1	123	115	8	6.50
	0.3	123	113	10	8.13
	0.5	123	120	3	2.44
	0.7	123	121	2	1.63
	1.0	123	123	0	0.00
20	0.1	123	108	15	12.20
	0.3	123	101	22	17.89
	0.5	123	113	10	8.13
	0.7	123	118	5	4.07
	1.0	123	112	11	8.94
30	0.1	123	98	25	20.33
	0.3	123	96	27	21.95
	0.5	123	107	16	13.01
	0.7	123	113	10	8.13
	1.0	123	112	11	8.94
40	0.1	123	91	32	26.02

	0.3	123	93	30	24.39
	0.5	123	103	20	16.26
	0.7	123	109	14	11.38
	1.0	123	105	18	14.63
50	0.1	123	94	29	23.58
	0.3	123	93	30	24.39
	0.5	123	104	19	15.45
	0.7	123	108	15	12.20
	1.0	123	105	18	14.63
60	0.1	123	91	32	26.02
	0.3	123	91	32	26.02
	0.5	123	103	20	16.26
	0.7	123	107	16	13.01
	1.0	123	100	23	18.70

4.3 DISCUSSION ON THE EFFECT OF MANGO SEED POWDER AS COAGULANT ON THE WATER SAMPLE.

From the table above, we can get to know the effectiveness of the mango seed powder as a coagulant. From the practical carried out, mango seed as a coagulant was less effective towards the removal of turbidity from the water sample because mango seed powder contains lower level of protein which helps in the coagulation process unlike that of the mango. This can as well be as a result of high turbidity of the water sample to be treated. Research has it that mango seed powder contains active components that have coagulation properties, making it effective to remove impurities from water but not as effective as that of moringa seed powder. The efficiency of mango seed powder as coagulant depends on factors such as the initial turbidity of the water sample, dosing rate and pH of the water. Studies have shown that the optimum dosage of mango seed powder for water treatment ranges from 100 to 500mg/L. At this dosage, mango seed powder can remove up to 90% of turbidity and 70% of organic matter from water depending on the initial turbidity and quantity of water to be treated.

TABLE 4.2 RESULTS OF THE TURBIDITY REMOVAL AND TURBIDITY REMOVAL CO-EFFICIENCY (%) FOR DIFFERENT COAGULANT DOSAGE USING CRUDE MORINGA SEED EXTRACT POWDER.

Time (mins)	Coagulant dosage (g)	Initial turbidity(NTU)	Final turbidity (NTU)	Turbidity removal (NTU)	Turbidity removal co-efficiency (%)
10	0.1	123	100	23	18.70
	0.3	123	27	96	78.05
	0.5	123	25	98	79.67
	0.7	123	42	81	65.85
	1.0	123	29	94	76.42
20	0.1	123	89	34	27.64
	0.3	123	24	99	80.49
	0.5	123	23	100	81.30
	0.7	123	38	85	69.11
	1.0	123	28	95	77.24

30	0.1 0.3 0.5 0.7 1.0	123 123 123 123 123	87 24 19 35 26	36 99 104 88 97	29.27 80.49 84.55 71.54 78.86
40	0.1 0.3 0.5 0.7 1.0	123 123 123 123 123	70 19 15 32 22	53 104 108 91 101	43.09 84.55 87.80 73.98 82.11
50	0.1 0.3 0.5 0.7 1.0	123 123 123 123 123	60 15 13 28 20	63 108 110 95 103	51.22 87.80 89.43 77.24 83.74
60	0.1 0.3 0.5 0.7 1.0	123 123 123 123 123	50 13 10 27 18	73 110 113 96 105	59.35 89.43 91.87 78.05 85.37

4.4 DISCUSSION ON THE EFFECT OF CRUDE MORINGA SEED PODWER ON THE WATER SAMPLE

From the practical carried out, it is observed that moringa seed powder is an effective natural coagulant for portable water treatment unlike that of the mango seed which was less effective. Moringa seed powder is more effective than mango seed powder because it contains higher level of positively charged proteins called cationic polyelectrolyte. These protein attracts negatively charged particles such as dirt and bacteria causing them to clump together and settle to the bottom of the beaker used in carrying out the practical.

TABLE 4.3 RESULTS OF THE TURBIDITY REMOVAL AND TURBIDITY REMOVAL CO-EFFICIENCY (%) FOR DIFFERENT COAGULANT DOSAGE USING HYBRID COAGULATION(0.3g) WHEN MANGO IS HIGHER IN PERCENTAGE

Time (mins)	Coagulant dosage (g)	Initial turbidity(NTU)	Final turbidity (NTU)	Turbidity removal (NTU)	Turbidity removal co-efficiency (%)
10	0.3 (90/10) 0.3 (80/20) 0.3 (70/30) 0.3 (60/40) 0.3 (50/50)	61 61 61 61 61	58 57 48 60 54	3 4 13 1 7	4.92 6.56 21.31 1.64 11.48
20	0.3 (90/10) 0.3 (80/20) 0.3 (70/30)	61 61 61	54 45 50	7 16 11	11.48 26.23 18.03

	0.3 (60/40) 0.3 (50/50)	61 61	60 50	1 11	1.64 18.03
30	0.3 (90/10) 0.3 (80/20) 0.3 (70/30) 0.3 (60/40) 0.3 (50/50)	61 61 61 61 61	49 43 47 53 45	12 18 14 8 16	19.67 29.51 22.95 13.11 26.23
40	0.3 (90/10) 0.3 (80/20) 0.3 (70/30) 0.3 (60/40) 0.3 (50/50)	61 61 61 61 61	48 42 44 50 42	13 19 17 11 19	21.31 31.15 27.87 18.03 31.15
50	0.3 (90/10) 0.3 (80/20) 0.3 (70/30) 0.3 (60/40) 0.3 (50/50)	61 61 61 61 61	45 40 42 50 40	16 21 19 11 21	26.23 34.43 31.15 18.03 34.43
60	0.3 (90/10) 0.3 (80/20) 0.3 (70/30) 0.3 (60/40) 0.3 (50/50)	61 61 61 61 61	44 40 38 48 39	17 21 23 13 22	27.87 34.43 37.70 21.31 36.07

TABLE 4.4 RESULTS OF THE TURBIDITY REMOVAL AND TURBIDITY REMOVAL CO-EFFICIENCY (%) FOR DIFFERENT COAGULANT DOSAGE USING HYBRID COAGULATION(0.3g) WHEN CRUDE MORINGA IS HIGHER IN PERCENTAGE.

Time (mins)	Coagulant dosage (g)	Initial turbidity(NTU)	Final turbidity (NTU)	Turbidity removal (NTU)	Turbidity removal co-efficiency (%)
10	0.3 (40/60) 0.3 (30/70)	61 61	58 36	3 25	4.92 40.98

	0.3 (20/80) 0.3 (10/90) 0.3 (100)	61 61 61	28 43 44	33 18 17	54.10 29.51 27.87
20	0.3 (40/60) 0.3 (30/70) 0.3 (20/80) 0.3 (10/90) 0.3 (100)	61 61 61 61 61	43 28 22 30 39	18 33 39 31 22	29.51 54.10 63.93 50.82 36.07
30	0.3 (40/60) 0.3 (30/70) 0.3 (20/80) 0.3 (10/90) 0.3 (100)	61 61 61 61 61	37 23 18 24 32	24 38 43 37 29	39.34 62.30 70.49 60.66 47.54
40	0.3 (40/60) 0.3 (30/70) 0.3 (20/80) 0.3 (10/90) 0.3 (100)	61 61 61 61 61	34 20 15 21 30	27 41 46 40 31	44.26 67.21 75.41 65.57 50.82
50	0.3 (40/60) 0.3 (30/70) 0.3 (20/80) 0.3 (10/90) 0.3 (100)	61 61 61 61 61	32 19 15 20 27	29 42 46 41 34	47.54 68.85 75.41 67.21 55.74
60	0.3 (40/60) 0.3 (30/70) 0.3 (20/80) 0.3 (10/90) 0.3 (100)	61 61 61 61 61	31 19 14 19 20	30 42 47 42 41	49.18 68.85 77.05 68.85 67.21

TABLE 4.5 RESULTS OF THE TURBIDITY REMOVAL AND TURBIDITY REMOVAL CO-EFFICIENCY (%) FOR DIFFERENT COAGULANT DOSAGE USING HYBRID COAGULATION (0.5g) WHEN CRUDE MORINGA IS HIGHER IN PERCENTAGE.

Time (mins)	Coagulant dosage (g)	Initial turbidity(NTU)	Final turbidity (NTU)	Turbidity removal (NTU)	Turbidity removal co-efficiency (%)
10	0.5 (90/10) 0.5 (80/20) 0.5 (70/30) 0.5 (60/40) 0.5 (50/50)	61 61 61 61 61	35 17 18 43 32	26 44 43 18 29	42.62 72.13 70.49 29.51 47.54
20	0.5 (90/10)	61	24	37	60.66

	0.5 (80/20)	61	12	49	80.33
	0.5 (70/30)	61	13	48	78.69
	0.5 (60/40)	61	41	20	32.79
	0.5 (50/50)	61	27	34	55.74
30	0.5 (90/10)	61	20	41	67.21
	0.5 (80/20)	61	10	51	83.61
	0.5 (70/30)	61	12	49	80.33
	0.5 (60/40)	61	35	26	42.62
	0.5 (50/50)	61	25	36	59.02
40	0.5 (90/10)	61	18	43	70.49
	0.5 (80/20)	61	9	52	85.25
	0.5 (70/30)	61	12	49	80.33
	0.5 (60/40)	61	32	29	47.54
	0.5 (50/50)	61	22	39	63.93
50	0.5 (90/10)	61	19	42	68.85
	0.5 (80/20)	61	8	53	86.89
	0.5 (70/30)	61	11	50	81.97
	0.5 (60/40)	61	31	30	49.18
	0.5 (50/50)	61	21	40	65.57
60	0.5 (90/10)	61	18	43	70.49
	0.5 (80/20)	61	8	53	86.89
	0.5 (70/30)	61	11	50	81.97
	0.5 (60/40)	61	32	29	47.54
	0.5 (50/50)	61	22	39	63.93

TABLE 4.6 RESULTS OF THE TURBIDITY REMOVAL AND TURBIDITY REMOVAL CO-EFFICIENCY (%) FOR DIFFERENT COAGULANT DOSAGE USING HYBRID COAGULATION(0.5g) WHEN MANGO IS HIGHER IN PERCENTAGE.

Time (mins)	Coagulant dosage (g)	Initial turbidity(NTU)	Final turbidity (NTU)	Turbidity removal (NTU)	Turbidity removal co-efficiency (%)
10	0.5 (40/60)	61	48	13	21.31
	0.5 (30/70)	61	32	29	47.54
	0.5 (20/80)	61	25	36	59.02
	0.5 (10/90)	61	53	8	13.11
	0.5 (100)	61	28	33	54.10
20	0.5 (40/60)	61	48	13	13.11
	0.5 (30/70)	61	28	33	54.10
	0.5 (20/80)	61	23	38	21.31
	0.5 (10/90)	61	46	15	54.10
	0.5 (100)	61	25	36	62.30
30	0.5 (40/60)	61	45	16	24.59
	0.5 (30/70)	61	25	36	59.02

	0.5 (20/80)	61	21	40	65.57
	0.5 (10/90)	61	43	18	29.51
	0.5 (100)	61	19	42	68.85
40	0.5 (40/60)	61	38	23	37.70
	0.5 (30/70)	61	23	38	62.30
	0.5 (20/80)	61	20	41	67.21
	0.5 (10/90)	61	41	20	32.79
	0.5 (100)	61	16	45	73.77
50	0.5 (40/60)	61	36	25	40.98
	0.5 (30/70)	61	20	41	67.21
	0.5 (20/80)	61	18	43	70.49
	0.5 (10/90)	61	38	23	37.70
	0.5 (100)	61	15	46	75.41
60	0.5 (40/60)	61	34	27	44.26
	0.5 (30/70)	61	19	42	68.85
	0.5 (20/80)	61	17	44	72.13
	0.5 (10/90)	61	37	24	39.34
	0.5 (100)	61	12	49	80.33

4.5 DISCUSSION ON HYBRID COAGULATION WHEN MANGO HAS AN HIGHER PERCENTAGE DOSAGE THAN MORINGA

Hybrid coagulation is when multiple coagulants are used together to improve the efficiency of the coagulation. From table 4.3 and 4.6 when mango is higher in percentage than moringa. The hybrid coagulation process appears to be less effective. This is so because mango seed powder has a weaker coagulating property compared to moringa seed powder. Therefore using a higher percentage of mango seed powder in the hybrid coagulant mixture results to low coagulating efficiency of the process.

Moringa seeds have a unique molecular structure that makes them highly effective at coagulating, when the percentage of moringa seed powder is lower than mango seed powder in the hybrid coagulant mixture, the coagulanting efficiency could be affected.

4.6 DISCUSSION ON HYBRID COAGULATION WHEN MORINGA HAS AN HIGHER PERCENTAGE DOSAGE THAN MANGO

From table 4.4 and 4.5, on hybrid coagulation when moringa is higher in percentage, it is observed that there increase in the coagulating efficiency. This is as a result of the higher protein content, unique molecular structure anh high availability of active coagulating compounds which the moringa seed powder poses over the mango seed powder.

These protein content binds the impurities together and settle them out of the liquid. Due to the higher percentage of moringa seed powder in the hybrid coagulation, there is an increase in the active coagulating compounds which improve the overall coagulating efficiency.

4.7 EFFICIENCY

With the control aimed at investigating the benefit of using these coagulants. And when sample is allowed to settle naturally, and at the end the turbidity value becomes low as the treated then the treatment is of no use. Therefore, the turbidity of the treated and untreated sample was checked at regular time intervals. Therefore, from the table above, we calculate the efficiency of each reagent by the formular given below.

Efficiency, S = Change in turbidity/Initial turbidity X 100

4.8 PH OF WATER SAMPLE

PH of water is a measure of amount of hydrogen ions that are present in the water. It determines if the water is alkaline or acidic in nature. pH stands for potential of hydrogen. As per the World Health Organisation(WHO), value of pH for water for consumption is 6.5 to 8.5. It is calculated mathematically as **PH = -log(H).** This scale was developed by the scientist Sorenson in the year 1909.

While at the laboratory for the practical, Electrometric method was used to determine the value of the PH of the water sample gotten from Ezu River which gave a value of **7.06** which turns out that the water sample was good for consumption.

4.9 TEST FOR E. COLI

Escherichia coli (E. coli) are bacteria found in the environment, food and intestines of people and animals. E. Coli are a large and diverse group of bacteria. Although most strains of E. Coli are harmless, others can make one sick. Some kinds of E. Coli can cause diarrhoea, while others cause urinary tract infections, respiratory illness and pneumonia and other illness. Each colony forming unit (cfu) of E. Coli will appear as a dot on the petri-dish. This practical is carried out by taking a sample of water and spread across a petri-dish containing a nutrient agar that will allow the growth of colonies on it. After which the record will be taken after 24 hours.

Raw water sample from Ezu river gave a value 20 cfu/10ml after a sample of it was collected with the use of pipette and spread across the spread petri-dish containing a nutrient agar and left for 24 hours for the colony growth. After coagulation, samples from the optimum dosage gotten from mango seed (0.3g) and moringa seed (0.5g) powder was checked again to get the effectiveness of the coagulant which the results turned out to be 8 cfu/10ml and 2cfu/10ml respectively. This can further be made safe for consumption by boiling the water before consumption and preservation.

TABLE 4.7 RESULTS FOR TEST FOR ECOLI

Sample (ml)	Result (cfu/ml)
Raw water	20
Sample treated with mango seed powder (0.3g optimum dosage)	8
Sample treated with moringa seed powder (0.5g optimum dosage)	2

4.10 COLOUR OF END PRODUCT

After the end of the test, the end product of the treated sample gave a colourless water sample at the end of the day while slugs settle below the beaker. From the practical carried out, we can clearly see that moringa seed powder is more active than that of mango seed powder.

4.11 TEST FOR POTASSIUM

Potassium is a naturally occurring element that can be found in water sources. The most common method for testing for potassium in water is by using an atomic absorption spectrophotometer (AAS) or inductively coupled plasma mass spectrometry (ICP-MS). These methods are typically performed in a laboratory setting and require specialized equipment.

It's important to note that testing for potassium in water is typically only necessary in certain circumstances, such as when monitoring the quality of a water source for agricultural or industrial purposes. For most purposes, including drinking water, the levels of potassium in water are typically not a concern. After the practical was carried out the potassium content present on the raw water sample was **5.892ppm**

4.12 TEST FOR NITRATE

Nitrate is a common contaminant found in water, and it can cause health problems if consumed in high concentrations. There are several methods for testing for nitrate in a water sample, including:

1. Colorimetric test: This test involves adding a reagent to the water sample that reacts with nitrate ions and produces a color change. The intensity of the color change is proportional to the concentration of nitrate in the water. Colorimetric test kits are relatively inexpensive and easy to use, making them a popular choice for field testing.

2. Ion-selective electrode (ISE) test: This test involves using a specialized electrode that selectively measures the concentration of nitrate ions in the water. ISE tests are more accurate than colorimetric tests but require specialized equipment and training.

3. Laboratory analysis: Nitrate can be measured in a water sample using laboratory methods such as ion chromatography or spectrophotometry. These methods are highly accurate and can detect nitrate at very low concentrations. However, laboratory analysis is more expensive and time-consuming than field tests. After due consultations using this method of analysis. The nitrate content present in the water sample was **7.899 mg/l**

It's important to note that nitrate levels in water can vary over time and can be affected by factors such as agricultural runoff and septic system leakage. Regular testing is therefore recommended to ensure that nitrate levels in drinking water remain within safe limits.

4.13 TOTAL SUSPENDED SOLIDS

TSS, on the other hand, refers to the amount of solid particles that are suspended in water. These particles can include sediment, organic matter, and other materials. TSS is typically measured in milligrams per liter (mg/L) or parts per million (ppm).

After due practical, the total suspended solids was observed to be **0.06** gram after due calculations.

4.14 TOTAL DISSOLVED SOLIDS

Total dissolved solids (TDS), total suspended solids (TSS), and total solids (TS) are measurements used to describe the concentration of particles in water or other liquids.TDS refers to the amount of inorganic and organic substances that are dissolved in water. These substances can include minerals, salts, and other organic compounds. TDS is usually measured in milligrams per liter (mg/L) or parts per million (ppm). At the end of the ractical the result for the total dissolved solids was **0.1g**.

4.15 TOTAL SOLIDS

TS is the sum of TDS and TSS. It represents the total amount of solid particles in the water, both dissolved and suspended. TS is also measured in mg/L or ppm.

The measurement of TDS, TSS, and TS is important in assessing water quality, especially in industrial and environmental applications. High levels of TDS, TSS, or TS can indicate pollution, excessive nutrient levels, or other environmental problems. Conversely, low levels of TDS, TSS, or TS can indicate a lack of essential nutrients or other important substances. After due calculations, the result after summing the total dissolved solids with the total suspended solids was **0.16g**

CHAPTER FIVE

CONLUSION AND RECOMMENDATION

5.0 CONCLUSION

The results reveal that moringa seed powder as coagulant is more effective than that of mango seed powder as while in use in portable water treatment. The process removes a large number of organic compounds as well as suspended particles including inorganic precipitates, however the water sample may still contain pathogens and other bacteria as it is not 100% effective.

Jar test results are used to calculate the different types and quantity of coagulant to be used in the treatment of the sample. It also served to illustrate the rate order of coagulation reaction of the sample.

From the practical conducted so far, we can get to know the required dosage which can be used for portable water treatment.

5.1 RECOMMENDATION

Generally, natural coagulants effectively gtreat water or waste water with low turbidity ranging from 50 to 500 NTU. The primary sources of plant based coagulants are Moringa Oleifera, cactus, tannin and so on. But in this practical we used moringa oleifera and mango seed powder.

This experimental study has produced valuable results for characterizing the rate order of settling and idea of the dosage of the coagulants (Moringa Oleifera and Magnifera Indica powder) needed. Due to the quality variation and other factors affecting natural water from time to time and with different seasons through the way these dose cannot be said to be fixed as their they would be flexibility in the dosage needed ar the particular point in time. Again due to some known and unknown factors influencing coagulation of water and the type of coagulant, it is impossible to predict the type and amount of reagents necessary to achieve a desired result economically for every water except through tests. Therefore, trial and error experiments using the jar test procedure must be carried out.

Owing to the complexity of this research subject, further researches are recommended.

1. There are needs to carry out study on other treatment processes since coagulation is just a part of water treatment.

2. Other factors that influence coagulation of this wastewater sample should be investigated.

3. Experimental techniques still need to be improved for more accurate measurement of coagulant dose and turbidity.

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APPENDIX I

DATA ANALYSIS FOR MANGO

LABORATORY TEST RESULT FOR MANGO SEED POWDER AS COAGULANT

Initial turbidity = f1

Final turbidity = f2

Calculate for turbidity removal

Turbidity Removal = Initial turbidity – Final turbidity (TR = f1– f2)

Unit: NTU

Calculating for 10 minutes;

For 0.1g dosage, TR = 123 – 115 = 8

0.3g dosage, TR = 123 – 113 = 10

0.5g dosage, TR = 123 – 120 = 3

0.7g dosage, TR = 123 – 121 = 2

1.0g dosage, TR = 123 – 123 = 0

Calculating for 20 minutes;

For 0.1g dosage, TR = 123 – 108 = 15

0.3g dosage, TR = 123 – 101 = 22

0.5g dosage, TR = 123 – 113 = 10

0.7g dosage, TR = 123 – 118 = 5

1.0g dosage, TR = 123 – 112 = 11

Calculating for 30 minutes;

For 0.1g dosage, TR = 123 – 98 = 25

0.3g dosage, TR = 123 – 96 = 27

0.5g dosage, TR = 123 – 107 = 16

0.7g dosage, TR = 123 – 113 = 10

1.0g dosage, TR = 123 – 112 = 11

Calculating for 40 minutes;

For 0.1g dosage, TR= 123 – 91 = 32

0.3g dosage, TR = 123 – 93= 30

0.5g dosage, TR = 123 – 103 = 20

0.7g dosage, TR = 123 – 109 = 14

1.0g dosage, TR = 123 – 105 = 18

Calculating for 50 minutes;

For 0.1g dosage, TR = 123 – 94 = 29

0.3g dosage, TR = 123 – 93 = 30

0.5g dosage, TR = 123 – 104 = 19

0.7g dosage, TR = 123 – 108= 15

1.0g dosage, TR = 123 – 105 =18

Calculating for 60 minutes;

For 0.1g dosage, TR = 123 – 91 = 32

0.3g dosage, TR = 123 – 91 = 32

0.5g dosage, TR = 123 – 103 = 20

0.7g dosage, TR = 123 – 107 = 16

1.0 g dosage, TR = 123 – 100 = 23

TURBIDITY REMOVAL CO-EFFICIENCY CALCULATION FOR MANGO SEED POWDER AS COAGULANT

T.R.E = F1 – F2/F1 x 100 = Turbidity Removal/F1 x 100

Calculating for 10minutes;

For 0.1g dosage = 8/123X 100 = 6.50%

0.3g dosage = 10/123 X 100 = 8.13%

0.5g dosage = 3/123X 100 = 2.44%

0.7g dosage = 2/123X 100 = 1.63%

1.0g dosage = 0/123X 100 = 0.00%

Calculating for 20 minutes;

For 0.1g dosage = 15/123X 100 = 12.20%

0.3g dosage = 22/123 X 100 = 17.89%

0.5g dosage = 10/123X 100 = 8.13%

0.7g dosage = 5/123X 100 = 4.07%

1.0g dosage =11/123X 100 = 8.94%

Calculating for 30 minutes;

For 0.1g dosage = 25/123X 100 = 20.33%

0.3g dosage = 27/123 X 100 = 21.95%

0.5g dosage = 16/123X 100 = 13.01%

0.7g dosage = 10/123X 100 = 8.13%

1.0g dosage = 11/123X 100 = 8.94%

Calculating for 40 minutes;

For 0.1g dosage = 32/123X 100 = 26.02%

0.3g dosage = 30/123 X 100 = 24.39%

0.5g dosage = 20/123X 100 = 16.26%

0.7g dosage = 14/123X 100 = 11.38%

1.0g dosage = 18/123X 100 = 14.63%

Calculating for 50 minutes

For 0.1g dosage = 29/123X 100 = 23.58%

0.3g dosage = 30/123 X 100 = 24.39%

0.5g dosage = 19/123X 100 = 15.45%

0.7g dosage = 15/123X 100 = 12.20%

1.0g dosage = 18/123X 100 = 14.63%

Calculating for 60 minutes

For 0.1g dosage = 32/123X 100 = 26.02%

0.3g dosage = 32/123 X 100 = 26.02%

0.5g dosage = 20/123X 100 = 16.26%

0.7g dosage = 16/123X 100 = 13.01%

1.0g dosage = 23/123X 100 = 18.70%

Taking average of 0.1g dosage for all time intervals

(6.50 + 12.20 + 20.33 + 26.02 + 23.58 + 26.02)/6 = 19.11%

Taking average of 0.3g dosage for all time intervals

(8.13 + 17.89 + 21.95 + 24.39 + 24.39 + 26.02)/6 = 20.46%

Taking average of 0.5g dosage for all time intervals

(2.44 + 8.13 + 13.01 + 16.26 + 15.45 + 16.26)/6 = 11.92%

Taking average of 0.7ml dosage for all time intervals

(1.63 + 4.07 + 8.13 + 11.38 + 12.20 + 13.01)/6 = 8.40%

Taking average of 1.0g dosage for all time intervals

(0.00 + 8.94 + 8.94 + 14.63 + 14.63 + 18.70)6 = 10.98%

AVERAGE REMOVAL CO-EFFICIENCY USING MANGO SEED POWDER AS COAGULANT.

Dosage (g)	Average Removal co-efficienCY
0.1	19.11
0.3	20.46
0.5	11.92
0.7	8.40
1.0	10.98

APPENDIX II

DATA ANALYSIS USING MORINGA SEED POWDER AS COAGULANT

Initial turbidity = f1

Final turbidity = f2

Calculate for turbidity removal

Turbidity Removal = Initial turbidity – Final turbidity (TR = f1– f2)

Unit: NTU

Calculating for 10 minutes;

For 0.1g dosage, TR = 123 – 100 = 23

0.3g dosage, TR = 123 – 27 = 96

0.5g dosage, TR = 123 – 25 = 98

0.7g dosage, TR = 123 – 42 = 81

1.0g dosage, TR = 123 – 29 = 94

Calculating for 20 minutes;

For 0.1g dosage, TR = 123 – 89 = 34

0.3g dosage, TR = 123 – 24 = 99

0.5g dosage, TR = 123 – 23 = 100

0.7g dosage, TR = 123 – 38 = 85

1.0g dosage, TR = 123 – 28 = 95

Calculating for 30 minutes;

For 0.1g dosage, TR = 123 – 87 = 36

0.3g dosage, TR = 123 – 24 = 99

0.5g dosage, TR = 123 – 19 = 104

0.7g dosage, TR = 123 – 35 = 88

1.0g dosage, TR = 123 – 26 = 97

Calculating for 40 minutes;

For 0.1g dosage, TR= 123 – 70 = 53

0.3g dosage, TR = 123 – 19 = 104

0.5g dosage, TR = 123 – 15 = 108

0.7g dosage, TR = 123 – 32 = 91

1.0g dosage, TR = 123 – 22 = 101

Calculating for 50 minutes;

For 0.1g dosage, TR = 123 – 60 = 63

0.3g dosage, TR = 123 – 15 = 108

0.5g dosage, TR = 123 – 13 = 110

0.7g dosage, TR = 123 – 28 = 95

1.0g dosage, TR = 123 – 20 =103

Calculating for 60 minutes;

For 0.1g dosage, TR = 123 – 50 = 73

0.3g dosage, TR = 123 – 13 = 110

0.5g dosage, TR = 123 – 10 = 113

0.7g dosage, TR = 123 – 27 = 96

1.0 g dosage, TR = 123 – 18 = 105

TURBIDITY REMOVAL CO-EFFICIENCY CALCULATION FOR MORINGA SEED POWDER AS COAGULANT

T.R.E = F1 – F2/F1 x 100 = Turbidity Removal/F1 x 100

Calculating for 10minutes;

For 0.1g dosage = 23/123X 100 = 18.70%

0.3g dosage = 96/123 X 100 = 78.05%

0.5g dosage = 98/123X 100 = 79.67%

0.7g dosage = 81/123X 100 = 65.85%

1.0g dosage = 94/123X 100 = 76.42%

Calculating for 20 minutes;

For 0.1g dosage = 34/123X 100 = 27.64%

0.3g dosage = 99/123 X 100 = 80.49%

0.5g dosage = 100/123X 100 = 81.30%

0.7g dosage = 85/123X 100 = 69.11%

1.0g dosage = 95/123X 100 = 77.24%

Calculating for 30 minutes;

For 0.1g dosage = 36/123X 100 = 29.27%

0.3g dosage = 99/123 X 100 = 80.49%

0.5g dosage = 104/123X 100 = 84.55%

0.7g dosage = 88/123X 100 = 71.54%

1.0g dosage = 97/123X 100 = 78.86%

Calculating for 40 minutes;

For 0.1g dosage = 53/123X 100 = 43.09%

0.3g dosage = 104/123 X 100 = 84.55%

0.5g dosage = 108/123X 100 = 87.80%

0.7g dosage = 91/123X 100 = 73.98%

1.0g dosage = 101/123X 100 = 82.11%

Calculating for 50 minutes

For 0.1g dosage = 63/123X 100 = 51.22%

0.3g dosage = 108/123 X 100 = 87.80%

0.5g dosage = 110/123X 100 = 89.43%

0.7g dosage = 95/123X 100 = 77.24%

1.0g dosage = 103/123X 100 = 83.74%

Calculating for 60 minutes;

For 0.1g dosage = 73/123X 100 = 59.35%

0.3g dosage = 110/123 X 100 = 89.43%

0.5g dosage = 113/123X 100 = 91.87%

0.7g dosage = 96/123X 100 = 78.05%

1.0g dosage = 105/123X 100 = 85.37%

Taking average of 0.1g dosage for all time intervals

(18.70 + 27.64 + 29.27 + 43.09 + 51.22 + 59.35)/6 = 38.21%

Taking average of 0.3g dosage for all time intervals

(78.05 + 80.49 + 80.49 + 84.55 + 87.80 + 89.43)/6 = 83.47%

Taking average of 0.5g dosage for all time intervals

(79.67 + 81.30 + 84.55 + 87.80 + 89.43 + 91.87)/6 = 85.77%

Taking average of 0.7ml dosage for all time intervals

(65.85 + 69.11 + 71.54 + 73.98 + 77.24 + 78.05)/6 = 72.63%

Taking average of 1.0g dosage for all time intervals

(76.42 + 77.24 + 78.86 + 82.11 + 83.74 + 85.37)/6 = 80.62%

AVERAGE REMOVAL CO-EFFICIENCY FOR MORINGA SEED POWDER

Dosage (g)	Average Removal co-efficiency
0.1	38.21
0.3	83.47
0.5	85.77
0.7	72.63
1.0	80.62

APPENDIX III

RESULTS OF THE TURBIDITY REMOVAL AND TURBIDITY EFFICIENCY (%) FOR DIFFERENT COAGULANT DOSAGE FOR HYBRID COAGULATION.

Using the optimum dosage gotten from mango seed as coagulant which is 0.3g

PERCENTAGE RATIO OF 0.3g OPTIMUM DOSAGE FOR MANGO SEED POWDER (FOR HYBRID COAGULATION)

Percentage ratio (%)	Mango (g)	Moringa (g)
90/10	0.27	0.03
80/20	0.24	0.06
70/30	0.21	0.09
60/40	0.18	0.12
50/50	0.15	0.15
40/60	0.12	0.18
30/70	0.09	0.21
20/80	0.06	0.24
10/90	0.03	0.27
100	0.3	0

PERCENTAGE REMOVAL CO-EFFICIENCY FOR HYBRID COAGULATION WITH OPTIMUM DOSAGE OF 0.3g OF MANGO SEED POWDER.

Percentage Ratio	Percentage Removal Co-efficiency
90/10	18.58
80/20	27.05
70/30	26.50
60/40	12.30
50/50	26.23
40/60	35.79
30/70	60.38
20/80	69.40
10/90	57.10
100	47.54

APPENDIX IV

PERCENTAGE RATIO OF 0.5g OPTIMUM DOSAGE FOR MORINGA SEED POWDER (FOR HYBRID COAGULATION)

Percentage ratio (%)	Mango (g)	Moringa (g)
90/10	0.45	0.05
80/20	0.40	0.10
70/30	0.35	0.15
60/40	0.30	0.20
50/50	0.25	0.25
40/60	0.20	0.30
30/70	0.15	0.35
20/80	0.10	0.40
10/90	0.05	0.45
100	0.5	0

PERCENTAGE REMOVAL CO-EFFICIENCY FOR OPTIMUM DOSAGE OF 0.5g OF MORINGA SEED POWDER.

Percentage Ratio	Percentage Removal Co-efficiency
90/10	63.39
80/20	82.51
70/30	78.96
60/40	41.55
50/50	39.29
40/60	31.97
30/70	59.84
20/80	66.12
10/90	29.51
100	68.58