UNIVERSITI PUTRA MALAYSIA

OPTIMIZATION OF USING MORINGA OLEIFERA SEED POWDER AS A COAGULANT IN THE TREATMENT OF WATER TURBIDITY

SAAD ABDULAMIR ABBAS

OPTIMIZATION OF USING MORINGA OLEIFERA SEED POWDER AS A COAGULANT IN THE TREATMENT OF WATER TURBIDITY

By

SAAD ABDULAMIR ABBAS ,

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Engineering
Universiti Putra Malaysia

October 2001

To my family, to all my friends who support me in all the times, to my lovely parents, my brother and sisters who pried day and night to ALLAH (s.w.) asking Him to guides me and gives me the power and the health to finish this work

Yours faithfully
Saad

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of requirement for the degree of Master of Science

OPTIMIZATION OF USING MORINGA OLEIFERA SEED POWDER AS A COAGULANT IN THE TREATMENT OF WATER TURBIDITY

By

SAAD ABDULAMIR ABBAS

October 2001

Chairperson: **Dr. Suleyman Aremu Muyibi**

Faculty: **Engineering**

Moringa Oleifera has a great potential in water treatment. Several researchers have reported on its various uses as a coagulant. *Moringa oleifera* seed was found, able to achieve 83% turbidity removal. The active ingredient in *Moringa oleifera* seeds is a polypeptide, which acts as cationic polymer.

The class of coagulants and flocculants known as polyelectrolytes (or polymers) is becoming more and more popular. A proper dosage of the right polyelectrolyte can improve finished water quality while significantly, reducing sludge volume and overall operating costs.

Some studies have focused mainly on the efficiency of *Moringa oleifera* seed extract as a coagulant. Some other studies have focused on quality of water treated by coagulation using two forms of seed (shelled and unshelled) using the water extract with turbid water model as the water source. Other study investigates the effects of fully extracting oil from *Moringa oleifera* on its coagulation effectiveness using turbid water from surface water as the raw water source.

There is a limitation in the primary coagulant characteristic of the protein, which exists in *Moringa oleifera* seed, as cationic polyelectrolytes when used to treat and remove water turbidity.

This study investigate the optimum value of extracting oil from *Moringa oleifera* seed, and determine the effect of applying *Moringa oleifera* on treatment and removal of water turbidity.

The seed of *Moringa oleifera* is processed by dehulling the coats and wings using Satake Rice Machine. Extraction of oil by hexane is carried out using cycles of extraction in Soxhlet apparatus.

Several grads of oil extraction such as 20, 25 and 27% oil removal were applied to turbid water of different turbidity values as low, medium and high. The optimum value, which was observed at 25% oil removal, was applied to surface water samples of two river water namely, Batang Kali River and Selangor River.

The results were significant for both model and surface water. In which, achievement up to 99% of turbidity removal was observed.

The result of this study supports the new trend for cheap and more environmental friendly ways of water treatment. This study exhibits a potential of using the *Moringa oleifera* as an alternative to conventional commercial coagulants.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

OPTIMIZATION OF USING MORINGA OLEIFERA SEED POWDER AS A COAGULANT IN THE TREATMENT OF WATER TURBIDITY

Oleh

SAAD ABDULAMIR ABBAS

Oktober 2001

Pengerusi: **Dr. Suleyman Aremu Muiybi**

Faculti: **Kejurutraan**

Biji benih Moringa Oleifera mempunyai potensi besar dalam rawatan air. Beberapa pakar penyelidik telah melaporkan kegunaannya sebagai agen pemekatan. Biji benih Moringa Oleifera yang dijumpai boleh menukarkan kekeruhan sehingga mencapai 83%. Ramuan aktif yang terdapat dalam biji benih Moringa Oleifera adalah polipeptida, yang bertindak sebagai polimer kationik.

Kelas bagi agen pemekat dan penggumpal ini dikenali polielektrolit (atau polimer) semakin menjadi popular. Polielektrolit dengan dos yang bersesuaian boleh memperbaiki kualiti air disamping dapat mengurangkan lumpur dan seterusnya mengurangkan kos operasi.

Kebanyakan penyelidikan berkisar kepada keberkesanan ekstrak biji benih Moringa Oleifera sebagai agen pemekatan. Sebahagian penyelidikan lagi memfokuskan kepada kualiti air yang dirawat dengan pemekatan dua bentuk biji benih (berselaput dan tak berselaput) menggunakan ekstrak air daripada model air keruh sebagai sumber. Dalam kes lain pula, penyelidikan terhadap

kesan ekstrak minyak daripada Moringa Oleifera ke atas kekesanan penggumpalannya menggunakan air keruh dari permukaan sebagai sumber.

Wujudnya batasan, iaitu, ciri-ciri pertama pada protein yang wujud dalam biji benih Moringa Oleifera, sebagai polielektralit kationik bila digunakan sebagai agen pemekatan dalam rawatan air.

Projek ini menyiasat tentang nilai optimum pengekstrakan minyak daripada biji benih Moringa Oleifera dan penentuan keberkesanannya dalam rawatan serta penyingkiran kekeruhan air.

Moringa Oleifera telah melalui proses seperti `Dehulling', iaitu membuang selaput menggunakan Satake Rice Machine, dan pengekstrakan minyak menggunakan Soxhlet, serta heksana sebagai media pelarut.

Moringa Oleifera yang mempunyai nilai ekstrak minyak tersingkir yang berbeza, iaitu 20%, 25% dan 27% diapplikasikan kepada model air keruh yang mempunyai tahap kekeruhan berbeza, rendah, sederhana dan tinggi. Nilai optimum iaitu 25% minyak tersingkir diambil daripada air permukaan Sungai Batang Kali dan Sungai Selangor.

Hasil ujian ke atas kedua-dua model dan air permukaan, mencapai sehingga 98.5% dan 99%.

Hasil daripada penyelidikan telah memberikan satu fenomena baru dalam dekad ini, dimana satu lagi cara atau jalan dalam proses rawatan air yang lebih murah dan `mesra alam'. Kits berharap agar para penyelidik akan terus menyambung usaha sebegini demi kebaikan global.

ACKNOWLEDGEMENTS

Firstly, I like to give praise to ALLAH the Merciful, for his Mercy giving; from HIM I got the health, the power, the guide and the patience to finish this work.

I wish to express my sincere gratitude to Dr. Suleyman Aremu Muyibi for his supervision, patience, encouragement and help during the course of this research work. Also I would like to thank the other members of the supervisory committee Assoc. Prof Madya Megat Johari M. M. Noor. Prof Dr. Fakhru'l-Razi Ahmadun and Prof Madya Dr. Amir H. Kahdom for their great contributions and support.

This funding for this study was provided by MOSTE under IRPA grant 1998 cycle 2/3 to whom the authors is grateful.

Thanks also go to all staff, in the Public Health Laboratory at UPM and Chemistry Laboratory at UKM for their assistance in many ways.

I certify that an Examination Committee met on 17th October 2001 to conduct the final examination of Saad Abdulamir Abbas on his Master Science thesis entitled "Optimization of Using Moringa Oleifera Seed Powder as a Coagulant in the Treatment of Water Turbidity" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Azni Adris, Ph.D.
Faculty of Engineering,
Universiti Putra Malaysia
(Chairman)

Suleyman Aremu Muyibi, Ph.D.
Faculty of Engineering,
Universiti Putra Malaysia
(Member)

Fakhru'l-Razi Ahmadun, Ph.D.
Associate Professor,
Faculty of Engineering,
Universiti Putra Malaysia
(Member)

Amir HassanKadhum, Ph.D.
Associate Professor,
Faculty of Engineering,
Universiti Kebangsaan Malaysia
(Member)

AINI IDERIS, Ph.D.
Professor,
Dean of Graduate School,
Universiti Putra Malaysia

Date: 2 1 JAN 2002

The thesis submitted to the Senate of Universiti sutra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

AINI IDERIS, Ph.D.
Professor/
Dean of Graduate School
Universiti Putra Malaysia

Date: 14 MAR 2002

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions

----
Saad Abdulamir Abbas
Date:

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 Introduction

In many developing countries, water supply authorities make use of alum as a primary coagulant in turbidity removal. In situations where high concentrations of alum are needed, lime is also added to raise the pH of the water, thereby facilitating the treatment.

The cost of procuring these chemicals is increasing rapidly and most developing countries are finding it difficult to cope. The chemicals have to be imported in many cases and high exchange rates coupled with the general poor performance of the economies further compound the problem.

In Nigeria, for example, the big municipalities like Ibadan and Kano are spending 42 % and 65 % of their annual recurrent costs respectively, on water supply. (Water Resources and Engineering Construction Agency, Kano. Nigeria, communication 1989)

In the circumstances, many water supply companies tend to under dose with, chemicals, resulting in the production of low- quality drinking water. Such under dosing is inevitable if the water authorities are to meet the water demand of their teeming populations.

Therefore, where cheaper alternatives could be found, to replace or supplement the conventional treatment chemical, their use would be a welcome benefit for the poorer less developed countries (Muyibi 1994). In these regions, traditional processes of water purification have been using native sources of vegetable, animal or mineral nature, as a coagulants.

In developing countries, supply of sufficiently clarified drinking water of high hygienic quality may be problematical. Know-how and equipment for wastewater treatment as applied in the industrialized countries are rare especially in rural areas.

Important plant families, some genera of which have been traditionally used to clean water in private households are *Capparidaceae* and *Papilionaceae*. Branches and hark of Boscia senegalensis (Pers) Lam. ox Poir. Of the Capparidaceae family for example, have been added to the water for clarification. In Egypt and North Sudan, seeds of Papilionaceae including the genera Phaseolus (various bean cultivars). Pisum (peas), Arachis (peanuts), and Lstpintts (lupines) are used, although their clarifying effect is low. More efficient are plants of the genus vicia (field bean), which have been applied to water cleaning also in Bolivia.

Of special interest are *traditional water-cleaning methods* in Sudan where the seeds of *Moringaceae* are preferred. *Moringaceae*, although very similar to the Capparidaceae, form a family of their own including one genus (Moringa) and 14 species of which *Moringa oleifera* has gained considerable importance as flocculent, drug and food in nearly all tropic and subtropics regions. The seeds of six more frequent and cultivated species of *Moringa* have been found to contain flocculent components of the less frequent species; the seeds of *Moringa stenopetala* show the strongest flocculent effect comparable to that of aluminum sulphate. (Ursula Gassenschmidt, 1994).

Moringa oleifera has a great potential in water treatment. Several researchers have reported on its various uses as a coagulant, softening agent, and a bactericidal agent. The active ingredient is a polypeptide acting as cationic polymers (Muyibi, 1994).

In developing countries, great efforts have been made worldwide to optimize the use of this cheap native flocculants. As knowledge of the nature of the active compounds is of essential importance, flocculants compounds was isolated of several plants used for water treatment. Experiments were conducted with a pure protein from *M. oleifera* to gain insight into the flocculants mechanism and activity (Ursula Gassenchmidt, 1994).

1.2 Problem definition

The use of *Moringa oleifera* seed as a coagulant in the removal of water turbidity would be a viable replacement and / or supplement to the conventional chemicals.

Previous studies focused mainly on the efficiency of *Moringa oleifera* seed extract as a coagulant. Some have focused on the physical factors affecting the use of *Moringa oleifera* seed in the coagulation of model turbid water. Other studies have focused on the quality of water treated by coagulation using two forms of seed (shelled and unshelled) using the extract with model turbid water as the water source Other study was focused on the effect of extracting the whole quantity of oil from *Moringa oleifera* on the coagulation using turbid water from surface water source.

There is a limitation, in the primary coagulation's characteristic for the protein exists in the seeds of *the Moringa oleifera*, as cationic polyelectrolytes, some studies were concentrate on the development and enhancement of these characteristics, to improve the capability of the *Moringa oleifera* as a coagulant in reducing the turbidity of the water.

The objective of this study is:

1. To investigate the possibility of replacement of the conventional way of treating and removing water turbidity by using *Moringa oleifera* with a new approach of processing , including improvement and enhancement of the capability of *Moringa oleifera* as a coagulant in water treatment.

2. To investigate the optimum value of oil removal from the seed powder of *Moringa oleifera,* that gives the best turbidity removal.

1.3 Scope of the study

This study involved the following:

1. Dehulling and separation of the shells of the selected seeds of *Moringa oleifera*, seed's coat and wings were removed using Satake Rice Machine.

2. Extract the oil from the seeds using the followed, current procedures for oil extraction. This will include chemical extraction using solvent, which was selected considering the health and safety aspect.

Oil was extracted in different quantities from *Moringa oleifera* and the solid residue after processing was be used as a coagulant to investigate the best value of oil existence in *Moringa oleifera* seed which give the best turbidity removal.

CHAPTER II

Literature review

2.1 Dehulling & Extraction of Oil

Commercially there is no record of the oil extraction for the *M. oleifera* seeds but different ways of oil extraction can be adopted to extract the oil of *M oleifera*, because its seeds not too much deferent in structure and shape from other oil seeds. Like cotton seeds. In addition, I will consider the processing of the sesame oil seeds, as a procedure might be also adept partially.

Dehulling is an integral part of the modern oil extraction plants .It is also; recommended producing a high-quality oil and meal.

2.2 Extraction of Oil-from cotton seeds

Godin and Spensley (1971) have described the Pretreatment and extraction processes for the commercial production of Cottonseed oil. The cottonseeds are dried, cleaned, and delineated. The hulling or decorticating carried out using either a bar or disk-type huller. The separation and meals is accomplished in an assembly consisting of shakers and separators. The separated kernels are roiled into thin flakes between heavy smooth iron rolls for oil recovery by mechanical expression or solvent extraction. Cooking is necessary before mechanical expression and some times before solvent extraction. The flaked meals are subjected to heat treatment. For hydraulic pressing, the cooking time ranges from 120 min, temperatures varying from 79 to 91'C in the top pan and to a bout 107 to 112'C in the bottom pan. The moisture content is reduced from 11-12% to about 5-5.5%. For direct solvent extraction, flakes are first cooked and cooled to surface-dry the particles and put the granular state. When cooking is omitted before extraction, the meal must be heat processed to destroy free gossypol (Heywang et al, 1950).

The oil is extracted from the cottonseed by the following method:

Hydraulic press, screw expeller press, solvent extraction prepress, sol, extraction, and filtration extraction (Bell and Stipanovic 1977). In hydraulic pressing, the meals are discharged from the cooker into a mechanical cake former and the slabs are formed and enclosed in a press cloth. The cake thus produced contains 5.6 to 6.5% oil. Continuous pressing may be employed where cottonseed is crushed in a screw press. The oil is settled to remove bulk of the fine, then passed through a plate filter press, and pumped to storage tanks. The press cake is ground into meal and then ground cottonseed hulls are added to adjust the protein content given by the required standards. The meal contains about 2.5 to 4% oil. Please see figure 2.1 in Appendix.

More recently, the solvent extraction method has largely been employed the oil-solvent solution is filtered and clarified, unless a percolation-type, extractor is used. The micelle is passed through a tube extractor, which recovers 90% of the solvent. The oil concentrate is then passed through a stripping column, where sparging steam is applied to remove the remaining solvent. The meal thus extracted has only about 1 % residual oil. The crude cottonseed oil is refined to free most of its nonglyceride constituent's treatment with alkali, followed by bleaching and deodorization (Cherry and Berardi, 1983).

2.3 Particulate characteristics

The particulate in the water are categorized in to two major ~ size groups, Colloidal material, with an upper limit of approximately 1 µm and lower limit of approximately 5. µm, and suspended solids consisting of particulate larger than approximately 0.5 µm. Particulate smaller than 5 µm are considered to be in true solution. Colloids and coarse particulate suspension are also characterized according to nature of their water-solid interface. Hydrophobic particles have a well-defined interface between the water and solid phases and have a low affinity for water molecules. They are thermodynamically unstable and will aggregate inversely over time. Hydrophilic particulates are characterized by the lack of a clear phase boundary and are generally solutions of macromolecular organic compounds, such as proteins or humic acids (James, 1985). .

2.4 Coagulation

Coagulation is a complex process of combining small particles into large aggregates for subsequent separation by either sedimentation or filtration. The coagulation process, as practiced in both water purification and sludge dewatering activities, usually employs a particle destabilizing stage to increase the rate at which particles aggregate. Colloidal particles are destabilized, and are achieved mainly by neutralizing their electric charge by the process. Without coagulation, 1 micron (colloidal) sized particles could take up to 20 years to settle through 3 feet of water by gravitational forces alone.

Coagulation is usually achieved by the addition of chemical reagents, which by a bonding or adsorption mechanism nullify the repulsive forces on the colloidal particles surface. The corresponding reagents are called coagulants (Kem Tron 1999).

2.5 Flocculation

Flocculation is used to describe the action of polymeric materials, which form bridges between individual particles. Bridging occurs when segments of a polymer chain adsorb on different particles and help these particles aggregate (Kern Tron, 1999).

The destabilization step results in a disruption of the natural forces (van der Waals, hydrodynamic, and electrostatic) occurring between all suspended particles. Both van der Waals and hydrodynamic forces are ubiquitous elements that dictate equipment design and operating discipline, whereas, electrostatic forces can be manipulated by the addition of special charge-neutralizing chemicals (flocculating agents). When these charge-neutralizing agents are used, a dynamic evaluation of the composite state-of-electrical. -Charge on the particles becomes a necessary element for good coagulation control. Several accepted methods are currently in use to measure the state-of-charge on the particle. Each technique differs in the manner by which the data is acquired and the convention with which it is subsequently treated. Comparative test data indicate that a strong correlation exists between all methods, and each is suitable to establish the state of charge neutralization. One method -- streaming current -- has an advantage over all other methods for process control by providing a continuous, real-time indication of the state-of-charge on the particle, thereby facilitating the use of closed-loop control systems for automatically adjusting the coagulant dosage rates. (Zeta Monitor).

Particulate is providing to increase the rate of particulate collisions with out breaking up or disrupting the aggregates being formed. This phenomenon is called flocculation (James, 1985). The term coagulation also is applied to the overall process of particle aggregation, including both particle destabilization and particle transport. While the term, flocculation is used to describe only the transport step (Weber, 1972). For colloidal particles (less than 1 Din) Brownian motion provides some degree of particulate transport. This is known as per kinetic flocculation. For larger particulate Brownie motion is very slow, and transport requires mixing by mechanical means. Mechanical mixing device such as paddies or mechanical turbine mixers is used for this purpose. This sub process is termed or thokinetic flocculation.

2.6 Stability of particulate

The principal characteristics of fine particulate matter suspended in water is its relative stability, cause it to remain in suspension for along periods of time (James, 1985). Each colloid particle carries a like charge; witch in nature is usually negative. The sign and magnitude of the primary charge are frequently affected by pH and ionic content of the aqueous phase This like charge causes adjacent particle to repel each other and prevent agglomeration and flocculation. As result, charged colloids tend to remain discrete, dispersed, and in suspension (Weber, 1972 and Zeta-Meter, 1993). The particulate suspensions are thermodynamically unstable, and given sufficient time, colloids and fine particles will settle. However, this process is not economically feasible (James, 1985). On the other hand, the reduction or elimination of the charge makes the colloids gather. The form firstly small groups, then larger aggregates and finally in to visible floc particles witch settle rapidly and filter easily (Zeta, 1993). Coagulation-flocculation facilities must eliminate particulate stability and there by increase the rate of particulate removal.

2.7 Mechanism of stability

The principal of mechanism controlling the stability of hydrophobic and hydrophilic particulate particulates is electrostatic repulsion (Weber, 1972 and James, 1985). In the case of hydrophobic surfaces, an excess of anions may accumulate at the interface, producing an electrical potential that can repulse particulate of similar surface potential. For hydrophilic surfaces, typically electrical charges arise from dissociation of inorganic groups, for example, a carboxyl or other organic' acids group located on the particulate surface or interface. In addition to this electrostatic repulsion, particulate play also quite stable due to presence of adsorbed water molecules that provide a liquid barrier to successful particulate collisions (James, 1985).

2.8 Origin of the double layer

The double layer model is used to visualize the ionic environment in the vicinity of a charged colloid and explain how electrical repulsive forces occur. Initially attraction from the negative colloid causes some of the positive ions to form a firmly attached layer around the surface of the colloid. This layer of positive ions (often called counter- ions) is known as the stem layer (Zeta-Meter, 1993). This layer is approximately 5 Fin deep (James, 1985). Additional ions are still attached by the negative colloid but now they are repelled by the positive stem layer as well as nearly by positive ions that are also trying to approach the colloid A dynamic equilibrium results, forming a deface layer of counter-ions. The diffused positive ion layer has a high concentration near the colloid witch gradually decreases with distance until it reaches equilibrium with the normal counter-ion concentration in the solution see fig. 2-1

In a similar but opposite fashion, there is a lack of negative ions in the neighborhood, because they are repelled by the negative colloid. Negative ions are called co-ions because they have the same charge as the colloid. Their concentration will gradually increase as the repulsive forces of colloid are screened out by the positive ions until equilibrium is again reached with co-ion concentration in solution (Zeta-Meter, 1993 & Weber, 1972).

The situation changes with brackish or saline waters; the high level of water compress double layer *and* the potential carve. Now the zeta potential is only a fraction of the surface potential (Zeta-Meter, 1993).