



**EXTRACTION AND CHARACTERIZATION OF
COAGULATION ACTIVE AGENT FROM
MORINGA OLEIFERA FOR TURBIDITY AND
HARDNESS REMOVAL IN RAW WATER
SOURCES**

BY

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A thesis submitted in fulfilment of the requirements for the degree of
Master of Science Environmental Engineering

**School of Environmental Engineering
UNIVERSITI MALAYSIA PERLIS**

2012

DEDICATION

Thanks to Allah SWT for all power and health to me

To my beloved parents, H. Ir. Syafruddin Hasan, MT and Hj. Chairani br Sirait, BSc

My sister Hafnida and my brother Muhammad Taufik

Thank you for your support, love, prayers, guidance, confidence, and financial to

successfully complete my master study in UniMAP

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AKNOWLEDGMENT

I would like to express my deep and sincere gratitude to my supervisor, Dr. Fahmi Muhammad Ridwan. His wide knowledge and his logical way of thinking have been of great value for me. His encouraging and personal guidance have provided a good basis for this thesis. His opinion has helped me a lot in completing this thesis. Special thanks for him for understanding of time-absorbing process required in completing this thesis. Special thanks to co-supervisor Salsuwanda Selamat for her guidance and advices.

Thousand thanks to my unforgettable friends for helping me to complete this project. Particular appreciation goes to Norasmizan Abdullah, Roha Diana, Sheli Akma, A Nge Lay, Che Zulzikrami, Hassan Dhiaaldeem Mohammed, Tursunov Obid, Fatin Nadhirah, Najihah, Abdul Latif, Hamizi Yahya, Murali, Azhar, and others who are not mention here. Their assistance really means a lot to me.

Not forgetting, special thanks to the staff especially teaching engineers and technicians of Universiti Malaysia Perlis, for their information, help and guidance during my research. Last but not least, I would like to thank everyone involved who has given inspirations and guidance whether directly or indirectly. Thank you.

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ABBREVIATIONS

| | |
|--------------------------------------|------------------------------|
| CaCl ₂ .2H ₂ O | Calcium chloride dihydrate |
| DI | Distilled water |
| FTIR | Fourier Transform Infrared |
| kDa | Kilo Dalton |
| KCl | Potassium chloride |
| Mg/L | Milligram per liter |
| MO | Moringa oleifera |
| NaCl | Sodium chloride |
| NaOH | Sodium hydroxide |
| NTU | Nephelometric Turbidity Unit |
| pI | Isoelectric point |
| RPM | Rotation per minute |

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Pengekstrakan dan Pencirian Pengentalan Bahan Aktif dari *Moringa Oleifera* untuk Penyingkiran Kekeruhan dan Kekerasan di dalam Sumber Air Mentah

ABSTRAK

Objektif utama ujikaji ini adalah untuk mengenal pasti kapasiti bahan aktif yang diekstrak dari *Moringa Oleifera* (MO) oleh pelbagai jenis larutan bagi tujuan penyingkiran kekeruhan dan kekerasan di dalam sumber air mentah. Bahan aktif yang diekstrak juga dicirikan berasas kepada analisis kumpulan fungsi. Larutan-larutan NaCl, KCl dan air suling digunakan bagi tujuan pengekstrakan bahan aktif tersebut.

Bagi mencapai objektif ini, beberapa siri ujikaji telah dijalankan meliputi analisa kualitatif dan korelasi kuantitatif telahpun dibuat. Hasil ujikaji menunjukkan larutan NaCl 1N memberikan penyingkiran kekeruhan dan kelikatan lebih tinggi di dalam air mentah berbanding penggunaan larutan KCl 1N dan air suling. Sementara itu, pencirian kumpulan fungsi menggunakan FTIR bagi sisa pepejal selepas pengekstrakan menunjukkan bahawa penguraian ikatan-ikatan N-H dan C = O menggunakan larutan NaCl 1.0 N adalah lebih baik berbanding larutan KCl 1.0 N dan air suling. Protein yang terdapat dalam *Moringa oleifera* yang diekstrak dengan air suling, NaCl 1N, and KCl 1N yang paling efektif terdapat pada pH 7. Persamaan regresinya adalah $y = 1.634x + 0.0026$, dimana nilai koefisien korelasinya (R^2) adalah 0.9989.

Extraction and Characterization of Coagulation Active Agent from *Moringa Oleifera* for Turbidity and Hardness Removal in Raw Water Sources

ABSTRACT

The objective of this study is to explore the capacity of the active agent that extracted from *Moringa oleifera* (MO) by various solutions for turbidity and hardness removal in raw water sources. The extracted active agent was also characterized based on its functional group analysis. The solutions of NaCl, KCl and distilled water were used as the active agent extraction.

To achieve these objectives, some experiments have been performed and a qualitative explanation and quantitative correlation have been made. The results showed that NaCl 1N as solution delivered better removal capacity for turbidity and hardness in raw water in comparison to KCl 1N and distilled water. Meanwhile, the functional group characterization by FTIR of the residual solid after extraction indicated that the order of N-H and C=O bond removal for solution of NaCl 1N is larger than KCl 1N and distilled water. Proteins in *Moringa oleifera* extracted with distilled water, NaCl 1N, and KCl 1N are the most effective at pH 7. The regression equation $y = 1.634x + 0.0026$, where the correlation coefficient (R^2) value found is 0.9989.

CHAPTER 1

INTRODUCTION

1.1 Background

In conventional water treatment processes, aluminium sulphate (alum) and polyaluminum chloride are widely used for turbidity removal (Amirtharajah and Mills, 1982). However, some studies reported that aluminum which is the major component of alum and polyaluminum chloride may induce Alzheimer's disease (Crapper et al., 1973; Suet-Mei and Wing-Shiu, 1992). There is also the problem of reaction of alum with natural alkalinity present in the water leading to a reduction of pH and low efficiency in coagulation of cold water. Therefore, it is necessary to search for other cost effective and more environmentally acceptable alternative coagulants from natural resources to present a viable alternative for water treatment processes (Prasad, 2009).

Some studies on natural coagulants have been carried out and various natural coagulants were produced or extracted from plants such as *Moringa oleifera* (MO), *Prosopis juliflora* and *Cactus latifaria* (Diaz et al., 1999). Among plant materials that have been tested over the years, the seeds from *Moringa oleifera* have been shown to be one of the most effective primary coagulants for water treatment (Gassenschmidt, 1995; Muyibi and Okufu, 1995; Ndabigengesere and Narasiah, 1998).

In terms of water treatment applications, *Moringa oleifera* seed in diverse extracted and purified forms has proved to be effective at removing suspended material, generates lesser sludge volumes in comparison to alum, softens hard waters and acts as effective adsorber of cadmium (Ndabigengesere et al., 1995; Muyibi and Evison, 1996; Bhuptawat and Folkard, 2007; Mataka et al., 2006; Sharma et al., 2006). Coagulation active component in *Moringa oleifera* coagulant is supposed to remove the suspended solids in aqueous by sweep coagulation mechanism (Okuda et al., 1999). The cations might be electrically adsorbed to the active component with negative charge at coagulation. The active component may bind with other components by cations, which forms the enmeshment of suspended solids by the net like structure (Okuda et al., 2001b). Sweep coagulation gives considerably improved particle removal than when particles are destabilized just by charge neutralization. At least part of the reason is the greatly improved rate of aggregation, because of the increased solids concentration (Okuda et al., 2001a).

Several studies have been conducted on the performance of *Moringa oleifera* seeds as an alternative coagulant or coagulant aid for various aspects of water treatment such as turbidity, alkalinity, total dissolved solids and hardness removal in raw water. Earlier studies recommend the use of *Moringa oleifera* seeds extracts as coagulant for water treatment in African and South Asian countries where the plant is considered indigenous (Oslen, 1987; Qudsieh et al., 2008; Schulz and Okun, 1983). Madsen et al. (1987) carried out coagulation and bacterial reduction studies on turbid Nile water in the Sudan using *Moringa oleifera* seeds and observed turbidity reduction of 80-99.5% paralleled by a bacterial reduction of 1-4 log units (90-99.99%) within the first one to two hours of treatment, the bacteria being concentrated in the coagulated sediment.

Some studies have also investigated the performance of *Moringa oleifera* for hardness removal in hard water for drinking water purpose. It was observed that in addition to turbidity reduction, the hardness was also reduced after coagulation with *Moringa oleifera* synthetic hard water, naturally hard surface water and groundwater from tube wells (Muyibi and Evison, 1995; Fahmi et al., 2011). In another study, Sani (1990) carried out jar tests with *Moringa oleifera* as the primary coagulant using water samples from four different sources (via two surfaces and two shallow wells) with turbidities from 100 to 800 NTU and 80 to 150 NTU respectively and hardness of 180 to 300 mg/L as CaCO₃. It was observed that in addition to turbidity reduction of 92-99%, the hardness was also reduced to between 60-70% after coagulation during two hours settling.

The active agents of the *Moringa oleifera* seeds have been determined to be cationic peptides of relatively low molecular weight ranged from 6–16 kDa (Jahn, 1986). Amino acid analysis and sequencing of *Moringa oleifera* showed high contents of glutamine, arginine and proline as well as total of other 60 residues studied the efficiency and properties of *Moringa oleifera* as a natural coagulant and its mechanism of coagulation on turbid water. Some studies reported that coagulation efficiency of *Moringa oleifera* can be improved by extraction of its active agents with mono valence salt solution (Prasad, 2009; Mataka et al., 1999; Madrona et al., 2010). This improvement was apparently due to the salting-in mechanism in proteins whereby salt increases protein-protein dissociations, leading to increased protein solubility as the salt ions strength increases (Okuda et al., 2001b).

1.2 Problem Statement

Previous research has focused on the efficiency of *Moringa oleifera* seed extract as a coagulant powder on physical factors and quality of water to the reduction of water turbidity. Several studies were concentrated on the development and improvement of the characteristics of the *Moringa oleifera* to enhance the ability of *Moringa oleifera* as a coagulant for turbidity removal in water. However, lack of studies has been directed towards the characterization of the active component in *Moringa oleifera* extracted with various solutions. In this study *Moringa oleifera* was extracted with water, sodium chloride and potassium chloride solutions explore the capacity of the extracted active agent from *Moringa oleifera* for turbidity and hardness removal in raw water sources from the Timah Tasoh Reservoir and the prepared synthetic water. Moreover, the extracted active agent was characterized based on its functional group analysis. Furthermore, the determination of protein by the Lowry method using UV visible spectrophotometer for *Moringa oleifera* seed extracted with distilled water, sodium chloride (NaCl), and potassium chloride (KCl).

1.3 Scope of Research

This study explores the capacity of *Moringa oleifera* (MO) seed powder as a bio remedial approach towards its competitive sorption behavior for the removal of hardness and turbidity from water bodies. Raw water containing high concentration of hardness from Timah Tasoh Dam (Perlis, Malaysia) and synthetic (turbid water; hard water; turbid and hard water) were used in this research. The coagulation active agent in MO that extracted by NaCl, KCl and water were used at various dosages to clarify the

effect of pH for removal of hardness (Calcium and Magnesium) and turbidity. The coagulation active agent in *Moringa oleifera* were also characterized based on protein content and functional group in FTIR spectra.

1.4 Objective of Research

The general objective of this study was to investigate the capacity of the active agent of *Moringa oleifera* powder extracted with distilled water, NaCl, and KCl for turbidity and hardness removal in raw water sources from the Timah Tasoh Reservoir and Synthetic water. The specific objectives of the study are listed as the following:

1. To determine the effect of pH and type of extract solution for turbidity and hardness removal by *Moringa oleifera* seeds.
2. To characterize the active agent that has been extracted from *Moringa oleifera* based on the functional group analysis and removal efficiency of turbidity and hardness.
3. To determine the effect of protein content on the removal performance of turbidity and hardness in raw and synthetic water.

CHAPTER 2

LITERATURE RIVIEW

2.1 Introduction

Flocculation and coagulation are important processes in conventional water treatment process for removal of suspended solids in raw water. Coagulation is the addition of coagulant and rapid mixing, to aid the destabilization of colloids and suspensions of solids, and the destabilization of the initial aggregation of particles. Flocculation is a slow stirring or gentle agitation process to aggregate and form a stable rapid-settling floc. Coagulation and flocculation are terms used to describe the charge neutralization and aggregation of colloidal particles present in the water to reduce turbidity, color and organic matter, phosphorus, and sediment trace metals such as iron, manganese and chromium. Coagulation and flocculation are the basic steps in water treatment to produce a good source of raw water.

Several studies concentrated on the development and improvement of the characteristics of the *Moringa oleifera* to enhance the ability of *Moringa oleifera* as a coagulant for turbidity removal in water. However, lack of studies has been directed towards the characterization of the active component in *Moringa oleifera* that extracted with various solutions. In this study *Moringa oleifera* was extracted with water, sodium chloride (NaCl) and potassium chloride (KCl) solutions to explore the capacity of the

extracted active agent from *Moringa oleifera* for turbidity and hardness removal in raw water sources from the Timah Tasoh Reservoir and the prepared synthetic water.

2.2 Coagulation

Coagulation is the use of chemicals to make suspended solids gather or group together into small flocs. Colloidal particles are very small, and mixing is required before precipitation process. While the flocculation of colloidal particles has a larger agglomerate and form a flocculent. Cationic coagulation is achieved with a "stable" positively charged particles (cations) particles, because the suspended solids are kept separated from each other with a negative charge (Reynolds and Richards, 1995). If the raw water turbidity and color are lower than allowed for drinking water, it should be possible to avoid chemical coagulation in water treatment. A multi-stage filtration process will serve both to reduce turbidity and color at adequate levels and improve other water quality characteristics in a single unit. The effectiveness of coagulation processes in water treatment coagulant species depends on the interaction with particles and dissolved organic matter in raw water removes molecules that can cause contamination (Sawyer and McCarthy, 1978).

Coagulation is an intermediate step, but it is important for the physico-chemical water treatment and wastewater processes. This is the first step in the removal of colloidal particles serve to disrupt the particles. This destabilization has essentially neutralized the electric charge on the particle surface thus facilitating the agglomeration of colloidal (Hartman, 1949).