NATURAL FLOCCULANT FROM *Durio zibethinus* SEED STARCH FOR MUNICIPAL SOLID WASTE LANDFILL LEACHATE TREATMENT

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by

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
APHA	American Public Health Association
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CCD	Central Composite Design
CWM-DSS	Crosslinking Wet Milling Durian Seed Starch
DM-DSS	Dry Milling Durian Seed Starch
DSS	Durian Seed Starch
DO	Dissolved Oxygen
EDX	Energy Dispersive X-ray
FESEM	Field Emission Scanning Electron Microscopy
FI	Flocculation Index
FTIR	Fourier Transform Infrared
IAP	Industrial Anionic Polymer
ICP	Inductive Couple Plasma
IEP	Isoelectronic Point
MLS	Matang Landfill Site
NTU	Nephelometric Turbidity Unit
PAC	Polyaluminium Chloride
PACDM-DSS	Polyaluminium Chloride Dry Milling Durian Seed Starch
PACWM-DSS	Polyaluminium Chloride Wet Milling Durian Seed Starch
PACCWM-DSS	Polyaluminium Chloride Crosslinking Wet Milling Durian Seed Starch
PACIAP	Polyaluminium Chloride-Anionic Polymer
pH	Hydrogen Ions
PDA	Photometric Dispersion Analyser
PtCo	Platinium Cobalt
RSM	Response Surface Methodology
SEM	Scanning Electron Microscopy
SRF	Specific Resistance in Filtration
SS	Suspended Solid

SVI	Sludge Volume Index
S_{SW}	Solid Waste Water Stored
TKN	Total Kjedahl Nitrogen
WM-DSS	Wet Milling Durian Seed Starch
$W_{A(R)}$	Rainfall Water
$W_{B (L)}$	Bottom Leaving Water
W_{CM}	Cover Material Water
W_{E}	Water Evaporation
W_{LG}	Landfill Gas Loss Water
W_{SW}	Solid Waste Water
W_{TS}	Treated Sludge Water
W_{WV}	Water Vapor

PENGGUMPAL SEMULAJADI DARIPADA KANJI BIJI *Durio zibethinus* UNTUK OLAHAN LARUT LESAP KAMBUS TANAH SISA PEPEJAL PEMBANDARAN

ABSTRAK

Penggunaan penggumpal polialuminium klorida (PAC) sangat menonjol di dalam olahan larut lesap kambus tanah. Aplikasi PAC di dalam proses penggumpalan telah terbukti di antara penggumpal yang efektif untuk olahan larut lesap kambus tanah. Walaubagaimanapun, PAC dikenal pasti berpotensi menghasilkan lebihan toksik aluminium kepada persekitaran akuatik. Sebagai alternatif, kombinasi bersama penggumpal tambahan semulajadi boleh mengurangkan dos dan pergantungan kepada PAC. Di dalam kajian ini, penggumpal tambahan berasaskan bahan semulajadi daripada kanji biji durian (*Durio zibithenus*) telah digunakan untuk olahan larut lesap kambus tanah. Sampel larut lesap kambus tanah tapak telah diambil dari tapak pelupusan Matang yang terletak di Taiping, Perak. Kanji biji durian telah diekstrak menggunakan kaedah pengekstrakan kering dan kaedah pengekstrakan basah. Kanji terbaik yang diperolehi, diubahsuai dengan kaedah persilangan cantuman pengumpal kanji untuk memperbaiki proses rawatan. Keadaan eksperimen dalam penyikiran warna, keperluan oksigen kimia (COD), pepejal terampai dan kekeruhan telah dioptimumkan lagi menggunakan kaedah statistik tindak balas pemukaan (RSM). Di samping itu juga nilai kelajuan pemendakan (SV) dibandingkan dan digunakan untuk reka bentuk pengiraan tangki campuran dan tangki pemendakan. Berdasarkan pada hasil eksperimen, pengunaan penggumpal tambahan dari kanji pengekstrakan basah (WM-DSS) telah meninggikan peratus penyingkiran bagi warna, pepejal terampai dan kekeruhan

masing-masing melebihi sebanyak 0.4 %, 2.9 % dan 13.2 % berbanding PAC sahaja (88.8%, 65.9 %, 90.7 % dan 80.5 %). Malahan indeks kelajuan pemendakan juga bertambah baik dari 531.3 mL/g kepada 158.1 mL/g. Sebaliknya, pengunaan penggumpal tambahan daripada kanji pengekstarakan kering (DM-DSS) telah menurun dan mengurangkan peratus penyingkiran bagi warna, pepejal terampai dan kekeruhan masing-masing melebihi sebanyak 25 %, 1.6 % dan 2.8 % berbanding PAC sahaja (90.2 %, 59.6 % 97.2 % dan 95.0 %). Dalam hal ini, ia jelas menunjukan aplikasi pengekstrakan secara lembab boleh diyakini untuk digunakan sebagai kaedah pembangunan pengumpal tambahan berasaskan kanji. Pada masa yang sama, modifikasi persilangan cantuman pengumpal kanji (CWM-DSS) telah meninggikan peratus penyingkiran bagi warna, COD, pepejal terampai dan kekeruhan masing-masing melebihi sebanyak 1.7 %, 5.1 %, 14.8 %, and 14 % berbanding PAC sahaja (94.4 %, 55.8 %, 70.4 % dan 81.1 %). Tambahan pula, modifikasi persilangan cantuman kanji ini telah mampu mengurangkan 0.557 g/L dos PAC. Malahan, pengunaan CWM-DSS ia telah berjaya mengurangkan bilangan tangki pemendakan dari 6 kepada 3 unit tangki dan meningkatkan isipadu aturan olahan larut lesap kambus tanah yang telah dirawat dari 2376 m^3/hari kepada 2404.08 m^3/hari. Oleh yang demikian, ini sangat jelas dapat diperhatikan bahawa pengunaan pengumpal CWM-DSS dapat digunakan di dalam proses rawatan olahan larut lesap kambus tanah.

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ABSTRACT

The used of polyaluminium chloride (PAC) coagulant is prominent in landfill leachate treatment. PAC coagulant is proven to be among the effective coagulants for landfill leachate treatment. However, it was found that PAC coagulant has a toxic potential of aluminium residual to the aquatic environment. As an alternative, the combination of natural flocculants with inorganic coagulants could reduce the dosage and dependence on the PAC coagulant and improved the flocculant properties. In this study, natural based flocculants from durian seed starch were used for landfill leachate treatment. The landfill leachate samples were collected from Matang landfill located at Taiping, Perak. The durian seed starches were extracted using dry milling and wet milling extraction method. The best starch obtained was further modified by crosslinking modification method to improve the treatment process. The experimental condition in removing colour, Chemical Oxygen Demand (COD), suspended solid and turbidity were further optimized statistically using Response Surface Method (RSM). The settling velocity values were compared and used for mixing and settling tanks calculation design. According to the results, the use of wet milling durian seed starch (WM-DSS) as a flocculants increased the removal percentage of colour, suspended solids and turbidity by 0.4 %, 2.9 %, and 13.2 % compared to PAC coagulants alone (88.8%, 90.7 % and 80.5 %). Besides, the sludge velocity index (SVI) was also improved from 531.3 mL/g to 158.1 mL/g. In contrast, the use of dry milling durian seed starch (DM-DSS) flocculants had decreased the removal percentage of chemical oxygen demand (COD), suspended solids and turbidity by 25 %, 1.6 %, and 2.8 % compared to PAC coagulants alone (59.6 % 97.2

% and 95.0 %). In this respect, wet milling extraction method was effective to be used for starch flocculants synthesis. In fact, the crosslinking modification of the wet milling starch flocculants (CWM-DSS) further increased the removal percentage of colour, chemical oxygen demand (COD), suspended solids and turbidity by 1.7 %, 5.1 %, 14.8 %, and 14 % compared to PAC alone (94.4 %, 55.8 %, 70.4 % and 81.1 %). Moreover, this starch modification had able to reduce 0.557 g/L concentration of PAC coagulant for landfill leachate treatment. Besides, the used of CWM-DSS flocculants able to reduce the number of settling tank from 6 to 3 units and increased the volume of treated leachate from 2376 m^3/day to 2404.08 m^3/day. Therefore, it was clearly observed that the used of CWM-DSS flocculants is effective to be used for landfill leachate treatment process.

CHAPTER ONE

INTRODUCTION

1.1 Overview

Landfilling is the most extensively employed method for municipal solid waste (MSW) disposal system in Malaysia. It is preferred in tackling solid waste disposal due to its simple operational procedure and cost-effectiveness (Aziz et al., 2007). The demand for the landfilling method keeps on increasing due to the increase in population and economic growth experienced in urban and rural areas (Ofori et al., 2013). In Malaysia, there are more than one hundred of landfills that are still operates (Ogboo and Hussain, 2013). In Malaysia, landfill operations are still active and generating more than 30000 tons per day of solid wastes (Fauziah and Agamuthu, 2012).

Although landfilling is broadly recognised as a proper waste disposal method, the environmental pollution caused by the MSW landfill leachate has been one of the drawbacks of the system. In Malaysia, each ton of MSW generates 150 litres of leachate (Agamuthu and Fauziah, 2008). Based on daily MSW generation rate in 2010, it is estimated that over than 3.0 million litres of leachate is produced every day in Malaysia (Agamuthu and Masaru, 2010). Therefore, it is important to estimate the production of leachate during the life span of the landfills for environmental monitoring and potential risk management (Hannu, 2015).

Leachate is a polluted liquid that is produced from the water percolation through solid waste (Hassan et al., 2016). This percolated water contains dissolved and suspended materials from various disposed materials and bio-decomposition process. Commonly, landfill leachate is a high-strength wastewater with extreme levels of pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), inorganic salts and toxicity (Aziz et al., 2004). These contaminants are influenced by the waste biodegradation process (Hassan et al., 2016). In fact, the characteristics of leachate for each particular landfill are different depending on the time waste composition, landfilling practice, climatic conditions, landfill's conditions and the operation period of the landfill (Aziz et al., 2004). Nevertheless, contaminants like organic matters, ammoniacal-nitrogen, heavy metals and colour are normally the measured parameters in leachate quality assessment.

As a matter of fact, the treatment of leachate is necessary due to the contaminants that present in leachate. The leakage of untreated leachate into the environment will cause potential risks to water bodies. In fact, landfill leachate has been identified as a potential source of surface and groundwater contamination (Yang et al., 2013). Even worse, the leachate contaminants can also affect human physical and mental health (Tsarpali and Dailianis, 2012). Therefore, the understanding and management of landfill leachate are crucial. In this regards, feasible treatment methods for landfill leachate are gaining more and more attention.

1.2 Problem statement

Different methods have been developed for landfill leachate treatment. Generally, physical, chemical and biological methods are the common methods that are usually used for leachate treatment. Nevertheless, it is difficult to obtain effectiveness and satisfactory treatment in a single approached. In order to ensure satisfactory quality, landfill leachate requires multiple stages of treatment. Integrated treatment system combining physical, chemical and biological methods has gained a greater interest in treating the landfill leachate (Moreira et al., 2015; Wang et al., 2014; Del Moro et al., 2013). One of the methods is physico-chemical treatment