DEVELOPMENT OF NATURAL COAGULANT AID FROM *Artocarpus heterophyllus* SEEDS STARCH FOR LANDFILL LEACHATE TREATMENT

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by

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LIST OF ABBREVIATION

ANOVA	Analysis of Variance
BOD	Biochemical Oxygen Demand
CCD	Central Composite Design
COD	Chemical Oxygen Demand
DLVO	Derjaguin, Landau, Verwey, Overbeek Theory
DO	Dissolved Oxygen
EDX	Energy Dispersive X-ray
FT IR	Fourier Transform Infrared Spectroscopy
HCl	Hydrochloric Acid
H_2SO_4	Sulphuric Acid
IEP	Isoelectrical Point
JSS	Jackfruit Seeds Starch
KOH	Potassium Hydroxide
NaOH	Sodium Hydroxide
NTU	Nephelometric Turbidity Units
PACl	Polyaluminium Chloride
PtCo	Platinium-Cobalt Scale
RSM	Response Surface Methodology
SEM	Scanning Electron Microscopy
TOC	Total Organic Content
VFA	Volatile Fatty Acids
XOC	Xenobiotic Organic Compounds

LIST OF SYMBOLS

R^2	Coefficient of determination
p	Probability in ANOVA analysis
mg/L	Milligram per litre

PENGHASILAN BAHAN BANTU PENGGUMPAL SEMULAJADI DARIPADA KANJI BIJI *Artocarpus heterophyllus* UNTUK OLAHAN LARUT RESAP TAPAK KAMBUS TANAH

ABSTRAK

Sebelum kaedah olahan yang lain diperkenalkan, kaedah penggumpalan-pembekuan telah banyak dilakukan sebagai rawatan olahan larut resap. Walaupun penggunaan polyaluminuim klorida (PACl) berpotensi dalam menghasilkan sisa toksik Al ke dalam persekitaran akuatik, namun penggumpal yang berasaskan Al seperti PACl adalah penting dalam olahan larut resap. Sebagai alternatif, penggumpal yang berasaskan kanji telah dihasilkan dari biji buah nangka. Kanji dari biji buah nangka (JSS) mempunyai kadar peratusan penyingkiran bahan pencemar yang rendah jika dibandingkan dengan PACl; COD (10.8%), warna (15.9%), kekeruhan (25%) dan pepejal terampai (7.5%). Dari kajian awal mendapati, kadar optima bagi pH dan dos untuk JSS dan PACl ialah masing-masing pada pH 5 dan 3000 mg/L serta pH 5 dan 900 mg/L. Kemudian, kajian lanjut mengenai JSS sebagai bahan bantu penggumpal semulajadi dijalankan bersama-sama PACl dalam rawatan olahan larut resap. Keputusan dari ujian balang dijalankan pada keadaan optima, iaitu pada pH 5, 600 mg/L PACl dan 500 mg/L JSS menunjukkan peningkatan kadar peratus penyingkiran COD kepada 33.5%, manakala parameter yang lain tidak menunjukkan sebarang peningkatan jika dibandingkan dengan PACl sebagai penggumpal utama. Walaupun PACl sebagai penggumpal utama lebih berkesan di dalam keseluruhan prestasi penggumpalan; COD (2.7%), warna (93.5), kekeruhan (95.6%) dan pepejal terampai (90.3%), namun di bawah pengoptima menggunakan RSM, jumlah dos yang

digunakan bagi kedua-dua penggumpal telah berkurang kepada 12.4% bagi PACl (dari 600 mg/L kepada 523.32 mg/L) dan 20% bagi JSS (dari 500 mg/L kepada 400 mg/L) pada kadar peratusan penyingkiran yang sama seperti yang dilaporkan di kajian awal. Oleh yang demikian, JSS boleh dipilih sebagai bahan bantu penggumpal yang boleh dilaksanakan di dalam rawatan olahan larut resap berdasarkan kelebihannya dalam mengurangkan dos yang digunakan oleh PACl. Keseluruhan kajian menunjukkan JSS sebagai bahan bantu penggumpal boleh dilaksanakan dalam olahan alarut resap dari segi ketersediaan bekalan, harga pengeluaran, prestasi penggumpal dan pengurusan alam sekitar.

DEVELOPMENT OF NATURAL COAGULANT AID FROM *Artocarpus heterophyllus* SEEDS STARCH FOR LANDFILL LEACHATE TREATMENT

ABSTRACT

Coagulation-flocculation has been extensively used as landfill leachate treatment, prior to other methods. Al-based coagulant like polyaluminium chloride (PACl) is prominent in landfill leachate treatment, though the applications of PACl may introduce potentially toxic Al residuals into aquatic environment. As alternative, starch-based coagulants has been produced from jackfruit seeds. In comparison with PACl, JSS has a lower percentage removal of pollutants i.e. COD (10.8%), colour (15.9%), turbidity (25%) and suspended solids (7.5%). From preliminary study had ascertained that optimum pH and dosages for JSS and PACl were at pH 5 and 3000mg/L, pH 5 and 900 mg/L, respectively. Then, JSS was further studied to be used together with PAC as coagulant aid in landfill leachate treatment. Jar test result demonstrated that at optimum condition of pH 5, 600 mg/L of PACl and 500 mg/L of JSS has increased the percentage removal of COD up to 33.5%, while other parameters does not show any increment in percentage removal when compared to PACl as primary coagulant. Though PACl was more effective in overall coagulation performance, i.e. COD (2.7%), colour (93.5%), turbidity (95.6%) and suspended solids (90.3%), but under the optimization using response surface methodology (RSM), the amount of dosages used in both coagulants had reduced by 12.4% for PACl (from 600 mg/L to 523.32 mg/L) and 20% for JSS (from 500 mg/L to 400 mg/) with similar percentage removal from preliminary study. Therefore, JSS could be feasible selective coagulant aid in landfill leachate treatment, benefitted in reducing dosage of PACl

used, depending on leachate condition. The overall findings had concluded that JSS as coagulant aid was fairly feasible for landfill leachate treatment in terms of supply availability, production price, coagulation performance and sustainable environment management.

CHAPTER 1

INTRODUCTION

1.1 Background

Landfill still remains the most commonly employed treatment for municipal solid waste (MSW) disposal around the world, which generates a high-strength wastewater with complex constituents referred to as landfill leachate. The generation of solid waste is inevitable in the day to day activity of humans and animals. As humans strive to keep the environment clean to avoid infectious diseases from bacteria and viruses by dumping solid waste in landfills, they create yet another environmental problem. From previous studies has proved that leachate contains various organic materials (biodegradable and non-biodegradable carbon, humic acids, and fulvic acids) and the inorganic materials such as colloidal, heavy metals and non-organic salts like sodium, calcium, sulphate, ammonia, and high concentration toxics (Aziz *et. al.*, 2004; Kang *et. al.*, 2002).

The major potential environmental impacts related to landfill leachate are pollution of groundwater and surface water. The risk of groundwater pollution is probably the most severe environmental impact from landfills because historically most landfills were built without engineered liners and leachate collection systems (Agamuthu and Fauziah, 2008). Decomposing waste within the landfills generates greenhouse gases (methane and carbon dioxide) as well as the production of a liquid known as leachate when precipitation infiltrates. When leachate move downwards from landfill into ground-water as a result of infiltrated precipitation, ground-water gets contaminated likewise if the waste is buried below the water table

(Aizenchtadt, *et. al.*, 2008). The ground water and surface water are the source of our potable water, they should be protected from such pollutants otherwise the cost of treating drinking water will rise and the life of biodiversity in surface water bodies will be endangered.

Since landfills and leachate production cannot be completely avoided, the only thing to do is to as much as possible reduce leachate production and treat the generated ones to eliminate or reduce the level of contamination in them to discharge consent levels before releasing to the environment (receiving water bodies). During the recent years many new methods- physicochemical, biological and combine biological with physicochemical have been proposed and tested (Blight *et. al.*, 1999).

1.2 Problem Statements

In the realm of problem statement, coagulants that has been used in industries are mostly based on chemical derivatives, namely alum ($AlCl_3$), ferric chloride ($FeCl_3$), and polyaluminium chloride (PACl). While the effectiveness of these coagulants are well-recognized, there are nonetheless, disadvantages associated with the usage of these coagulant such as the ineffectiveness in lower temperature, relatively high procurement to costs, detrimental effect on human health, production of large sludge volumes and significantly affect the pH of leachate. It is therefore desirable to replace the chemical coagulants with starch-based coagulant from *Artocarpus heterophyllus* seeds to counteract the aforementioned drawbacks.

1.3 Research Objectives

The aim of the present research study is to develop a novel starch-based coagulant from jackfruit *(Artocarpus heterophyllus)* seeds and investigate the effectiveness of this natural coagulant for leachate treatment. Specific objectives are:

i. To develop and characterize the natural coagulant from *Artocarpus heterophyllus* seeds starch

ii. To establish the optimum factors of starch-based coagulant as an alternative coagulant to remove carbon oxygen demand (COD), suspended solids, colour, turbidity and ammoniacal-nitrogen in anaerobic leachate using Response Surface Methodology (RSM).

iii. To determine the efficiency of jackfruit seeds starch as a natural coagulant and coagulant aid.

1.4 Scope and Limitation of Study

Development of starch based coagulant from jackfruit seeds as an alternative coagulant and coagulant aid to treat landfill leachate is studied in this research. This study was focuses on:

i. Starch from jackfruit seed was extracted with a modified method of Tulyathan *et. al.* (2002) and Mukprasit and Sajjaanantakul (2004). Coagulant characterisation was done concurrently.

ii. Efficiency of JSS as an alternative coagulant and coagulant aid was studied by testing raw leachate from Matang Landfill Site (MLS) and treated leachate samples on parameters i.e. turbidity, suspended solids, colour, and COD.

iii. Determination of optimum coagulation operational conditions for JSS applications as coagulant aid in tandem with PACl 18% using RSM.

There are several limitations in this research work listed as following:

i. Coagulation-flocculation treatment using jackfruit seeds starch-based coagulants is only proposed as an alternative pre-treatment for anaerobic landfill leachate, not as a comprehensive leachate treatment. A comprehensive landfill leachate treatment required a combination of leachate treatment methods. Therefore, it required a wider research scope.

ii. Since the landfill leachate characteristics varied over numerous reasons, the findings from this study could only be generalized to anaerobic municipal solid waste landfill leachate with similar conditions. Generalization of the empirical findings to landfill leachate as a whole required a greater study scope.

iii. Economic analysis of the coagulants was not carried out in great detail. Therefore, the production cost was roughly estimated based on laboratory results and latest published literature. This might be different in the context of actual industrial mass production and implementation.

1.5 Thesis Layout

In this thesis, there are five chapters covering all the information in this study. Chapter 1 is a brief introduction to this study. It explains the objectives and scope of this study and gives an introduction on the background of the study. As for Chapter 2, it focuses on the development of similar studies done by many other researchers. Chapter 3 is about the methodologies used in this study. It gives detailed information on the research design and testing procedures employed. Chapter 4, on the other hand, is utterly important as it encompasses all the findings and discussions for this study. The overall findings are concluded in Chapter 5. Suggestions are propounded in this chapter as well as for research work furtherance and refinement. These recommendations may help the researchers to develop better research frameworks in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter gives a general overview of this research work on the generation and characteristics of the leachate and the treatment process, and also coagulation-flocculation for leachate treatment process.

2.2 Landfill leachate

The general forms of waste treatment include landfill, incineration, and refuse composting. The landfill is an important and basic part for waste treatment in a majority of cities at present. The problem with landfill is the landfill leachate pollution. Furthermore, the landfill leachate problem is a long term issue, since the landfill leachate was formed long time after closing of the site. From the start till the end there should be effective control and management for the production of leachate.

Leachate is commonly generated from precipitation, surface run-off, and infiltration or intrusion of groundwater percolating through the landfill (Aziz *et.al.,* 2010). Leachate is difficult to be treated to satisfy the discharge standards for its variable composition and high proportion of refractory materials (Comstock *et. al.,* 2010). Many treatment methods have been used to treat the leachate, such as advanced oxidation techniques, membrane processes, biological processes, coagulation–flocculation methods and so on (Gálvez*et. al.,* 2005). For the characteristics of leachate change with advancing years of the landfill, these methods have some shortages such as decreasing treatment efficiencies and increasing cost (Khattabi *et. al.,* 2002).