

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

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

by

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TABLE OF CONTENTS

Acknowledgement.....	ii
Table of Contents	iii
List of Tables.....	vii
List of Figures	x
List of Abbreviation	xii
List of Symbols	xii
Abstrak	xiv
Abstract	xvi

CHAPTER 1- INTRODUCTION

1.1 Background of Study	1
1.2 Problem Statements	2
1.3 Research Objectives.....	3
1.4 Scope and Limitation of Study	3
1.5 Thesis Layout.....	5

CHAPTER 2- LITERATURE REVIEW

2.1 Overview	6
2.2 Landfill Leachate	6
2.2.1 The Generation of Landfill Leachate.....	7
2.2.2 The Factors of Influence of Leachate Quality	9
2.2.2.1 Composition of Solid Waste.....	9

2.2.2.2	The Effect of Landfill Age	11
2.2.2.3	Method of Landfilling	11
	
2.2.3	Characteristics of Landfill Leachate	12
2.2.3.1	Organic Matters	12
2.2.3.2	Ammoniacal-Nitrogen	13
2.2.3.3	Heavy Metals	13
2.2.3.4	Colour	15
2.2.4	Landfill Leachate Treatment	15
2.2.4.1	Biological Leachate Treatment.....	15
2.2.4.2	Physical-Chemical Leachate Treatment	16
2.3	Coagulation-Flocculation.....	17
2.3.1	Stability of Colloidal suspension	19
2.3.2	Electrical Double Layer.....	19
2.3.3	Zeta Potential and Suspension Stability	21
2.4	Coagulants and Coagulant Aids	22
2.4.1	Coagulant Aids	27
2.4.2	Polyaluminium Chloride (PACl).....	27
2.4.3	Jackfruit Seed Starch (JSS).....	30
2.5	Summary of Literature Review.....	34
 CHAPTER 3- RESEARCH METHODOLOGY		
3.1	Research Framework	35
3.2	Instrumentations, Chemicals and Reagents	37
3.3	Preparation of Jackfruit Seeds Starch (JSS)	38
3.4	Matang Landfill Leachate Sampling.....	39

3.5 Jar Test for Coagulation Performance Study	40
3.6 Analytical Procedures	41
3.7 Experimental Design.....	43
3.7.1 Preliminary Study	43
3.7.2 Optimization of JSS as Coagulant Aid using RSM.....	45

CHAPTER 4- RESULTS AND DISCUSSIONS

4.1 Overview.....	47
4.2 Raw Leachate Characterisation.....	47
4.3 Coagulant Characterization.....	52
4.3.1 Jackfruit Seeds Starch (JSS).....	52
4.3.1.1 Physico-Chemical Properties.....	53
4.3.1.2 Structural Morphology	60
4.3.2 Physico-Chemical Properties of Polyaluminium Chloride (PACl)	62
4.4 Preliminary Study (Classic Optimisation)	63
4.4.1 Effect of Coagulant Dose of JSS	63
4.4.2 Effect of pH of JSS.....	65
4.4.3 Effect of Coagulant Dose of PACl	68
4.4.4 Effect of pH of PACl.....	70
4.4.5 Effect of Dosage of JSS as Coagulant Aid	73
4.4.6 Effect of PACl as Main Coagulant	77
4.5 Optimization for JSS as Coagulant Aid using RSM.....	81
4.5.1 Statistical Analysis	82
4.5.2 Analysis of Variance (ANOVA)	84
4.5.3 COD Removal	88

4.5.4	Process Optimization	89
4.5.5	Comparison of Coagulation Performances	91
4.6	Sludge Characterization of Optimum Condition	94
4.6.1	Settleability Parameters	94
4.6.2	Fourier Transform Infrared Spectroscopy	95
4.6.3	Surface Morphology at Optimum Conditions	98

CHAPTER 5- CONCLUSIONS AND RECOMMENDATIONS

5.1	Conclusions	103
5.2	Recommendations	104

REFERENCES		105
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APPENDICES

LIST OF PUBLICATIONS

LIST OF TABLES

		Page
Table 2.1	Chemical composition of landfill leachate concentration ranges (mg/L)	10
Table 2.2	Variation with age in the typical concentration of common factors of landfill leachate	11
Table 2.3	Comparison of coagulants in water and wastewater treatment	24
Table 2.4	Comparison of coagulant aids in water and wastewater treatment	28
Table 2.5	Chemical and physical properties of PACl product	29
Table 3.1	Instruments for study	37
Table 3.2	Chemicals and reagents	37
Table 3.3	Analytical procedures	42
Table 3.4	Controlled variables and their conditions for preliminary batch studies to determine optimum dosage and optimum pH	44
Table 3.5	Controlled variables and their conditions for batch study to determine optimum dosage of PACl 18% (primary coagulant)	44
Table 3.6	Controlled variables and their conditions for batch study to determine optimum dosage of JSS (as coagulant aid)	45
Table 3.7	Coded and actual values of factors for PACl 18% with JSS (as coagulant aid) coagulation optimization	45
Table 3.8	Experimental matrix for PACl 18% with JSS (as coagulant aid) coagulation optimization	46
Table 4.1	Matang Landfill Site raw leachate characteristics	48
Table 4.2	Physical properties of JSS	50
Table 4.3	Functional groups of JSS	58
Table 4.4	Biochemical compound analyses of JSS	59
Table 4.5	Intrinsic characteristics of JSS granule architectures	60
Table 4.6	Physical properties of PACl	62

Table 4.7	Optimum coagulant dose for different parameter responses in JSS-leachate coagulation	64
Table 4.8	Optimum pH values for different parameter responses in JSS-leachate coagulation selected optimum dosage at 3000 mg/L	66
Table 4.9	JSS leachate coagulation performance at selective coagulation	68
Table 4.10	JSS-leachate coagulation performance at selected optimum dosage (3000 mg/L) and pH (pH 5)	68
Table 4.11	Optimum coagulant dose for different parameter response in PACl-leachate coagulation	70
Table 4.12	Optimum pH values for different parameter response in PACl leachate coagulation at selected optimum dosage at 900 mg/L	71
Table 4.13	PACl-leachate coagulation performance at selective coagulation	72
Table 4.14	PACl-leachate coagulation performance at selected optimum dosage (900 mg/L) and pH (pH 5)	72
Table 4.15	Optimum JSS dosage as coagulant aid for different parameter responses in JSS-PACl leachate coagulation at selected optimum pH at pH 5	74
Table 4.16	Comparison between optimum pH and optimum dosage of PACl as primary coagulant with selected optimum dosage of JSS as coagulant aid (at controlled pH of 5, dosage of PACl of 900 mg/L)	76
Table 4.17	Optimum PACl dosage as main coagulant for different parameter response in JSS-leachate coagulation at selected optimum dosage of JSS and pH (500 mg/L, pH 5)	78
Table 4.18	Comparison between optimum pH and optimum dosage of PACl as primary coagulant with selected optimum dosage of PACl as main coagulant (At controlled pH of 5, dosage of JSS of 500 mg/L)	80
Table 4.19	Optimum dosage of JSS (500 mg/L) as coagulant aid for different parameter responses at optimum dosage of PACl (600 mg/L) and optimum pH of 5 in leachate coagulation performance	81
Table 4.20	Experimental design matrix for optimization of JSS as coagulant aid	83
Table 4.21	Analysis of variance (ANOVA) for response surface quadratic for COD removal for JSS as coagulant aid	85
Table 4.22	Model validation at RSM	90

Table 4.23	SVI	94
Table 4.24	Settleability parameters at different optimum condition of coagulants	95
Table 4.25	Comparison of FTIR spectrum between JSS as coagulant aid floc and RSM floc	96
Table 4.26	Comparison of FTIR spectrum between JSS and PACl as coagulant, JSS as coagulant aid and optimisation using RSM	97

LIST OF FIGURES

		Page
Figure 2.1	Five phases of landfill stabilization.	7
Figure 2.2	Electrical double layer (Gouy-Chapman-Stern Model)	21
Figure 2.3	Classification of coagulants in water and wastewater	23
Figure 2.4	Jackfruit on tree	31
Figure 2.5	Jackfruit seed covered with brown spermoderm	31
Figure 3.1	Flow chart of the overall research work	36
Figure 3.2	Location of Matang Landfill Site	40
Figure 4.1	Effect of pH on zeta potential of JSS (1000 mg/L)	54
Figure 4.2	FTIR transmittance spectra of JSS	55
Figure 4.3	SEM images of lyophilized JSS at 3000x from this study	61
Figure 4.4	SEM-EDX analysis of JSS	61
Figure 4.5	Effect of pH on zeta potential of PACl (40 mg/L)	63
Figure 4.6	Effect of JSS dosage on the removal of COD, colour, turbidity, suspended solids and ammoniacal-nitrogen by using JSS (pH 5) as primary coagulant in leachate treatment	65
Figure 4.7	Effect of pH on the removal of COD, colour, turbidity, suspended solids and ammoniacal-nitrogen by using JSS (3000 mg/L) as primary coagulant in leachate treatment	67
Figure 4.8	Effect of PAC dosage on the removal of COD, colour, turbidity, suspended solids and ammoniacal-nitrogen by using PACl (pH 6) as primary coagulant in leachate treatment	69
Figure 4.9	Effect of pH on the removal of COD, colour, turbidity, suspended solids and ammoniacal-nitrogen by using PACl (900 mg/L) as primary coagulant in leachate treatment	71
Figure 4.10	Effect of JSS dosage as coagulant aid on the removal of COD, colour, turbidity, SS and ammonia by using PACl as coagulant in leachate treatment	74

Figure 4.11	Comparison between optimum pH and optimum dosage of PACl as primary coagulant with selected optimum dosage of JSS as coagulant aid	76
Figure 4.12	Effect of PACl dosage as main coagulant on the removal of COD, colour, turbidity, SS and ammonia by using JSS as coagulant aid in leachate treatment	78
Figure 4.13	Comparison between optimum pH and optimum dosage of PACl as primary coagulant with selected optimum dosage of PACl as main coagulant	80
Figure 4.14	Design Expert Plot; normal probability plot of studentized residual of COD	87
Figure 4.15	Design Expert Plot; predicted versus actual values plot for COD	87
Figure 4.16	Response surface plot for COD	88
Figure 4.17	Comparison of JSS, PACl, JSS as coagulant aid and RSM for coagulation performance in leachate treatment at respective overall optimum pH and dosages values, based on the removal rates of a) COD, b) colour, c) turbidity, d) SS	93
Figure 4.18	SEM-EDX for optimum JSS as primary coagulant (pH 5, 3000 mg/L)	99
Figure 4.19	SEM-EDX for optimum PACl as primary coagulant (pH 5, 900 mg/L)	100
Figure 4.20	SEM-EDX for optimum JSS as coagulant aid (pH 5, 600 mg/L of PACl, 500 mg/L of JSS)	101
Figure 4.21	SEM-EDX for optimization using RSM (pH 5, 523.32 mg/L of PACl, 400 mg/L of JSS)	102

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 ₂ SO ₄	Sulphuric Acid
IEP	Isoelectrical Point
JSS	Jackfruit Seeds Starch
KOH	Potassium Hydroxide
NaOH	Sodium Hydroxide
NTU	Nephelometric Turbidity Units
PAlCl	Polyaluminium Chloride
PtCo	Platinum-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 polyaluminium 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 kelebihanannya 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).