A STUDY ON STRYHCNOS POTATORUM AND PISUM SATIVUM AS NATURAL COAGULANTS FOR MEAT FOOD PROCESSING WASTEWATER

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DEDICATION

To Maa and Abah,
The reason of what I became today.
Thanks for the endless love and great support.

To lecturers,
Thanks a lot for the guidance and helping.

To my beloved brothers and sisters,
Thanks for making me happy and support.

To the friends,
I will always remember you,

Thank you all…

Love,
-Fadzillah Pahazri-

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ABSTRACT

Wastewater generated from meat food processing industry has significant effects on the environment. Many methods have been reported for removing turbidity, total suspended solids (TSS), chemical oxygen demand (COD), oil and grease (O&G) and colour from meat food processing wastewater (MFPW). The most common method among them is flocculation-coagulation process which is widely used. Although inorganic coagulants are prominent in wastewater treatments, its application may cause toxic residual. In this study, the attempt has been made to study the performance of *S. Potatorum* (nirmali) and *P. Sativum* (pea) seed as natural coagulants in the flocculation process. A further aim is to determine the optimum conditions for the treatment of MFPW effluents such as coagulant dosage, mixing rate and pH. An adsorption study was also carried out to study the adsorption potential of these coagulants to treat MFPW. A lab-scale treatment tank was developed to evaluate the effectiveness in MFPW treatment. Jar test results showed that optimum dosage, pH and mixing rate for *S. Potatorum* were pH 8 with dosage of 150 mg/L and 150 rpm mixing rate with the removal of turbidity, TSS, COD, O&G and colour are 91%, 97.6%, 58.4%, 79.9% and 84.3% respectively. Meanwhile, for *P. Sativum,* the optimum condition were observed at pH 8 with dosage of 150 mg/L and 150 rpm mixing rate with the removal of turbidity, TSS, COD, O&G and colour 87.8%, 97.3%, 65.5%, 77.9% and 76.5% respectively. The adsorption study was found that the analysis fitted well to the Langmuir isotherm for both natural coagulants. Results show that the percentage of turbidity, TSS, COD, O&G removal by chemical coagulants are quite similar than natural coagulants when lab-scale treatment tank was used to treat the MFPW. This indicated that these natural coagulants have a potential to use as alternative in wastewater treatment.

ABSTRAK

Air sisa yang dihasilkan daripada industri pemprosesan makanan berasaskan daging mempunyai kesan yang ketara terhadap alam sekitar. Banyak kaedah telah dilaporkan untuk merawat kekeruhan, jumlah pepejal terampai (TSS), keperluan oksigen kimia (COD), minyak dan gris (O&G) dan warna dari air sisa pemprosesan makanan daging (MFPW). Kaedah yang paling umum adalah proses pengumpalan dan pengelompokan yang digunakan secara meluas. Walaupun penggunaan penggumpal bukan organik terkenal dalam rawatan air sisa, namun ianya boleh menyebabkan sisa toksik berbahaya. Dalam kajian ini, eksperimen telah dijalankan untuk mengkaji prestasi *S. Potatorum* dan *P. Sativum* sebagai koagulan semulajadi dalam proses pengelompokan menggunakan ujian Jar. Tujuan lain kajian ini adalah untuk menentukan keadaan optimum bagi rawatan MFPW iaitu kadar percampuran, pH dan halaju pengacauan. Kajian penjerapan juga dijalankan untuk mengkaji potensi penjerap penggumpal ini untuk merawat air sisa pemprosesan daging. Sebuah tangki rawatan makmal juga direka untuk menilai keberkesanan rawatan air sisa pemprosesan daging. Keputusan ujian Jar menunjukkan bahawa dos yang optimum, pH dan halaju pengacauan untuk *S. Potatorum* adalah pada pH 8 dengan dos campuran 150 mg/L dan 150 rpm dengan penyingkiran kekeruhan, pepejal terampai (TSS), keperluan oksigen kimia (COD), minyak dan gris (O & G) dan warna ialah 91%, 97.6% 58.4%, 79.9% dan 84.3%. Sementara itu, untuk *P. Sativum*, optimum proses adalah pada pH 8 dengan dos 150 mg/ L dan 150 rpm halaju pengacauan, memberikan kadar pengurangan jumlah pepejal terampai (TSS), keperluan oksigen kimia (COD), minyak dan gris (O&G) dan warna masing-masing 87.8%, 97.3%, 65.5%, 77.9% dan 76.5 %. Kajian penjerapan mendapati bahawa analisis itu sesuai dengan isoterm Langmuir untuk kedua-dua bahan penggumpal semula jadi. Keputusan menunjukkan bahawa peratusan kekeruhan, jumlah pepejal terampai (TSS), keperluan oksigen kimia (COD), minyak dan gris (O&G) dan warna daripada

eksperimen koagulan kimia tidak jauh berbeza daripada koagulan semulajadi apabila tangki rawatan makmal digunakan untuk merawat air sisa pemprosesan daging. Ini menunjukkan bahawa sistem tangki pembekuan rawatan makmal ini boleh digunakan untuk mengurangkan bahan pencemar dari air sisa pemprosesan daging.

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LIST OF ABBREVIATIONS

°C	Degree Celsius
µm	Micrometer
APHA	American Public Health Association
BOD_5	Biochemical oxygen demand
COD	Chemical oxygen demand
GPS	Global Positioning System
H_2SO_4	sulphuric acid
MFPW	Meat food processing wastewater
mg/L	Milligram/Liter
mm^3/y	Milimiter cubic/Year
N	Nitrogens
NaOH	sodium hydroxide
NTU	Nephelometric Turbidity Unit
TN	Total Nitrogen
O&G	Oil and grease
P	Phosphorus
PAC	Polyaluminium chloride
PET	Polyethylene Terephthalate
Pt.Co	Platinum-Cobalt Scale
rpm	Revolutions per minute
TDS	Total dissolved solids
TP	Total Phosphorus
TSS	Total suspended solid

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Environment pollution is seriously increasing throughout the world because of economic growth and increased human activity. Wastewater is one of the major pollution problems that give effects to the water bodies and also human health. Wastewater originates from household wastes human and animal wastes, industrial wastewaters and groundwater infiltration. Wastewater basically is the flow of used water from a community. The nature of wastewater includes physical, chemical and biological characteristics which depend on the industrial contributions, weather and infiltration. It is 99.94 percent water by weight and the remaining 0.06 percent is material dissolved or suspended in the water. The dissolved and suspended solids in wastewater contain organic and inorganic material (Lee and Lin, 2000).

One of the wastewater that has raised environmental concern is the discharge from the food industries activities. Meat food processing industry is considered highly polluted wastewater due to the level contents from fats, bloods and also scraps of meat from the operation process (Bickers and Oostrom, 2000). Sena *et al.* (2008), had shown that the effluent of meat processing industry in Brazil having a high pollutant load due to the high concentrations of total solids (TS), turbidity, oils and greases (O&G), high biochemical oxygen demands (BOD_5) and chemical oxygen demands (COD). This wastewater was dark brown in color, with a strong and putrefied smell. Meanwhile Bohdziewicz *et al.* (2003), reported that the effluent from meat processing industry in Poland was characterized by considerable pollutant

load, substantial amounts of suspended matter and high concentrations of total nitrogen varying from 49 to 287 mg/L and phosphorus 15 to 27 mg/L.

Activities in meat food processing require a lot of water. About 62 mm^3/y of water was used to watering and washing livestock, cleaning vehicles, and rinsing carcasses and by-products (Sroka *et al.*, 2004). In addition, water is also used for cleaning purposes during the meat processing activities. Wastewater generated from these industries has significant effects on the environment. The nature of the processes involved in the processing industry greatly affects the type, composition and concentration of contaminants in wastewater (Rahman *et al.*, 2014). In addition, the pollution loads of waste water discharge from the meat processing industry vary according to season, day or shift. No matter whether direct or indirect discharge of wastewater meat industry, the majority of the dissolved organic matter and particles must be removed before discharge into drains or rivers (Thirugnanasambandham *et al.*, 2015). According to Caixeta *et al.* (2002), the city of Uberlândia in Brazil has 10 enterprises in area of meat food processing and slaughterhouses which in most of them, the wastewaters are not treated and the effluent was directly discharged to the receiving waterways. Consequently, this discharge of wastewaters into the receiving waterways has caused problems of bad smell and proliferation of vectors in the population of the region.

Many methods have been reported for removing COD, TSS, O&G and colour from meat food processing wastewater (MFPW), for instance upflow anaerobic sludge blanket (UASB), column flotation, anaerobic treatment, ultrafiltration and reverse osmosis and sequencing batch reactor (Caixeta *et al.*, 2002; Bohdziewicz *et al.*, 2003; Baskar and Sukmaran, 2015). The most common method among them is flocculation-coagulation process which is a widely used due to its relatively simple operation and low cost (Daud *et al.*, 2015). Coagulation, flocculation and sedimentation are the three major processes in wastewater treatment process. These processes were considered in order to achieve the full capacity of the wastewater treatment process (Kumar *et al.*, 2014).

The most commonly used coagulants in wastewater treatment are aluminium and ferric salts. However, there are some disadvantages with those in-coagulants (Gao *et al.*, 2007; Chen *et al.*, 2010). Recent studies have reported that component of aluminium salts could lead to human health implications, such as Alzhemeir's disease and the cause of cancer (Devrimci *et al.*, 2012; Hamid *et al.*, 2014). There

were also the problem of reaction of alum with the alkalinity present in the water leading to a reduction of pH and low efficiency in coagulation in cold water (Ramavandi, 2014). Due to this problem, presently there is an increasing interest to utilise the natural and cheaper materials to remove organic pollutants from wastewaters.

To ease the problems associated with chemicals coagulants, several studies have pointed out the introduction of natural coagulants. For example, Mishra *et al.*, (2002), used the plantago *pysllium mucilage* to treat the sewage and tannery effluent. Hamadani *et al.* (2011), also use the same coagulant in semi-aerobic landfill leachate treatment. The use of natural coagulants had shown high efficiency of pollutants removal in the effluent treatment.

Natural polymer based flocculants have started gaining importance for their eco-friendly nature. In this case study, the potential of *Strychnos potatorum* and *Pisum sativum* will be evaluated as a natural coagulant. The removal efficiency of COD, TSS, O&G and colour will be assessed by using *Strychnos potatorum* and *Pisum sativum* and also the presence of aluminiun sulphate and ferrous sulfate as the chemical coagulants. The development of the pilot scale treatment system will be established and the efficiency of the removal of COD, TSS, O&G and colour will be assessed.

1.2 Problem Statement

Most of the industries choose to discharge the effluent with the cheapest way which is to release directly into the drain and river. In Malaysia, public wastewater treatment plants are insufficiently provided and due to that, wastewater is discharged directly from factories and industries to such public waters such as drains and rivers. Industrial wastewaters can be very strong in terms of pollutant concentrations and hence can contribute significantly to the overall pollution load imposed on the environment (Ng, 2005). Discharge of effluent into water bodies can cause water depletion and results in aquatic pollution (Dohare and Meshram, 2014). The food industry is one of the industries that have highest consumptions of water and is one of the biggest producers of effluents per unit of production (Singh *et al.*, 2014).

Among various kinds of food industries, meat processing is one of the industries that contributed to the degradation of environment.

One of the meat food processing industries is located in small and medium industry in Parit Raja, Batu Pahat, Johor, Malaysia. It produces whole meal pita bread, kebab frozen, marinated beef, chicken and mutton, beef, and chicken and mutton satay. As the industry that doing business based on the meat food processing, this industry requires large amounts of water for carrying out activities during the processing of the food. Based from the site investigation, wastewater from this industry was discharged into drains without any prior treatment. In addition, during the rainy season, the effluent will be flowing into the nearest water bodies. Consequently, the drain adjacent to the industrial area has been contaminated with pollutants contained in wastewater from the meat food processing. In addition, the villagers here complained about the smell come from the river. It was uncomfortable to them to live with the smell comes from the river.

The wastewater flow directly into the drains also may cause drainage pollution. Meat food processing industry produces wastewater with loads of fat, oil, grease and solids. Meat processing wastewater usually contains high concentrations of nitrogen, which must be removed before discharge to water bodies (Bickers and Oostrom, 2000). In addition, presence of plenteous amount of biodegradable organic materials in the meat processing wastewater binds oxygen and reduces its availability which ultimately causes death of aquatic animals. This wastewater also contains several toxic compounds including unionized ammonia, chromium and tannins that are directly involved in the deaths of aquatic animals (Rahman *et al.*, 2014).

Coagulation-flocculation process has been widely used wide world for wastewater treatment and aluminium and ferric salts are commonly used as coagulants. This process is known as low cost and efficient in removal organic pollutants from wastewaters. However, the using of aluminium and ferric salts in wastewater treatment can bring harm to environment and human healths other than the cost are quite expensive. There are many advantages of using natural coagulants in wastewater treatment. *S. Potatorum* and *P. Sativum* especially high contains in polysaccharide, starch and albumin proteins (Yadav *et al.*, 2014) as an active agents which makes it suitable as coagulants. Therefore this research is using natural coagulants in order to fill the gap of previous process and experiments.

1.3 Objectives of Study

The aim of this study was to investigate the efficiency of coagulation-flocculation process removal of turbidity, COD, TSS, colour and O&G from MFPW. The specific objectives of the study can be outlined as follows:

1. To study the effectiveness of *S. potatorum* and *P. sativum* as a natural coagulant for removing turbidity, TSS, COD, O&G and colour from MFPW and the influence of operating parameters; mixing rate, dosage and pH during the coagulation-flocculation process.
2. To investigate the adsorptions capacity of *S. potatorum* and *P. sativum* to remove COD, turbidity, colour and O&G from MFWP along with the parameters that affected the sorption process.
3. To evaluate the efficiency of the lab-scale system to treat the MFWP.

1.4 Research Questions

On the basis of objective of study, there are some research questions was developed to guide the study.

1) How much percentage of organic pollutants from MFPW can be removing by using the natural coagulants?
2) What is the optimum condition of mixing rate, dosage and pH that suitable for coagulation-flocculation process?
3) How good are the adsorption capacity of the natural coagulants in the coagulation process?
4) What is the parameters that effected the adsorption process?
5) How effective the coagulation-flocculation system to treat meat food processing wastewater in lab-scale process?

1.5 Scope of Study

The MFPW was collected from a meat processing industry in Parit Raja, Batu Pahat Johor, Malaysia. The raw meat processing wastewater was analyzed for the parameters such as pH, BOD, COD, TSS, turbidity, O&G, and colour.

The effectiveness of the use of *S. potatorum* and *P. sativum* as natural coagulants was measured through the removal of the five parameters of pollutants in meat food processing wastewater which are turbidity, TSS, COD, colour and O&G. Various dosages of different coagulant were tested to find the optimum dosage and their environmental factors such as pH effects were evaluated. The adsorption test was conducted by varying the amount of adsorbent, pH and contact time in jar test to investigate the potential adsorption of these sorbent and the factors that affecting the capacity of adsorption. Finally, the coagulation-flocculation system was set-up in a lab-scale to simulate the treatment process by using optimum value from all the above experimental works.

1.6 Significant of Study

Environment pollution is seriously increasing throughout the world because of economic growth and increased human activity. In order to control the environment pollution, the wastewater from industry need to be treated before discharged into rivers. This pollution is greatly affected human health and the environment if it is not properly treated. These impacts can include harm to fish and wildlife populations, oxygen depletion and contamination of drinking water. Through this study, the process that selected to treat meat food processing wastewater can reduced the cost and environmental friendly. This purpose can be achieved by using natural coagulation as coagulants in coagulation-flocculation process. Natural coagulants is non-toxic and locally available makes treatment cost is cheaper. The use of *S. potatorum* and *P. sativum* is not explored by many researchers especially in meat food processing wastewater. This study is important since this study was lead to an environmentally coagulation-flocculation system by using natural coagulant as an alternative to replace the chemical coagulant.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter describes overview of related theory and previous research relevant to the study of removal of pollutants using flocculation-coagulation process. This chapter discuss about wastewater, characteristics of meat food processing wastewater (MFPW), coagulation and flocculation process details and also factors that influence the coagulation-flocculation processes. This chapter also gives explanation about the chemical and natural coagulant that was used in wastewater treatment and the efficiency of these coagulants. In this chapter also, the adsorption process and the adsorption isotherm for wastewater was discussed. Finally, the key findings of literature review will be discussed and gaps of research will be highlighted.

2.2 Meat Food Processing Wastewater (MFPW)

Waste in the food industry mainly include residual organic raw material after processing. Disposal and use of waste materials is a difficult task because of poor biological stability, high water activity, poor oxidative stability, pathogenicity and optimum enzyme activity. Industrial waste generated by different foods can be determined by the level of their production (Rahman *et al.*, 2014). One of the branches of the food industry which has the greatest impact on the degradation of the natural environment is the meat industry (Bohdziewicz *et al.*, 2003). Activities in

meat processing plants used plenty of water during the processing of meat product in their operation. In addition, water is also used for cleaning purposes in the processing area. Wastewater is generated and discharge of this wastewater has a great effect to the environmental (Rahman *et al*., 2014).

2.2.1 Effects of Untreated MFPW to Environment

The presence of fertile total biodegradable organic material in the MFWP and reducing the availability of oxygen binding ultimately leads to the death of aquatic animals. In addition, eutrophication may occur due to certain macronutrients (N, P) and the excessive growth of algae and minerals that cause the death of aquatic inhabitants. Moreover, this wastewater also contains a number of toxic compounds of ammonia, including trade unions, chromium and tannins that are directly involved in the death of aquatic animals (Rahman *et al*., 2014).

Meat processing industry produces wastewater with loads of fat, oil, grease and solids. MFPW usually contains high concentrations of nitrogen (typically 70 – 250 mg/L), which must be removed before discharge to water bodies (Bickers and Oostrom, 2000). Meat processing industry raises environmental issues caused by the residual potential health risks that generate as quickly biodegradable organic waste solids (Cosmin and Alexe, 2014).

Rahman *et al.* (2014), also reported in their study that the production of waste during processing of meat products is not desirable because it causes a deterioration of the quality of the final product and also cause some serious health threat if not disposed-off. Meat processing industry waste material contains large quantities of organic compounds for which disposal is difficult. Efficient uses of byproducts have a direct impact on the economy and reduce environmental pollution.

2.2.2 Characteristics of Untreated Wastewater from Meat Food Processing Industries

The characteristic of untreated MFWP primarily depends on the process at the industries such as cutting, utilization of spices and cleaning works. The characteristic also depends on the type of management practice related to water use and waste

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