



**UNIVERSITI PUTRA MALAYSIA**

***POTENTIAL OF DRAGON FRUIT PEELS (DFP) IN THE REMOVAL OF  
TURBIDITY, TOTAL DISSOLVED SOLIDS (TDS) & TOTAL SUSPENDED  
SOLIDS (TSS) FROM LANDFILL LEACHATE***

**NUR AZLIN KATHER MAHIDDIN**

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**BY**

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## ABSTRACT

### POTENTIAL OF DRAGON FRUIT PEELS (DFP) IN THE REMOVAL OF TURBIDITY, TOTAL DISSOLVED SOLIDS (TDS) & TOTAL SUSPENDED SOLIDS (TSS) FROM LANDFILL LEACHATE

NUR AZLIN KATHER MAHIDDIN

**Introduction:** Dragon fruit is the tropical fruit belongs to the Cactaceae family (cactus species), known as pitaya or pitahaya. The peel of dragon fruit is often regarded as a waste that has the potential to be a coagulant for physical-chemical of wastewater. Landfill leachate is a complicated wastewater with high concentration of pollutants and has been identified as potential sources of ground and surface waters contamination. Two most common type of dragon fruit are *Hylocereus polyrhizus*-purple pink/red fleshed (DFPP) and *Hylocereus undatus*-white fleshed (DFPW). **Objectives:** The main aims of this study is to determine the potential of both DFPP and DFPW in the removal of turbidity, total dissolved solids (TDS) and total suspended solids (TSS) from landfill leachate. **Methodology:** DFPP and DFPW were prepared in the lab and were applied to the leachate at several dosages using standard jar test method and sedimentation times were recorded. Physicochemical parameters i.e. turbidity, TDS and TSS were measured in lab using HACH Turbidimeter 2100N, portable TDS meter (Model HACH) and vacuum filter apparatus respectively. **Results and Discussion:** DFPP was able to remove 60% of turbidity and 23% of TSS at an optimum dosage of 50 mg/L. In terms of TDS removal efficiency, 65% was able to be removed from raw leachate by using 90 mg/L of DFPP. Results showed that when using DFPW at an optimum dosage of 90 mg/L, removal percentage of 67%, 69% and 36% for turbidity, TDS and TSS respectively, can be reached. As the sedimentation time increases, the removal percentage also increased for all three parameters. **Conclusion:** Results indicated that both DFP have coagulant capabilities but DFPP were better in removing turbidity and TDS compared to DFPW. Yet, in terms of TSS removal, DFPW was a better coagulant than DFPP. For DFPP, between turbidity and TDS, DFPP was better in removing turbidity than TDS. Thus, it can be concluded that dragon fruit has the potential to be used as a natural coagulant for leachate treatment.

**Keywords:** Dragon fruit peel, leachate, turbidity, TDS, TSS, coagulation-flocculation

## ABSTRAK

### POTENSI KULIT BUAH NAGA (DFP) DALAM PENYINGKIRAN KEKERUHAN, PEPEJAL TERLARUT (TDS) & PEPEJAL TERAMPAI (TSS) DARI LARUT RESAP TAPAK PELUPUSAN

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**Pengenalan:** Buah naga adalah buah-buahan tropika tergolong dalam keluarga Cactaceae (spesies kaktus), yang dikenali sebagai pitaya atau Pitahaya. Kulit buah naga sering dianggap sebagai satu bahan buangan yang mempunyai potensi untuk menjadi koagulan untuk rawatan air sisa. Larut resap tapak pelupusan adalah air sisa rumit dengan kepekatan yang tinggi bahan pencemar dan telah dikenal pasti sebagai sumber potensi pencemaran tanah dan air permukaan. Dua jenis buah naga yang biasa ditemui adalah *Hylocereus polyrhizus*-buah naga isi ungu-merah jambu/merah (DFPP) dan *Hylocereus Undatus*-buah naga isi putih (DFPW). **Objektif:** Tujuan utama kajian ini adalah untuk menentukan potensi kedua-dua DFPP dan DFPW dalam penyingkiran kekeruhan, pepejal terlarut (TDS) dan pepejal terampai (TSS) dari tapak pelupusan larut resapan. **Metodologi:** DFPP dan DFPW telah disediakan di makmal dan telah dicampurkan ke dalam air larut resapan tapak pelupusan dengan beberapa dos berbeza, dengan menggunakan standard kaedah ujian balang dan masa pendedapan telah direkodkan. Parameter fizikokimia iaitu kekeruhan telah diukur di makmal menggunakan HACH Turbidimeter 2100N, TDS menggunakan meter mudah alih TDS (Model HACH) dan TSS menggunakan alat vakum penapis. **Keputusan dan Perbincangan:** DFPP mampu menghilangkan 60% daripada kekeruhan dan 23% daripada TSS pada dos optimum 50 mg / L. Dari segi kecekapan penyingkiran TDS, 65% dapat dikeluarkan dari air larut resapan mentah dengan menggunakan 90 mg / L DFPP. Hasil kajian menunjukkan bahawa apabila menggunakan DFPW pada dos optimum sebanyak 90 mg / L, peratusan penyingkiran 67%, 69% dan 36% masing-masing bagi kekeruhan, TDS dan TSS, boleh dicapai. Apabila masa pendedapan bertambah, peratusan penyingkiran juga meningkat bagi ketiga-tiga parameter. **Kesimpulan:** Keputusan menunjukkan bahawa kedua-dua DFP mempunyai keupayaan koagulan tetapi DFPP adalah lebih baik dalam menghilangkan kekeruhan dan TDS berbanding DFPW. Namun, dari segi penyingkiran TSS, DFPW adalah koagulan yang lebih baik daripada DFPP. Untuk DFPP, antara kekeruhan dan TDS, DFPP adalah lebih baik dalam menghilangkan kekeruhan daripada TDS. Oleh itu, dapat disimpulkan bahawa buah naga mempunyai potensi untuk digunakan sebagai koagulan semula jadi untuk rawatan larut resapan.

**Kata kunci:** kulit buah naga, larut resapan tapak pelupusan, kekeruhan, pepejal terlarut, pepejal terampai, koagulan-flokulan

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## LIST OF ABBREVIATIONS

|      |  |
|------|--|
| DFP  | Dragon Fruit Peel  |
| DFPP | <i>Hylocereus polyrhizus</i> -purple pink/red fleshed dragon fruit |
| DFPW | <i>Hylocereus undatus</i> -white fleshed dragon fruit              |
| TDS  | Total Dissolved Solids   |
| TSS  | Total Suspended Solids   |

## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

Landfill is the most common method for waste disposal. In Malaysia, landfills are being filled up rapidly due to the current daily generation of approximately 30 000 tonnes of municipal solid waste (Fauziah & Agamuthu, 2012). Landfilling is the main disposal method practiced; about 90 - 95% of the collected wastes is still disposed in landfills, with a recycling rate of 5 -10% despite the fact that 70 - 80% of the waste is recyclable (Periathamby & Shahul, 2010).

Poorly managed landfills can pose a threat to both environment and human health. Normally, landfill will produce a liquid stream known as leachate which is a major problem of most landfill sites. Leachate is defined as the liquid that pass through a landfill which contain suspended and dissolved matter. It is caused by the precipitations that pass through waste deposited in a landfill.

Thus, landfill leachate is a complicated wastewater with high concentration of pollutants. These pollutants include organic contaminants (measured as BOD or COD), ammonia, suspended solids, heavy metals and inorganic salts (Trebouet, Schlumpf, Jaouen, & Quemeneur, 2001). This contributes to high turbidity, total dissolved solids (TDS) and total suspended solids (TSS). Leachate generated in municipal landfill

contains large amounts of organic and inorganic contaminants (Kettunen & Rintala, 1998). Thus, leachate treatment deem necessary to avoid or minimize surface water or adjacent groundwater contamination, and the accompanying health effects.

Traditionally, conventional landfill leachate treatment processes have been similar to those that have been used for regular wastewater which includes biological, physical and chemical (physicochemical) treatment processes (Kakalanga, 2012). Coagulation-flocculation process is an example of physicochemical treatment which have gained wide attention for its high removal efficiency of dissolved chemical compounds and turbidity from wastewater via the addition of conventional chemical coagulants, namely alum, ferric chloride and polyaluminium chloride (PAC) (Vishali & Karthikeyan, 2014).

Yet there are many disadvantages in the usage of chemical coagulants which includes high operation costs, large sludge volumes, and associated effects on human health like Alzheimer's disease (Flaten, 2001). Thus, there is significant importance in substituting to a coagulant derived from natural resources. Naturally occurring coagulants are biodegradable and are presumed safe for human health and in time there has been more interest in the subject of natural coagulants, especially to reduce the problems of water and wastewater treatment in developing countries and to avoid some health risks (Muralimohan, Palanisamy, & Vimaladevi, 2014). Other benefits of natural coagulants are abundance of material, cost effective, highly biodegradable and toxic-free and low sludge volume (Yin, 2010).

Coagulants are the components that promote aggregation and sedimentation of suspended particles in a solution (Nharingo, Zivurawa, & Guyo, 2015). Till date, the

four natural coagulants which were the main focus on the reviews of plant-based natural coagulants for water and wastewater treatment in few previous research are *Moringa oleifera* seeds, Nirmali seeds, tannin and *Opuntia ficus indica* cactus (Vijayaraghavan, G.; Sivakumar, T.; Vimal Kumar, 2011; Yin, 2010).

Research reported that cactus *Latifaria* has the potential for use as a natural water treatment coagulant (Diaz et al., 1999) while cactus *Opuntia* exhibits high turbidity removal efficiency for sewage and seawater treatment (Zhang, Zhang, Luo, & Yang, 2006). Another study indicates that *Opuntia ficus indica* grows produces “mucilage” that contains polygalacturonic acid (biopolymer) with interesting coagulating-flocculating capabilities (Torres, 2012).

Dragon fruit is the tropical fruit belongs to the Cactaceae family (cactus species), known as pitaya or pitahaya. Dragon fruit is native to Mexico, Central America and South America; but now widely cultivated as fruit crops in Southeast Asian countries such as Vietnam, Taiwan, Philippines and Malaysia (Nerd & Mizrahi, 1997). In Israel, Malaysia, and Taiwan, the commercial production of dragon fruit is up to 16000–27000 kg/ha annually while between 18,000 – 22,000 kg/ha of fruits per year have been produced from Sri Lanka (Mizrahi & Nerd, 1999; Pushpakumara, Gunasena, & Karyawasam, 2005). There are three known type of dragon fruit yet the famous two are *Hylocerus undatus* -white fleshed (DFPW) and *Hylocerus polyrhizus* -purple pink fleshed (DFPP).

Dragon fruit peels (DFP) are believed to be rich in pectin, i.e., heterogeneous structural polysaccharide contain  $\alpha$ -1,4-linked D-galacturonic acid (D-GalA) residues (Ridley, Neill, & Mohnen, 2001). According to Choy et al., (2014) the mucilage which consists

of galacturonic acids is generally the predominant active coagulation agent present in cacti mucilage regardless of species. Thus, dragon fruit peel is believed to have the coagulant capabilities based on previous research done on cactus (Shafad, Ahamad, Idris, & Abidin, 2013).

## 1.2 Problem Statement

Landfill leachate has been generally known as high-strength waste water that is most difficult to deal with (Schoeman, Steyn, Slabbed, & Venter, 2003). This liquid has a dark colour and a foul odor and contains complex chemical and organic compounds (Galeano, Vicente, & Gil, 2011). Runoff water from landfill leachate containing suspended solids and ammonical nitrogen can be potential toxic to the aquatic organisms and threaten fish life (Salem, Hamouri, Djemaa, & Allia, 2008). This was also indicated in a study by Baun, Jensen, Bjerg, Christensen, & Nyholm, (2000) who found that dissolved organic matter in leachates seems to be toxic against algae, *Selenastrum capricornutum*, and luminescent bacteria, *Vibrio fischeri*. Toxicity effect of leachate to human living in such leachate polluted areas has also been reported by (Fauziah, Izzati, & Agamuthu, 2013). Some of the detrimental effect of leachate polluted water could be bacterial related diseases such as diarrhea, severe bacillary dysentery, and typhoid fever, other intestinal diseases as well as genitourinary tract and blood infections (Lyndon & Kojo, 2015).

Turbidity is a concern as increased turbidity will correlate with decreased disinfection effectiveness (Mccoy & Olson, 1986). Turbidity can provide food and shelter for pathogens and if not being removed, turbidity can promote regrowth of pathogens in the distribution system, leading to waterborne disease outbreaks, which have caused significant cases of gastroenteritis throughout the world (Jadhav & Mahajan, 2012). Aberration in the hematology of fish raised in leachate-contaminated waters has also been documented (Van Vuren, 1986).

Leachate also has high concentration of total dissolved solids (TDS) (Al-Yaqout & Hamoda, 2003). The increase in salinity due to increase in TDS concentration also increases toxicity by changing the ionic composition of water (Aziz, Umar, & Yusoff, 2010). High TDS in water could clog fish gills lowering their growth rate (Emenike, Fauziah, & Agamuthu, 2012).

Total suspended solids (TSS) is a solid matter in the leachate, consist of organic matter, inorganic matter, clay and microorganism (Rong, 2009). Suspended solids accumulate toxic components that will reach the bottom of the water. Phytoplankton and bacteria can live or adhere on to suspended solids (Mulligan, Davarpanah, Fukue, & Inoue, 2009).

The most common chemical coagulant used is aluminium. It is characterized as poisoning factor for encephalopathy and study of various reports on impact of aluminum on human health indicate that there is strong evidence on aluminium based coagulants linked in the development of neurodegenerative ill-nesses as senile dementia (Okuda, Baes, Nishijima, & Okada, 1999) and with Alzheimer's disease (Rondeau, Jacqmin-

Gadda, Commenges, & Dartigues, 2001). There are few environmental drawbacks associated with the usage of such chemical coagulant which are the production of large sludge volumes as well as the fact that they significantly affect pH of treated water (Yang et al., 2007).

Based on previous studies, the search for low cost, effective and environmentally safe natural coagulant is very much in need to assist in the removal of turbidity, TDS and TSS from landfill leachate. However in Malaysia, to date, there has been no reported study on the use of DFP in the removal of turbidity, TDS and TSS from landfill leachate. Therefore, this study would provide a new insight and an environmentally friendly method to remove turbidity, TDS and TSS from landfill leachate.

Usage of DFP as a natural coagulant for landfill leachate treatment directly contributes in the initiatives of global sustainable technology since the dragon fruit plant is relatively abundant, biodegradable and non-toxic. In time, there is no reported study on potential of DFP in the removal of turbidity, TDS and TSS from landfill leachate. Thus the aim of this study are to measure the removal percentage of turbidity, TDS and TSS by DFPP & DFPW with different dosage (10, 30, 50, 70 & 90 mg/L) and different sedimentation time (5 to 60 min) before and after treatment with DFP coagulants. This study also aimed to study the correlation between dosage of DFP and sedimentation time, with the removal percentage of turbidity, TDS and TSS from landfill leachate.

### **1.3 Research Justification**

Landfill leachate is a complicated wastewater with high concentration of pollutants that lead to high turbidity, TDS and TSS, and has been identified as potential sources of ground and surface waters contamination (Mott, Hartz, & Yonge, 1987). Thus treatment of this type of wastewater deem necessary. Many treatment processes have been explored in previous research as an effort to minimize the environmental and health impact resulted from landfill leachate contamination. Conventional landfill leachate treatments can be classified into three major groups: (a) leachate transfer: recycling and combined treatment with domestic sewage, (b) biodegradation: aerobic and anaerobic processes and (c) chemical and physical methods: chemical oxidation, adsorption, chemical precipitation, coagulation/flocculation, sedimentation/flotation and air stripping (Renou, Givaudan, Poulain, Dirassouyan, & Moulin, 2008).

Coagulation/flocculation has been widely adopted as one of the most effective methods to remove colloidal particles in water or wastewater treatment by adding highly charged cations, colloidal particles are destabilized, thereby, forming larger aggregates and flocs that can be effectively separated by subsequent sedimentation, flotation or filtration units (Mounir, Abdeljalil, & Abdallah, 2014). Among the advantages of coagulant are simplicity and effectiveness of treatment that can be achieved due to addition of coagulants which resulted in the destabilization of colloidal particles and therefore, ease the sedimentation of flocs as the particle size increase.

There are two types of coagulants which are natural and chemical-based coagulants. Disadvantages of inorganic and synthetic coagulants are it causes Alzheimer's disease

and similar health related problems, reduction of pH, high costs, production of large sludge volume and low efficiency in coagulation of cold water (Ravikumar & K, 2013). In contrast, natural coagulants which is plant-based are non-toxic, environmental friendly (Bratby, 2006), and safe (Asrafuzzaman, Fakhruddin, & Hossain, 2011).

Dragon fruit peel is believed to be rich in pectin, i.e., heterogeneous structural polysaccharide contain  $\alpha$ -1,4-linked D-galacturonic acid (D-GalA) residues (Ridley et al., 2001) and in the research done by Choy et al., (2014) state that the mucilage which consists of galacturonic acids is generally the predominant active coagulation agent present in cacti mucilage regardless of species. As dragon fruit come from the same family as cactus, it is believed that they share the same coagulant capabilities.

#### **1.4 Objectives**

The main objective of this study is to determine the potential of Dragon Fruit Peels (DFP) in the removal of turbidity, total dissolved solids (TDS) and total suspended solids (TSS) from landfill leachate. The specific objectives were:

- 1) To prepare the DFPP and DFPW coagulants.
- 2) To measure the level of initial turbidity, TDS and TSS in leachate prior to treatment with DFP coagulants.
- 3) To measure the removal percentage of turbidity, TDS and TSS by DFP coagulants with different dosage (10, 30, 50, 70 & 90 mg/L) and sedimentation time (5 to 60 min).

- 4) To compare the removal percentage of turbidity, TDS and TSS between DFPP and DFPW coagulants with different dosage (10, 30, 50, 70 & 90 mg/L).
- 5) To study the correlation between dosage of DFP and sedimentation time, with the removal percentage of turbidity, TDS and TSS from landfill leachate.

### **1.5 Research Hypothesis**

- 1) DFPP contribute to higher removal of turbidity, TDS and TSS compared to DFPW.
- 2) There is significant association between between dosage of DFP and sedimentation time, with the removal percentage of turbidity, TDS and TSS from landfill leachate.

### **1.6 Conceptual Framework**

Among two type of landfill, sanitary landfill was chosen due to the systematic waste collection system implemented which includes leachate collection ponds. There are many constituents of landfill leachate, but only turbidity, TDS & TSS was measured in this study. This study aimed to provide another natural coagulant intervention apart from the existing one such as *Moringa oleifera*. The coagulant interested to be studied was made out of dragon fruit peel which was expected to reduce the turbidity, TDS & TSS level in leachate at the end of experiment.

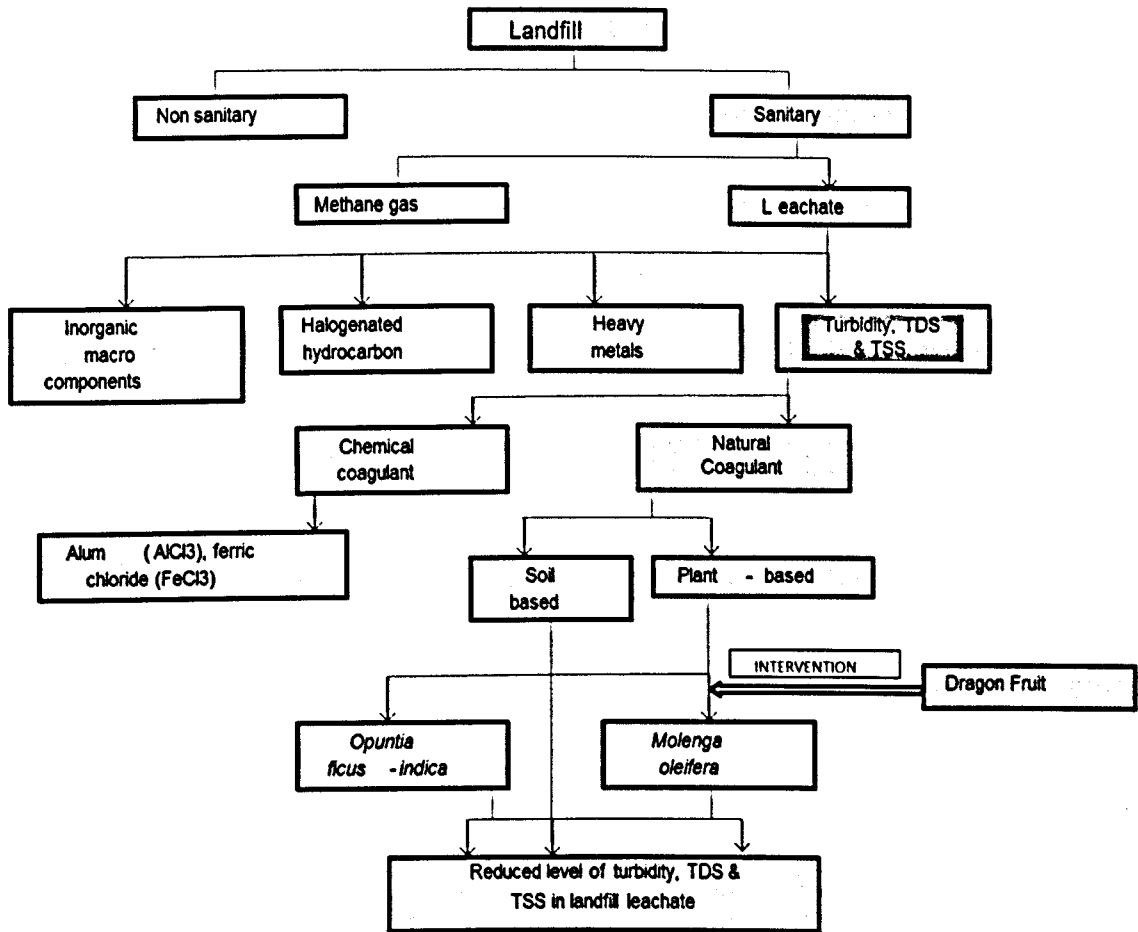


Figure 1.1: Conceptual Framework

- Parameters to be measured
- The intervention is to use dragon fruit (peel) to remove the parameters mentioned above

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Landfill**

Increasingly affluent lifestyles, continuing industrial and commercial growth in many countries around the world in the past decade has been accompanied by rapid increases in both the municipal and industrial solid waste production (Renou et al., 2008). Solid waste management has become a major environmental problem in Malaysia as over 23,000 tonnes of waste is produced daily in Malaysia and, the amount is expected to reach 30,000 tonnes by 2020 (Zainol, Aziz, & Yusoff, 2012). Due to the advantage of dumping high quantities of MSW at economical cost, landfills are the primary means of municipal solid waste (MSW) disposal in many countries worldwide (Aziz et al., 2010). As high amount of MSW are produced daily in Malaysia and the preferred way of disposing them are through dumping in landfill sites, thus it become the focus of this study.

#### **2.2 Sanitary landfill**

The most common municipal solid waste (MSW) disposal method is sanitary landfill due to such advantages as simple disposal procedure, low cost, and landscape-restoring effect on holes from mineral workings (Bashir, Aziz, Yusoff, & Adlan, 2010). This

method also help to minimizes environmental insults and other inconveniences, and allows waste to decompose under controlled conditions until its eventual transformation into relatively inert, stabilized material (Renou et al., 2008). However, the production of highly contaminated leachate is a major drawback of this method (Wiszniewski, Surmacz-Górska, Robert, & Weber, 2007).

### **2.3 Leachate**

Leachate from municipal landfills are defined as the aqueous effluent generated as a consequence of rainwater percolation through wastes, chemical biological processes in waste's cells and the inherent water content of wastes themselves. The combination of the previous factors results in a dark effluent (Rivas, Beltrán, Carvalho, Acedo, & Gimeno, 2004). Landfill leachates have been identified as potential sources of ground and surface waters contamination, as they may percolate through soils and subsoils, causing extensive pollution of streams, creeks and water wells, if they are not properly collected, treated and safely disposed (Mott, Hartz, & Yonge, 1987). Leachate may contain large amount of organic contaminants which can be measured as chemical oxygen demand (COD) and biological oxygen demand (BOD), ammonia, halogenated hydrocarbons, suspended solid, significant concentration of heavy metals and inorganic salts (Trebouet et al., 2001). The entire component indicated previously lead to high turbidity, total dissolved solids (TDS) and total suspended solids (TSS) in leachate. Landfill leachate has been generally known as a high-strength waste water that is most difficult to deal with thus satisfactory treatment of leachate is no easy task (Schoeman et al., 2003).

## **2.4 Turbidity**

Turbidity is a measurement of how cloudy water appears which technically mean it is a measure of how much light passes through water, and it is caused by suspended solid particles that scatter light. These particles may be microscopic plankton, stirred up sediment or organic materials, eroded soil, clay, silt, sand, industrial waste, or sewage (Mounir et al., 2014). The major concern over turbidity is related to decrease in disinfection efficiency and is of primary importance since disinfection is the final treatment barrier (Mccoy & Olson, 1986).

## **2.5 Total dissolved solids (TDS)**

Total dissolved solids (TDS) encompass the material in water which is termed unfilterable because of its minute size and the particulates pass through existing filters when filtered. Example are microscopic ions such as Na, Cl, Mg, and Ca (Crotts, 1996). This material has to be removed, as it causes deterioration of water quality by reducing the clarity (e.g. causing turbidity or colour), causing infection, and eventually carrying toxic compounds, adsorbed on their surfaces (Tzoupanos & Zouboulis, 2008).

## **2.6 Total suspended solids (TSS)**

Total suspended solids (TSS) are another component of leachate that means any solid matter in the leachate, and they consist of organic matter, inorganic matter, clay and microorganism (Rong, 2009). Effluent that have high concentration of suspended solids

can potentially interfere with the disinfectant efficiency because when microorganisms are entrapped within flocs, it would not be properly attacked by disinfectants (Narkis, Armon, Offer, Orshansky, & Friedland, 1995).

## **2.7 Leachate treatment**

Due to a variety of pollutants in the leachate, the treatment is a major concern in urban waste management (Nikazar, 2012). Several processes derived from water and wastewater treatment have been applied for the treatment of leachate which include aerobic and anaerobic biological treatments, photo-oxidation and membrane processes, chemical oxidation and precipitation, activated carbon and adsorption and coagulation-flocculation (Trebouet et al., 2001). A very important step in water and in wastewater treatment is the coagulation-flocculation process, which is widely used, due to its simplicity and cost-effectiveness (Tzoupanos & Zouboulis, 2008).

## **2.8 Coagulation-flocculation**

The whole treatment process of coagulation-flocculation can be divided into two distinct procedures, which should be applied consecutively. The first one termed coagulation, is the process whereby destabilization of a given colloidal suspension or solution is taking place. The function of coagulation is to overcome the factors that promote the stability of a given system. It is achieved with the use of appropriate chemicals, usually aluminium or iron salts, the so-called coagulant agents. The second sub-process, termed flocculation, refers to the induction of destabilized particles in order to come together, to

make contact and thereby, to form large agglomerates, which can be separated easier usually through gravity settling (Bratby, 2006). Material in wastewater carries negative charge and the electrostatic repulsive forces prevent the particles to get together and thus the solution is stable and need longer time to sediment. To reduce the sedimentation time, destabilization is required and this is the main role of coagulants through mechanism such as adsorption and charge neutralization, subsequently then flocculation promotes the aggregation and flocs formation (Tzoupanos & Zouboulis, 2008).

As the colloidal particles in a solution carry electrical charges on their surface which are normally negative charges, this stable system of colloid should be un-stabilized by the application of coagulants (Mahvi & Razavi, 2005) with the opposite charge.

Studies have been reported on the examination of coagulation–flocculation for the treatment of landfill leachates, aiming at process optimization, i.e., selection of the most appropriate coagulant (Tatsi, Zouboulis, Matis, & Samaras, 2003).

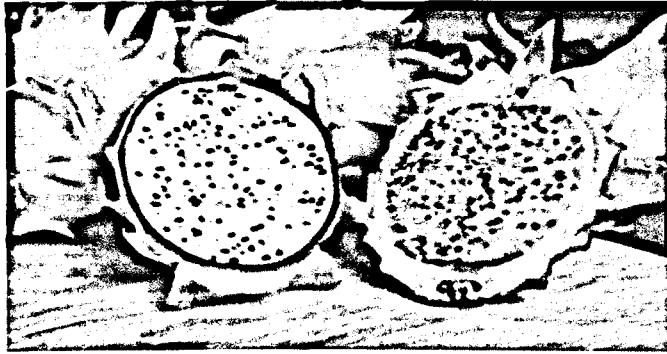
Despite the superiority of chemical coagulants in treating turbid water, they are still lacking in terms of green chemistry (Choy et al., 2014). Residual aluminium in alum treated water has been the center of debate as it is linked to serious health issues such as the development of Alzheimer's disease (AD) (Flaten, 2001) and senile dementia (Rondeau et al., 2001). As for iron salts, careful process controls are necessary as excessive iron residual in the treated water will lead to highly visible rust or blood colored stains (Gebbie, 2005) caused by the hydrolysis of iron salts.

In contrast to chemical coagulants, plant-based natural coagulants are eco-friendly and generally toxic free (Bratby, 2006). Nowadays, there is a high demand to find an

alternative coagulant which is preferably from natural, renewable sources and safe for human health (Shafad et al., 2013). Several studies have been done on natural coagulants produced or extracted from plants, animals, or microorganisms (Katayon et al., 2006). Example are *Moringa oleifera* which is one of the effective coagulants and has been tested to be used as a primary coagulant in water and wastewater treatment, and cactus plant which has been discovered to have the potential as coagulant (Diaz et al., 1999). Till date, reviews on plant-based natural coagulants were mainly focused on the four most common natural coagulants which included *Moringa oleifera* seeds, Nirmali seeds, tannin and *Opuntia ficus indica* cactus in the water and wastewater treatments (Yin, 2010). Fruit waste is an example of a biomaterial that is suitable to be derived into plant-based natural coagulants. Fruit waste such as peels and seeds comprised a significant amount of up to 50% of the total fruit weight and are commonly non-edible (Choy et al., 2014).

## **2.9 Dragon fruit**

Coming from the family Cactaceae, dragon fruit of *Hylocereus* genus or also known as pitaya is a round, juicy, and highly nutritious fruit (Idris et al., 2013). The two famous type of dragon fruit are *Hylocereus undatus* (white-fleshed: DFPW) and *Hylocereus polyrhizus* (purple-pink/red fleshed: DFPP).



**Figure 2.1: Dragon fruits**

*Source: Google Image*

The commercial production of dragon fruit in Israel, Malaysia, and Taiwan, is up to 16000–27000 kg/ha annually (Mizrahi & Nerd, 1999; Pushpakumara et al., 2005). Various dragon fruit based products such as beverages, jams, and candied fruits are commercially produced in Malaysia and its peel are discarded as solid waste from food industries (Jamilah, Shu, Kharidah, Dzulkifly, & Noranizan, 2011). It has been reported that the *Hylocereus polyrhizus* skin has the ability to remove  $Mn^{2+}$  from aqueous solution (Namal Priyantha, Lim, & Dahri, 2013) while the fruit (*Hylocereus undatus*) foliage has been used for methyl orange dye removal (Haddadian, Shavandi, Zainal, Halim, & Ismail, 2013). It is reported that cactus *Latifaria* has the potential for use as a natural water treatment coagulant (Diaz et al., 1999). Previous study indicate that cactus *Opuntia* exhibited high turbidity removal efficiency for sewage and seawater treatment (Katayon et al., 2006). Hence, the positive outcome of the latter study justifies further research on usage of cactus opuntia as a natural macromolecular coagulant to treat other types of highly turbid wastewater such as landfill leachate (Belayneh & Batu, 2015). A recent study indicates that *Opuntia ficus indica* produces “mucilage” that contains polygalacturonic acid (biopolymer) with interesting coagulating-flocculating capabilities

with 65% of the initial COD being removed at pH 10 (dose of 50 mg/L) (Torres, 2012). Another study showed that mucilage derived from the species *Opuntia ficus indica* demonstrated high efficiency of the cactus to eliminate turbidity compared to aluminium sulfate ( $\text{Al}_2(\text{SO}_4)_3$ ) (Pichler, Young, & Alcantar, 2012). The mucilage extract increased particulate-settling rates 330% compared with aluminium sulfate, at dosage concentration of 3 mg/L, while its performance was equivalent at doses 0.3% of the required  $\text{Al}_2(\text{SO}_4)_3$  concentration. Hence, the positive outcome of studies on cactus-based wastewater coagulation justifies further research on other natural coagulants (Idris et al., 2013). Thus, as dragon fruit is a family of cactus species, it is believed that dragon fruit have the coagulant capabilities based on previous research done on cactus. In previous research, colloids in foliage of dragon fruit has been identified to be cationic and similar to the seeds of *M. oleifera* and thus the possible coagulation mechanism that were suggested are adsorption and charge neutralization (Idris et al., 2013).

## **CHAPTER 3**

### **METHODOLOGY**

#### **3.1 Study Design**

This is an experimental study to determine the potential of DFP in the removal of turbidity, TSS and TDS. Based on EQA Standard 1974 (2009), the tests usually involve the determination of BOD, COD, TSS and TS. However, to determine specific components according to research question and objectives, other test may also be performed. Experimental study design is relatively used to determine the effectiveness of an intervention.

#### **3.2 Sample location & sampling**

Wastewater sample was collected from Tanjung Dua belas sanitary landfill site in Kuala Langat, Selangor. The sanitary landfill design capacity is 1000 tonne per day and estimated to have lifespan of about 20 years. The sanitary landfill has an area of 160 acres. The date of commencement for this sanitary landfill was on 11th January 2010. Types of waste received are domestic waste, industrial and others which are collected from Majlis Daerah Kuala Langat, Majlis Perbandaran Sepang, Perbadanan Putrajaya, and KLIA and private waste collector.

The leachates were collected in 10 L plastic bottles which were rinsed several times with the leachate before being filled with the leachate. The pH measurement was taken *in-situ* with the aid of a portable pH meter (Model HACH). The samples were then stored in a refrigerator at about 4°C before the time of use. Other physicochemical parameters which are turbidity, TDS and TSS were measured in lab using HACH Turbidimeter 2100N, portable TDS meter (Model HACH) and vacuum filter apparatus respectively (American Public Health Association, American Water Works Association, & Water Environment Federation, 1999).

### 3.3 Procedure flowchart

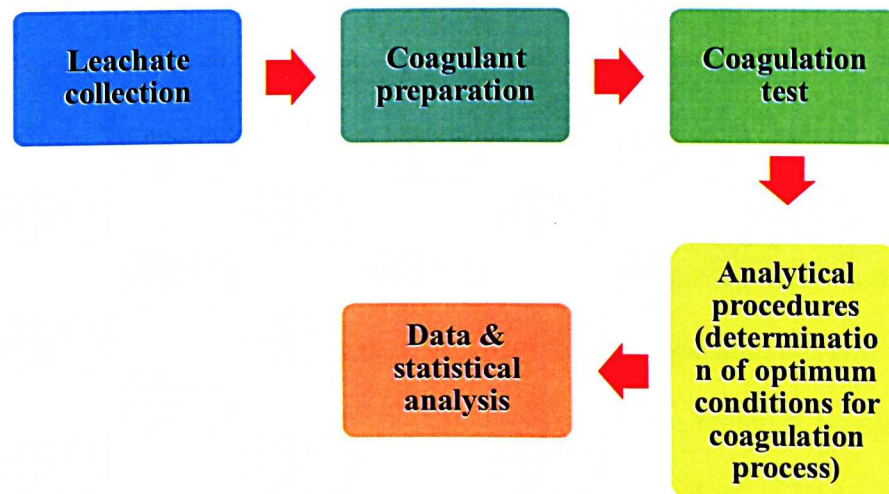
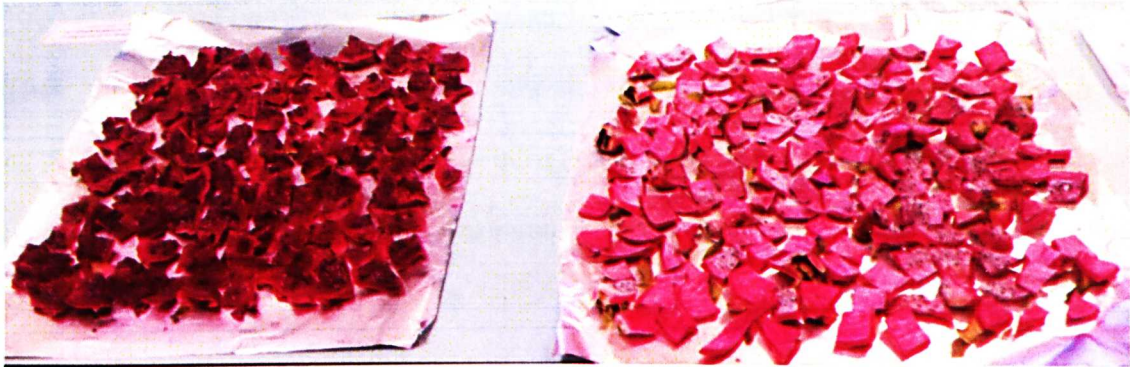


Figure 3.1: Research procedure flowchart

### 3.4 Coagulant preparation



**Figure 3.2: DFPP and DFPW prior drying**

#### 3.4.1 Preparation of dragon fruit peel in powder form

Dragon fruits *Hylocereus polyrhizus*-purple pink fleshed (DFPP) and *Hylocereus undatus*-white fleshed (DFPW) was randomly purchased from a bulk from local supermarkets. The skin of the fruit was removed, washed with tap water and subsequently cut into small pieces to facilitate drying. Then, it was dried in the oven at 85°C until a constant mass was obtained. The dried sample was then blended and sieved to obtain particles of diameter about 250  $\mu\text{m}$ . The powder was stored in a tight container and kept in the refrigerator (4°C) for further use (N. Priyantha, Lim, & Dahri, 2015).

### **3.4.2 Extraction method**

1000 mg of dried powder was suspended in 100 mL distilled water (Shafad et al., 2013). Then, the suspension was filtered through the vacuum filter apparatus using Whatman 42 filter paper (Prasad, 2009; Vega-rodriguez & Perez-casas, 2003). The extract was collected before it can be used as coagulant.

### **3.5 Coagulation test**

Coagulation tests were conducted using jar floc test unit. 500 mL of the turbid water was added into 6 beakers separately. In this study, pH was fixed for every experiment by adding 1.0 M H<sub>2</sub>SO<sub>4</sub> or 1.0 M NaOH (Idris et al., 2013). Therefore, the optimum pH needs to be selected and pH 7 (neutral pH) was selected as the optimum pH because it is closed to pH of river water (Shafad et al., 2013). Then, the coagulant was added into those beakers at different dosage. The speed and duration of the jar floc test used were based on the previous work done on *Moringa oleifera* where the steps involved rapid mixing at 100 rpm for 4 minutes and slow mixing at 40 rpm for 25 minutes before followed by sedimentation for 30 minutes (Suleyman Aremu Muyibi, Mohd. Noor, Leong, & Loon, 2002). By referring to Shafad et al., (2013), after sedimentation the residual turbidity of the clarified water collected from the middle of the beaker was measured using Hach Turbidimeter, TDS using portable TDS meter (Model HACH), and TSS using vacuum filter apparatus (American Public Health Association et al., 1999). Experiments were conducted in duplicate (Shafad et al., 2013).

### **3.6 Analytical procedures (determination of optimum conditions for coagulation process)**

#### **3.6.1 Effect of coagulation dosage**

The jar flocc test unit which came with six beakers was filled with 500 ml leachate each, and then added with different dosage of coagulants. The dosage used were 10 mg/L, 30 mg/L, 50 mg/L, 70 mg/L and 90 mg/L to see the optimization of dragon fruit peels in a larger range as indicated in the previous study (Shafad et al., 2013). One of the beaker acts as a blank.

#### **3.6.2 Effect of sedimentation time**

The experiment was conducted using the optimum coagulation dosage values obtained through the previous experiment. Based on the study by Suleyman Aremu Muyibi et al., (2002) the sedimentation time was fixed at 30 minutes for previous experiment. Yet for this experiment, the sedimentation time was varied in the range of 5 mins, 10 mins, 30 mins, and 60 mins according to previous research to see the effect of increasing sedimentation time to the removal percentage of all parameters (Shafad et al., 2013).

### 3.7 Data and Statistical analysis

The dependent variables were removal percentage of turbidity, TDS and TSS. Both dragon fruit (*Hylocereus undatus* & *Hylocereus polyrhizus*) peels were the main treatment and, dosage along with sedimentation time were the sub-treatment.

Descriptive statistics breakdowns consisted of mean, standard deviation, t-test, and *p*-value. Statistical analysis software (SPSS) was used to generate statistics. Parameters removal percentage for both DFPP and DFPW were normally distributed, as assessed by Shapiro-Wilks test ( $p > 0.05$ ). There was homogeneity of variances for both coagulants as assessed by Levene's Test for Equality of Variances. The results were statistically analyzed using Paired t-test and Independent t-test. Paired t-test was used to compare the removal percentage of all parameters before and after addition of coagulants. Independent t-test was used to compare the removal percentage of parameters from leachate between DFPP and DFPW coagulants. To determine the correlation between coagulants dosage and sedimentation time with removal percentage of turbidity, TDS and TSS, Pearson Correlation was run.

### **3.7 Quality Control & Quality Assurance**

Measurements were taken in duplicate (Shafad et al., 2013). Instruments calibration was done prior measurement, as well as maintenance, according to instrument manual instructions. Instrument manufacturer's recommendations for calibration were used in accordance to the type of instrument used. As a minimum, one reagent blank was included with each sample set (American Public Health Association et al., 1999). By referring to Standard Methods for the Examination of Water and Wastewater, turbidity measurement was taken according to method 2130B and TSS measurement was taken according to method 2540D (American Public Health Association et al., 1999)

## CHAPTER 4

### RESULTS & DISCUSSION

#### 4.1 Raw leachate characteristics (initial reading)

Leachate characteristics can be determined using analytical methods which indicate the polluting strength of wastes. Table 4.1 shows the characteristics of raw leachate before the coagulants intervention where the value of total suspended solids (TSS) exceeds above the EQA standard.

**Table 4.1: Characteristics of raw leachate**

| <b>Parameters</b> | <b>Raw leachate concentration<br/>(Initial Reading)</b> | <b>*Standard</b> |
|-------------------|---|------------------|
| pH                | 7.4   | 6.0-9.0          |
| Turbidity (NTU)   | 322.75±3.89   | NA               |
| TDS (mg/L)        | 14750.00±353.55   | NA               |
| TSS (mg/L)        | 194.95±6.01   | 50               |

NA = Not Available

\*Standard = EQA 1974 (2009)

## 4.2 To measure the removal percentage of turbidity, TDS and TSS by both DFPP coagulants with different dosage

### 4.2.1 Turbidity removal

Both type of coagulants had different optimum dosage to remove turbidity in leachate. Figure 4.1 shows the turbidity removal in percentage by *Hylocereus polyrhizus*-purple pink/red fleshed (DFPP) and *Hylocereus undatus*-white fleshed (DFPW). The optimum turbidity removal was obtained at 60% with 50 mg/L of DFPP coagulant. When the coagulant dosage is increased above the optimal 50 mg/L, it decreased the turbidity removal to 50% (70 mg/L) and 33% (90 mg/L). In contrast, the optimum dosage for turbidity removal by DFPW was obtained at 90 mg/L with 67% of turbidity removal. This indicates that there is an increase of 7% turbidity removal compared to DFPP.

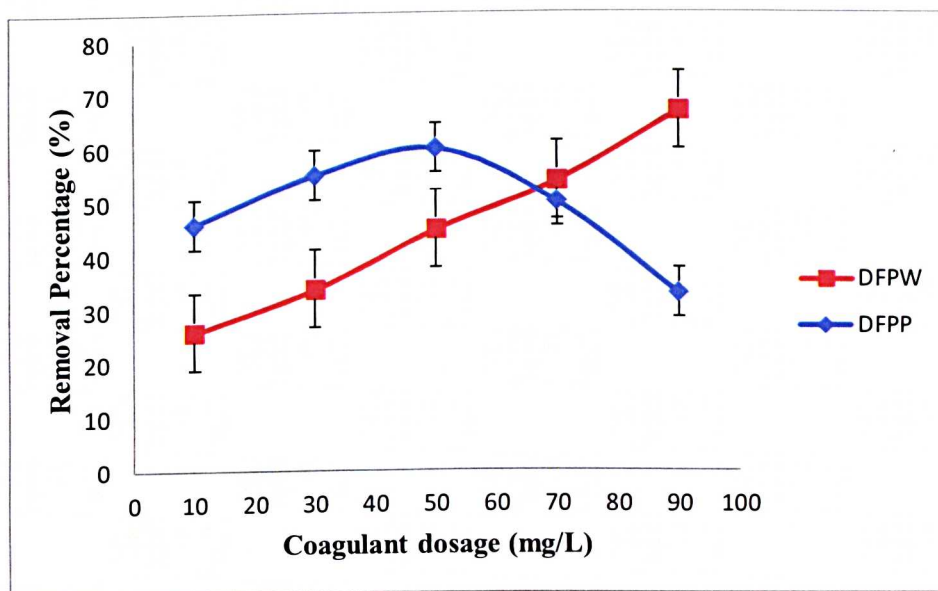


Figure 4.1: Removal percentage (%) of turbidity by DFPP & DFPW

#### 4.2.2 Removal of TDS

DFPP and DFPW had similar optimum dosage to remove TDS in leachate. By using both coagulants, the increase in dosage directly increase treatment efficiency. Based on Figure 4.2, 90 mg/L of DFPP showed the optimum removal efficiency of 65% for TDS. While 90 mg/L of DFPW contributed to 69% of TDS removal percentage.

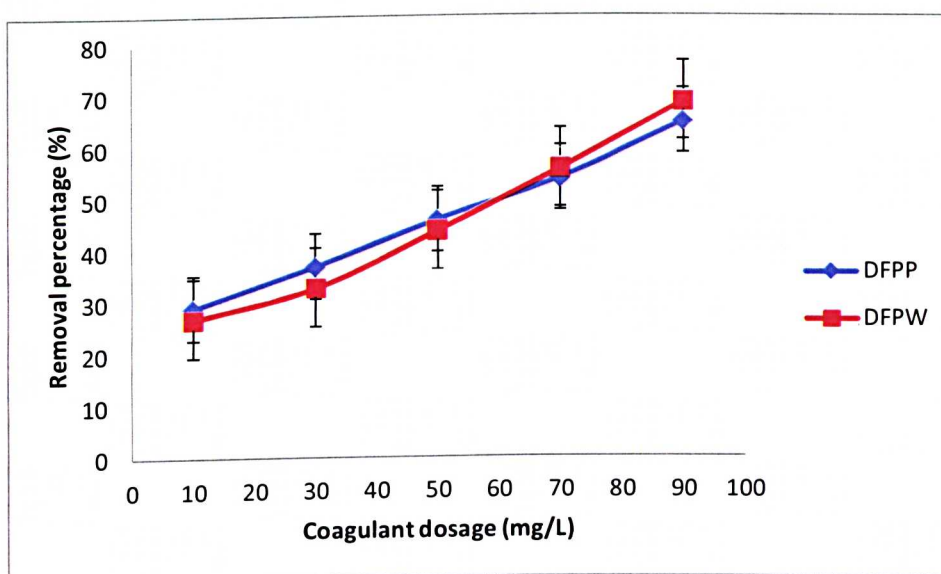
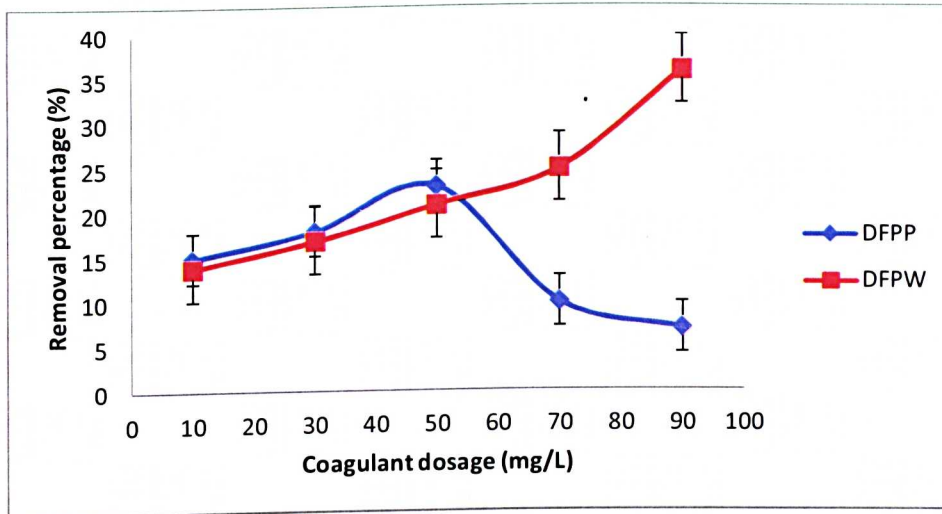


Figure 4.2: Removal percentage of TDS by DFPP & DFPW

#### 4.2.3 Removal of TSS

DFPP and DFPW had different optimum dosage to remove TSS in leachate. Figure 4.3 shows that 23% of TSS was removed optimally at 50 mg/L of DFPP. A further increase above this dosage resulted in the decreased of TSS removal percentage to 10% (70 mg/L) and 7% (90 mg/L). The optimum dosage for TSS removal by DFPW was 90

mg/L where 36% of TSS was removed. There is an increase of 13% TSS removal percentage by DFPW compared to DFPP.



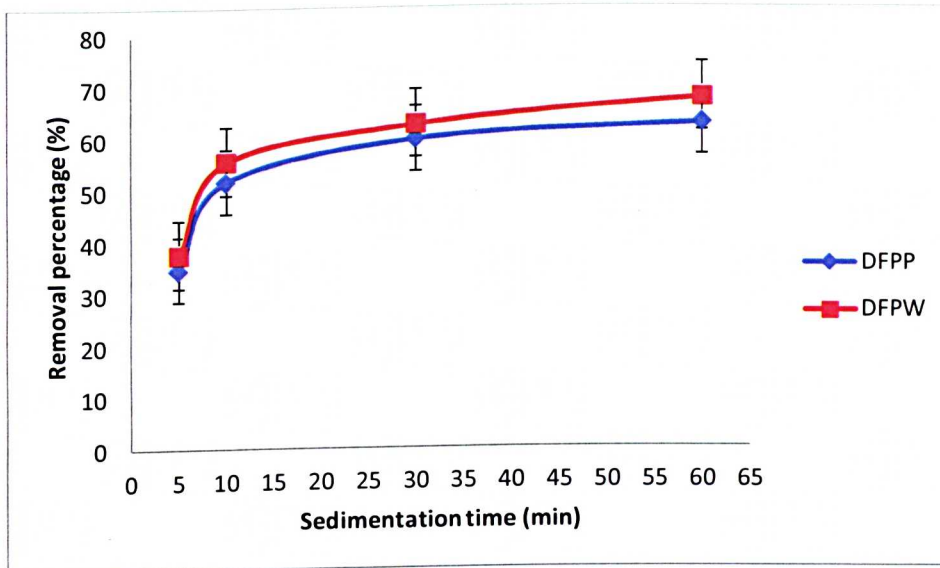
**Figure 4.3: Removal percentage of TSS by DFPP & DFPW**

### 4.3 To measure the removal percentage of turbidity, TDS and TSS by DFP coagulants with different sedimentation time

#### 4.3.1 Removal of turbidity

Based on Figure 4.4 which represent the removal percentage of turbidity by DFPP and DFPW, increases in sedimentation time do lead to higher removal percentage of turbidity. DFPP showed gradual increase of turbidity removal percentage from 35% (5 min), 52% (10 min), 60% (30 min), and to 63% (60 min). Similarly, DFPW also display an increasing pattern of turbidity removal percentage from 38% (5min), 56% (10 min), 63% (30 min), and to 68% (60min). When the sedimentation time provided is 10 minute,

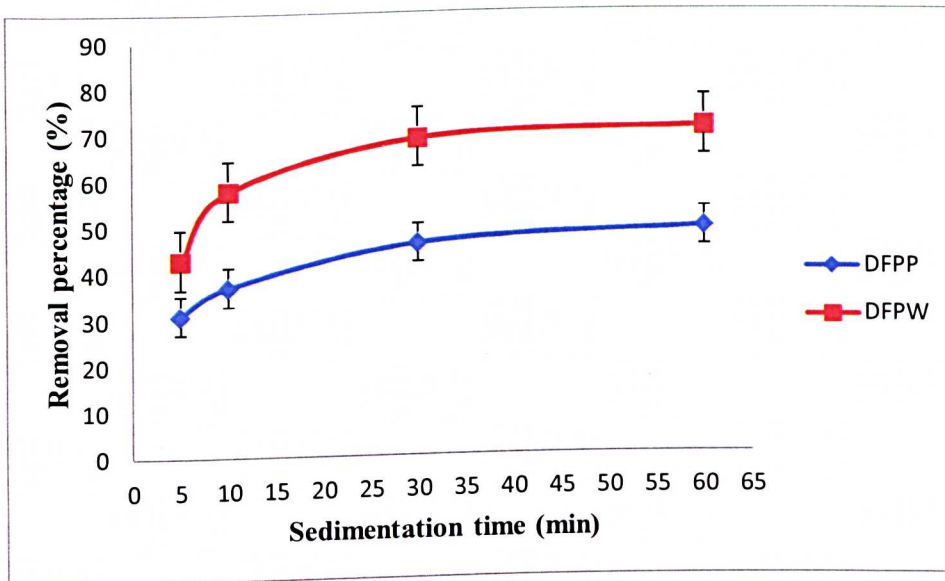
DFPW able to remove turbidity 3% more than DFPP, while after 60 minute, DFPW able to remove turbidity 8% more than DFPP.



**Figure 4.4: Removal percentage of turbidity by DFPP & DFPW**

#### 4.3.2 Removal of TDS

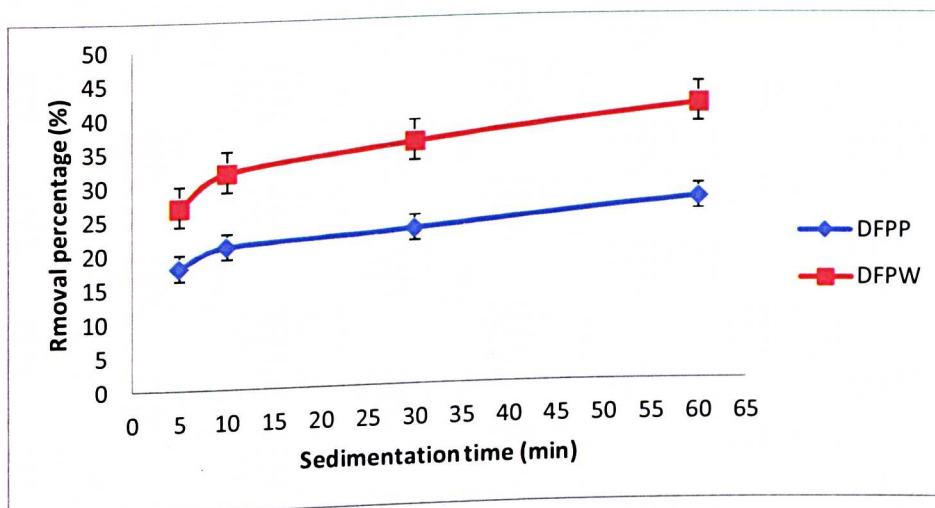
Based on Figure 4.5, increases in sedimentation time do lead to higher removal percentage of TDS by both coagulants. DFPP showed gradual increase of TDS removal percentage from 31% (5min) to 49% (60min). In contrast, DFPW display an increasing pattern of TDS removal percentage from 43% (5min) to 71% (60min). DFPW contribute to higher TDS removal percentage at 10min which was 58% compared to DFPP where the removal percentage was 37% at 10min.



**Figure 4.5: Removal of TDS by DFPP & DFPW**

#### 4.3.3 Removal of TSS

Removal percentage of TSS by DFPP and DFPW increases when the sedimentation time increases, as shown by Figure 4.6. DFPP showed gradual increase of TSS removal percentage from 18% (5min) to 27% (60min) while DFPW display an increasing pattern of TDS removal percentage from 27% (5min) to 41% (60min). DFPW (32%) contribute to 11% higher TSS removal percentage after 10 minute compared to DFPP (21%).



**Figure 4.6: Removal percentage of TSS by DFPP & DFPW**

**4.4 To compare the level of turbidity, TDS and TSS before and after treatment with DFP coagulants.**

There were significant differences between turbidity, TDS and TSS level before and after the treatment with DFP coagulants as shown in Table 4.2. Based on the results, after level for turbidity is lower after addition of DFPP ( $165.00 \pm 33.53$ ) compared to DFPW ( $176.60 \pm 51.69$ ). The after level for TDS also lower after addition of DFPP ( $7943.20 \pm 2066.33$ ) compared to DFPW ( $8001.60 \pm 2503.69$ ). In contrast, after level of TSS is lower after the addition of DFPW ( $151.20 \pm 16.78$ ) compared to DFPP ( $166.00 \pm 12.69$ ). Results indicated that both DFP coagulants have coagulant capabilities but DFPP were better in removing turbidity and TDS compared to DFPW. Yet, in terms of TSS removal, DFPW was a better coagulant than DFPP.

**Table 4.2: Comparison of parameters level before and after addition of coagulants**

| Parameters      | Coagulants | Before (Mean $\pm$ SD) | After (Mean $\pm$ SD) | t-test | p-value |
|-----------------|------------|------------------------|-----------------------|--------|---------|
| Turbidity (NTU) | DFPP       | 322.75 $\pm$ 3.89      | 165.00 $\pm$ 33.53    | 10.521 | <0.001* |
|                 | DFPW       |                        | 176.60 $\pm$ 51.69    | 6.248  | <0.001* |
| TDS (mg/L)      | DFPP       | 14750.00 $\pm$ 353.55  | 7943.20 $\pm$ 2066.33 | -8.246 | 0.001*  |
|                 | DFPW       |                        | 8001.60 $\pm$ 2503.69 | -6.858 | 0.002*  |
| TSS (mg/L)      | DFPP       | 194.95 $\pm$ 6.01      | 166.00 $\pm$ 12.69    | 27.624 | <0.001* |
|                 | DFPW       |                        | 151.20 $\pm$ 16.78    | 22.855 | <0.001* |

\*significant difference ( $p < 0.05$ )

#### **4.5 To compare the removal percentage of turbidity, TDS and TSS between DFPP & DFPW coagulants.**

There is no significant difference of coagulant capability to remove turbidity from raw leachate between DFPP (48.80  $\pm$  10.29) and DFPW (45.20  $\pm$  16.18), ( $p = 0.686$ ) as shown in Table 4.3. On average, DFPP was able to remove turbidity at similar rate with DFPW. Similar results were observed for TDS ( $p = 0.969$ ). DFPW remove TDS only 0.4% lower compared to DFPP. In terms of TSS removal, results indicated that there is no significant difference in coagulant capability for TSS removal between DFPP (14.60  $\pm$  6.35 mg/L) and DFPW (22.60  $\pm$  8.56 mg/L), at  $p = 0.132$ . Yet, in the removal of TSS, DFPW was capable to remove TSS 8% higher than DFPP. For DFPP, between turbidity and TDS, DFPP was better in removing turbidity (48.80  $\pm$  10.28), ( $p = < 0.001$ ) than TDS (46.20  $\pm$  14.10), ( $p = 0.002$ ).

**Table 4.3: Comparison of parameters removal percentage between DFPP and DFPW**

| Parameters | Coagulants | Parameters Removal Percentage (Mean $\pm$ SD) | t-test | p value |
|------------|------------|---|--------|---------|
| Turbidity  | DFPP       | 48.80 $\pm$ 10.28                             | -0.420 | 0.686   |
|            | DFPW       | 45.20 $\pm$ 16.18                             |        |         |
| TDS        | DFPP       | 46.20 $\pm$ 14.10                             | -0.40  | 0.969   |
|            | DFPW       | 45.80 $\pm$ 17.05                             |        |         |
| TSS        | DFPP       | 14.60 $\pm$ 6.35                              | 1.678  | 0.132   |
|            | DFPW       | 22.60 $\pm$ 8.56                              |        |         |

**4.6 To study the correlation between dosage of DFP and sedimentation time, with the removal percentage of turbidity, TDS and TSS from landfill leachate**

Table 4.4 shows the correlation between DFPP coagulant dosage and sedimentation time, with the removal percentage of turbidity, TDS and TSS from landfill leachate. Based on the results, DFPP dosage and TDS removal percentage have a statistically significant linear relationship ( $r = .998$ ,  $n=5$ ,  $p < .01$ ) with a strong positive correlation. This indicates that increase amount of DFPP coagulant lead to higher removal percentage of TDS. TSS removal by DFPP also have significant linear relationship with sedimentation time ( $r = .969$ ,  $n =4$ ,  $p <.05$ ). It is a weak positive correlation which indicates that increase in sedimentation time does have small effect on the increase of TSS removal percentage by DFPP. Analysis of result shows that there is no significant correlation between turbidity removal by DFPP with coagulant dosage ( $r = -.477$ ,  $n =5$ ,

$p = .417$ ) and sedimentation time ( $r = .811, n = 4, p = .189$ ). Analysis showed that DFPW dosage with turbidity ( $r = .997, n = 5, p < .01$ ), TDS ( $r = .992, n = 5, p < .001$ ) and TSS ( $r = .960, n = 5, p < .009$ ) removal percentage have a statistically significant linear relationship with strong positive correlations. This indicates that increase amount of DFPW coagulant dosage lead to higher removal percentage of turbidity, TDS and TSS. For sedimentation time, it only has significant linear relationship with TSS removal by DFPW ( $r = .955, n = 4, p = .45$ ). It is a weak positive correlation which indicates that increase in sedimentation time does have small effect on the increase of TSS removal percentage by DFPW. Analysis of result shows that there is no significant correlation between turbidity removal ( $r = .828, n = 4, p = .172$ ) and TDS removal ( $r = .831, n = 4, p = .169$ ) by DFPW with sedimentation time.

**Table 4.4 Correlation between dosage of DFPP & DFPW and sedimentation time, with the removal percentage of turbidity, TDS and TSS**

| Coagulants | Parameters          |                     | Coagulant dosage | Sedimentation time |
|------------|---------------------|---------------------|------------------|--------------------|
| DFPP       | Turbidity % removal | Pearson Correlation | -.477            | .811               |
|            |                     | Sig. (2-tailed)     | .417             | .189               |
|            | TDS % removal       | Pearson Correlation | .998**           | .915               |
|            |                     | Sig. (2-tailed)     | <.001            | .085               |
|            | TSS % removal       | Pearson Correlation | -.598            | .969*              |
|            |                     | Sig. (2-tailed)     | .287             | .031               |
| DFPW       | Turbidity % removal | Pearson Correlation | .997**           | .828               |
|            |                     | Sig. (2-tailed)     | <.001            | .172               |
|            | TDS % removal       | Pearson Correlation | .992**           | .831               |
|            |                     | Sig. (2-tailed)     | .001             | .169               |
|            | TSS % removal       | Pearson Correlation | .960**           | .955*              |
|            |                     | Sig. (2-tailed)     | .009             | .045               |

\*\* Correlation is significant at the 0.01 level (2-tailed)

\* Correlation is significant at the 0.05 level (2-tailed)

#### 4.7 Discussion on findings

The optimum turbidity removal by DFPP in this study was obtained at 60% with 50 mg/L of DFPP coagulant. The removal was decreased with the increased coagulant 70 mg/L (50%) and 90 mg/L (33%). The optimum dosage for turbidity removal by DFPW was obtained at 90 mg/L with 67% of turbidity removal.

This was consistent with the results from previous study. For example, DFP foliage was observed to remove turbidity up to more than 95% when the dose range were 200-800 mg/L (Idris et al., 2013). Another research on *Moringa oleifera* used as coagulant, 94% of turbidity removal was obtained at the dosage of 400 mg/L (Sarpong & Richardson, 2010).

When the colloidal particles in a solution which now refers to the leachate carry electrical charges on their surface which are normally negative charges, this stable system of colloid should be un-stabilized by the application of coagulants (Mahvi & Razavi, 2005) with the opposite charge. The colloids present in foliage of *H. undatus* (DFPW) are cationic which is similar to the seeds of *M. oleifera* (as DFPP also belong to the same family of fruit which are dragon fruits, therefore it is estimated to have similar properties). Thus, adsorption and charge neutralization have been proposed as the possible coagulation mechanism leading to formation of flocs (Choy et al., 2014; Idris et al., 2013). Charge neutralization occurs by direct reduction of net charge to zero upon addition of a coagulant or flocculants of opposite charge and can result in charge reversal if an overdose occurs.

Turbidity removal percentage by DFPP decreased after optimal 50 mg/L was due to overdosing where further addition of coagulant dosage now reverses and increases the charge of the suspended solids and therefore re-stabilizes these particles in the water (López-maldonado, Oropeza-guzmán, & Ochoa-terán, 2014). Previous research also state that large doses will eventually lead to overdosing result in the saturation of the polymer bridge sites. This resulted in the re-stabilization of the destabilized particles due

to insufficient number of particles to form more inter-particle bridges (Suleyman A Muyibi & Evison, 1995).

Analysis for TDS showed that 90 mg/L of DFPP optimally removed 65% of TDS, while 90 mg/L of DFPW contributed to 69% of TDS removal percentage. TDS is the total amount of mobile charged ions, including minerals, salts or metals (colloidal form) dissolved in a given volume of water (mg/L) which simply includes anything present in water other than the pure water molecule and suspended solids (Vuppaladadiyam, Sowmya, & Dasgupta, 2013).

Fruit waste composed of natural polymers such as polysaccharides and proteins. Example of polysaccharide is galacturonic acid which is a component in dragon fruit peel (Ridley et al., 2001). No overdosing occurred may be due to high concentration of TDS in raw leachate sample. Thus, the active sites available at polymeric chain were used optimally. The longer polymeric chain would be advantageous for coagulation as the number of active sites available for particle adsorption will be increased (Choy et al., 2014).

Removal of TDS should be taken into consideration as high TDS concentration have the capability to alter the physical and chemical characteristics of the receiving water (Al-Yaqout & Hamoda, 2003). Research done by Aziz, Umar, & Yusoff, (2010) support above statement as they indicated that the increase in salinity due to increase in TDS concentration also increases toxicity by changing the ionic composition of water.

Results showed that 23% of TSS was removed optimally at 50 mg/L of DFPP. A further increase above this dosage resulted in the decreased of TSS removal percentage to 10%

(70 mg/L) and 7% (90 mg/L). The optimum dosage for TSS removal by DFPW was 90 mg/L where 36% of TSS was removed.

When addition of DFPP coagulant increased above 50 mg/L, there is decrease in TSS removal percentage as this showed the effects of overdosing where the polyelectrolyte in excess causes the adsorption of polyelectrolyte chains onto the stable particles in suspension, having an adverse effect on water quality (López-maldonado et al., 2014).

There is possibility that if the coagulant dosage of DFPW was increased above 90 mg/L in future research, optimum dosage may increase. This is due to the results obtained in research done using DFP foliage which shown TSS removal up to more than 60% when the dose used were 500 mg/L (Idris et al., 2013).

In this study, DFPP showed gradual increase of turbidity removal percentage from 35% (5 min) to 63% (60 min). Similar trend was observed for DFPW 38% in 5min to 68% in 60min.

Material in wastewater carries negative charge and the electrostatic repulsive forces prevent the particles to get together and thus the solution is stable and need longer time to sediment. Research done by Guibai & Ry (1991) state that high-turbidity waters, containing up to a few percent of suspended solids, occur quite widely and present considerable treatment problems, especially because of low sedimentation rates. Another research propose that the turbidity of raw water is one of the target substances to be removed during coagulation sedimentation (Annadurai, Sung, & Lee, 2003). Coagulation and flocculation are one of the most widely adopted techniques to improve the esthetic appearance of turbid water due to its simplicity and effectiveness. This

technique results in the destabilization of colloidal particles and subsequently, the increment in particle size for the ease of sedimentation (Choy et al., 2014).

To reduce the sedimentation time, destabilization is required and this is the main role of coagulants through mechanism such as adsorption and charge neutralization, subsequently then flocculation promotes the aggregation and flocs formation (Tzoupanos & Zouboulis, 2008).

DFPP showed gradual increase of TDS removal percentage slightly lower compared to DFPW. This is possibly due to sedimentation that may take longer time as electrostatic repulsive forces keep on preventing the material in wastewater that mostly carries negative charge from approaching each other. Thus, in order to reduce the sedimentation time, coagulants have a vital role to destabilize the particles through mechanism such as adsorption and charge neutralization, subsequently then flocculation promotes the aggregation and flocs formation (Tzoupanos & Zouboulis, 2008). Another research by Mahvi & Razavi, (2005) also indicated similar process explanation where this stable system of colloid particles in a solution that carry electrical charges on their surface which are normally negative charges, should be un-stabilized by the application of coagulants.

Results in this study also showed that DFPW removal of TSS was slightly better compared to DFPP. The process of decreasing or neutralizing the electric charge on suspended particles is known as coagulation. Similar electric charges on small particles in water cause the particles to naturally repel each other and hold the small, colloidal particles apart and keep them in suspension thus, the coagulation/flocculation process

neutralizes or reduces the negative charge on the particles (Ebeling, Sibrell, Ogden, & Summerfelt, 2003). This allows initial aggregation of colloidal and fine suspended materials to form micro floc through the van der Waals force of attraction encouragement where flocculation is the process of bringing together the micro floc particles to form large agglomerations by physically mixing or through the binding action of flocculants, such as long chain polymers (Ebeling et al., 2003).

## CHAPTER 5

### CONCLUSION, LIMITATION & RECOMMENDATION

#### 5.1 Conclusion

Based on this study, it can be concluded that dragon fruit peel has potential to be used as natural coagulant for leachate treatment. The initial level of TSS is above the EQA standard of 50 mg/L. DFPP was able to remove 60% of turbidity and 23% of TSS at an optimum dosage of 50 mg/L. In terms of TDS removal efficiency, 65% was able to be removed from raw leachate by using 90 mg/L of DFPP.

As the sedimentation time increases, the removal percentage also increased for all three parameters. Results indicated that both DFP coagulants have coagulant capabilities but DFPP were better in removing turbidity and TDS compared to DFPW. In terms of TSS removal, DFPW was a better coagulant than DFPP. For DFPP, between turbidity and TDS, DFPP was better in removing turbidity than TDS. DFPP dosage and TDS removal percentage have a statistically significant positive correlation. No significant correlation between turbidity removal by DFPP with coagulant dosage and sedimentation time. Based on the results, DFPW dosage has a statistically significant linear relationship with turbidity, TDS and TSS removal. There is no significant correlation between turbidity and TDS by DFPW with sedimentation time. Dragon fruit peel has high potential and bright future to act as coagulant in large scale application in leachate treatment.

## **5.2 Limitation of study**

The exact composition of both dragon fruit was unknown and variability of pH was not tested for optimization of removal efficiency of parameters measured, were due to time constrain. The average of the duplicate determinations is accurate, but each individual determination may vary slightly from the true value. Last but not least, this study only assessed three parameters which were turbidity, TDS and TSS while there are many other constituents of leachate. This study did not observe more components, even though such measurements might be valuable, in order to allow more depth of understanding regarding the three parameters selected.

## **5.3 Recommendation**

Further studies should be conducted to measure the exact composition of DFP in order to understand the mechanism and characterization of dragon fruit peel so that it can be used optimally for larger scale treatment of leachate and other type of wastewater.

Physicochemical parameter of pH manipulation and optimization is recommended for future study in order to determine if there is any relationship between pH and optimum dosage along with the removal efficiency of parameters by using dragon fruit peel.

Research in future can also be done to evaluate the efficiency of dragon fruit peel in the removal of other constituents from landfill leachate.

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## APPENDICES

### APPENDIX 1: EXPERIMENTATION PICTURES



**Figure A1: DFPP**



**Figure A2: DFPW**



**Figure A3: Parameters measurement**



**Figure A4: Pure and diluted leachate**

## APPENDIX 2: RAW DATA TABULATION

**Table A2.1: Initial reading of parameters**

| Parameters | 1 <sup>st</sup> Reading | 2 <sup>nd</sup> Reading | Average |
|------------|-------------------------|-------------------------|---------|
| pH         | 7.3                     | 7.5                     | 7.4     |
| Turbidity  | 320.00*                 | 325.50*                 | 322.75  |
| TDS        | 14500*                  | 15000*                  | 14750   |
| TSS        | 190.70                  | 199.20                  | 194.95  |

\*dilution factor (50)

**Table A2.2: Average final reading of parameters (different coagulation dosage of DFPP)**

| Dosage<br>(mg/L) | Parameters |           |          |           |        |           |
|------------------|------------|-----------|----------|-----------|--------|-----------|
|                  | Turbidity  |           | TDS      |           | TSS    |           |
|                  | NTU        | % removed | mg/L     | % removed | mg/L   | % removed |
| 10               | 174.00     | 46.00     | 10472.00 | 29.00     | 166.00 | 15.00     |
| 30               | 146.00     | 55.00     | 9292.00  | 37.00     | 159.00 | 18.00     |
| 50               | 127.00     | 60.00     | 7966.00  | 46.00     | 149.00 | 23.00     |
| 70               | 162.00     | 50.00     | 6786.00  | 54.00     | 175.00 | 10.00     |
| 90               | 216.00     | 33.00     | 5200.00  | 65.00     | 181.00 | 7.00      |

Table A2.3: Average final reading of parameters (different coagulation dosage of DFPW)

| Dosage<br>(mg/L) | Parameters |           |          |           |        |           |
|------------------|------------|-----------|----------|-----------|--------|-----------|
|                  | Turbidity  |           | TDS      |           | TSS    |           |
|                  | NTU        | % removed | mg/L     | % removed | mg/L   | % removed |
| 10               | 238.00     | 26.00     | 10768.00 | 27.00     | 168.00 | 14.00     |
| 30               | 212.00     | 34.00     | 9880.00  | 33.00     | 162.00 | 17.00     |
| 50               | 178.00     | 45.00     | 8260.00  | 44.00     | 155.00 | 21.00     |
| 70               | 148.00     | 54.00     | 6500.00  | 56.00     | 146.00 | 25.00     |
| 90               | 107.00     | 67.00     | 4600.00  | 69.00     | 125.00 | 36.00     |

Table A2.4: Average final reading of parameters (different sedimentation time using optimum dosage of DFPP)

| Sedimentation time (min) | Parameters |           |          |           |        |           |
|--------------------------|------------|-----------|----------|-----------|--------|-----------|
|                          | Turbidity  |           | TDS      |           | TSS    |           |
|                          | NTU        | % removed | mg/L     | % removed | mg/L   | % removed |
| 5                        | 210.00     | 35.00     | 10164.00 | 31.00     | 160.00 | 18.00     |
| 10                       | 154.00     | 52.00     | 9304.00  | 37.00     | 158.00 | 21.00     |
| 30                       | 128.00     | 60.00     | 7966.00  | 46.00     | 148.00 | 23.00     |
| 60                       | 118.00     | 63.00     | 7578.00  | 49.00     | 141.00 | 27.00     |

Table A2.5: Average final reading of parameters (different sedimentation time using optimum dosage of DFPW)

| Sedimentation time (min) | Parameters |           |         |           |        |           |
|--------------------------|------------|-----------|---------|-----------|--------|-----------|
|                          | Turbidity  |           | TDS     |           | TSS    |           |
|                          | NTU        | % removed | mg/L    | % removed | mg/L   | % removed |
| 5                        | 200.00     | 38.00     | 8406.00 | 43.00     | 143.00 | 27.00     |
| 10                       | 142.00     | 56.00     | 6200.00 | 58.00     | 133.00 | 32.00     |
| 30                       | 121.00     | 63.00     | 4600.00 | 69.00     | 125.00 | 36.00     |
| 60                       | 104.00     | 68.00     | 4270.00 | 71.00     | 114.00 | 41.00     |