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THE POTENTIAL OF FRUIT SEED AS NATURAL COAGULANT IN TURBIDITY REMOVAL OF WATER

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BY

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ABSTRACT

THE POTENTIAL OF FRUIT SEED AS NATURAL COAGULANT IN TURBIDITY REMOVAL OF WATER.

MUHAMMAD IMRAN BIN SHAMSUDIN

Introduction: Clean water is very essential to human to live but to obtained clean safe water must undergo treatment or purification before consumption. Therefore, the widely use of alum as chemical coagulant has been the most popular for treatment of water in treatment plants but it can cause problem health, environmental problem and costly. Therefore, the alternative use by using fruits seed as natural coagulant in the reduction of turbidity of water been used as it is safe for human health, easy to obtain and cheap. **Objective:** To determine the effectiveness of fruit seed as natural coagulant in turbidity removal and the best fruit seeds with the optimum concentration dosage in turbidity removal using turbid water and time needed to remove turbidity using field sample. **Methodology:** This experimental study was conducted by using 5 fruits which are (Durian, Tarap, Cat's eye, Date and Jackfruit) seed extracts and artificial coagulant (alum) by using artificial kaolin water. Stock solutions of these coagulants were prepared, and jar test of their varying mixing ratios used to obtain optimum mass by using range from 1g ,2g and 3g and optimum dosages of 50, 100, 150 and 200 mg/l for fruit extract and alum respectively. The effects of these optimum dosages were tested against turbidity, pH, and temperature. **Result**: The use of date seed extract of 3g at 200 mg/l dosages showed the overall best result among other fruits extract with the resultant water fit with the WHO standard for drinking water (<5 NTU) by let it sediment for 24 hours by using kaolin water initial at 120 NTU but took longer more than 94-hour to reduce turbidity using field sample. Therefore, the exploitation of naturally available resources into water treatment in this research had shed some lights in the discovery of efficient, biodegradable and green flocculants as potential replacement to conventional synthetic chemical coagulants in reducing water turbidity.

Keywords: *Fruit Seed, Natural Coagulants, Alum, Turbidity Removal, WHO Standard for Drinking Water*

ABSTRAK

POTENSI BIJI BUAH-BUAHAN SEBAGAI KOAGULAN SEMULA JADI UNTUK PENGURANGAN KEKERUHAN AIR

MUHAMMAD IMRAN BIN SHAMSUDIN

Pengenalan: Air bersih sangat penting untuk kehidupan manusia tetapi untuk memperoleh air yang bersih mesti menjalani rawatan atau pembersihan sebelum digunakan. Oleh itu, penggunaan alum secara meluas sebagai koagulan kimia telah menjadi popular digunakan untuk rawatan air tetapi ia boleh menyebabkan masalah kesihatan, masalah alam sekitar dan kos yang mahal. Oleh itu, penggunaan alternatif dengan menggunakan biji buah sebagai koagulan semula jadi dalam pengurangan kekeruhan air digunakan kerana ia selamat untuk kesihatan manusia, mudah diperoleh dan harga yang murah. **Objektif:** Untuk menentukan keberkesanan biji buah sebagai koagulan semulajadi dalam penyingkiran kekeruhan dan menentukan biji buah yang terbaik dengan dos konsentrasi yang optimum dalam penyingkiran kekeruhan dengan menggunakan air kaolin tiruan dan masa yang diperlukan untuk penyingkiran kekeruhan menggunakan sampel sedia ada. **Kaedah:** Kajian eksperimen ini dijalankan dengan menggunakan 5 biji buah iaitu ekstrak biji Durian, Tarap, Kucing, Mata kucing dan Buah Nangka dan koagulan kimia (alum) dengan menggunakan air kaolin buatan. Penyediaan stok daripada koagulan ini disediakan, dan ujian balang dijalankan dengan menggunakan pelbagai nisbah yang berbeza-beza untuk mendapatkan optimum jisim dari 1g, 2g dan 3g dan dos dari 50, 100, 150 dan 200 mg/l untuk ekstrak biji buah dan alum. Kesan dos yang optimum ini diuji terhadap kekeruhan, pH, dan suhu. **Keputusan:** Penggunaan ekstrak biji kurma yang berjisim 3g dan dos 200 mg/l menunjukkan hasil terbaik keseluruhan antara ekstrak biji buah-buahan lain dan hasil pengurangan kekeruhan air yang sesuai dengan standard WHO untuk air minuman (<5 NTU) dengan membiarkan sedimen selama 24 jam dengan menggunakan air kaolin buatan yang kekeruhan awal di tahap 120 NTU tetapi mengambil masa lebih daripada 94 jam untuk mengurangkan kekeruhan menggunakan sampel sedia ada. Oleh itu, pengeksploitasian sumber semula jadi ke dalam rawatan air dalam kajian ini telah menghasilkan beberapa penemuan bahawa penggunaan koagulan semulajadi yang berhasil, biodegradasi dan hijau berpotensi sebagai pengganti koagulan kimia dalam mengurangkan kekeruhan air.

Kata Kunci: *Biji Buah, Koagulan Semula Jadi, Alum, Penyingkiran Kekeruhan, Standard WHO Untuk Air Minuman*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

Alum	Aluminum Sulphate
BOD	Biological Oxygen Demand
FAO	Food and Agricultural organization
g	Gram
L	Litre
mg/L	Milligram per liter
ml	Milliliters
NaCl	Sodium Chloride
NSDWQ	National standard for Drinking Water Quality
NTU	Nephelometric Turbidity Unit
SPSS	Statistical Package for Social Sciences
UPM	University Putra Malaysia
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Research Background

Water is essential to human, animal and plant to survive. The needed of water for cells, organs and tissue to function properly and for regulating body temperature (Mcintosh, 2016). Access of clean water is fundamental requirement as it plays an important role to human for drinking, coo1king and washing (Scott, 2017). Often, we will face many problems with water supply especially during flood events that occur annually in Malaysia. Flood event can cause rivers and streams become so murky and cloudy due to presence of high sediment and suspended solid contents. This event causes the disruption of access to clean water resources as it deteriorated the water quality (Rahman et al., 2018) Therefore, it is important to treat the water in varying forms of treatment or purification before can be used for consumption daily activities to ensure the water quality is within the world health organization standard (WHO, 2017). The turbidity is one of the important characteristic of drinking water quality.

Turbidity is measured by the intensity of light scattered by the water sample which is particles suspended in water and lead to the cloudiness of a solution. The turbid water in form of shady appearances as dirty sediment and indicates the presence of TSS (Total Suspended Solids) like silt, clay, organic matter which are very harmful for mankind and biologically The characteristic of turbidity in water

sample give an undesirable tastes and odours. Therefore, the removal of turbidity of water in form of suspended of colloidal material can be achieved by coagulation and flocculation process (Yang et al., 2014).

Before water distribute to the consumer, raw water must be through the following conventional procedures such as screening, plain sedimentation, coagulation-flocculation followed by sedimentation, filtration and disinfection (Ndabigengesere & Narasiah, 1998). Therefore, the important of coagulant is needed in the reduction of water turbidity and other contaminants. Coagulants can be divided into two which are artificial and natural coagulants. Artificial coagulants are widely used in water treatment such as aluminum sulphate (alum), ferric sulphate, ferrous sulphate, ferric chloride and ferric chloride sulphate. While the use of natural coagulant from the extract of plant origin, animal and microorganism such as Moringa oleifera seeds, Nirmali seeds, fava beans, Dolichos lab lab plant and others (Kawamura, 1991).

Alum (Aluminum sulphate) is s chemical compound that formed from the interaction of alkali metals (ammonia, sodium or potassium) that react with the trivalent metals (aluminium, chromium or iron). Several minerals have been used to produce alum which can be found in bauxite, alunite, cryolite and alum schist. Alum can be found in form of white crystalline solid and powder (Helmenstine, 2017). The particular properties of alum that easily dissolved in water, resulting acidic solution and slightly sweet taste. There are several types of alum which are potassium alum, ammonium alum, selenite alum, soda alum, and aluminum sulfate. Alum is the most popular and widely used in water treatment due to its effectiveness in turbidity removal of water (Bora, 2010). However, it has been found to pose serious health

effect such as Alzheimer's disease, economic and environment problems due to production of sludge that are voluminous and non-biodegradable. Besides that, the extra cost on addition of lime as to buffer its effect are needed in water treatment due to lower pH of the treated water (Muyibi, 2005).

The use of natural coagulants has been practiced for more than 2000 years especially in India, China, and Africa in water purification. They may originate from plant seeds, leaves, and roots (Kawamura, 1991). For example, *Moringa oleifera, Cicer arietinum* and *Dolichos lab* seed act as natural coagulants that had been used in turbidity removal (Asrafuzzaman et. al., 2011). Besides, there is no adverse effect to human health while the cost of these natural coagulants would be less expensive than conventional chemicals as they are easily obtained as it is abundance and they are biodegradable nature of sludge produce in water purification. Therefore, there seems to be renewed interest in applying natural coagulants for water treatment in emerging economies to replace the use of chemical coagulants (Nilanjana, 2005).

1.2 Problem Statement

The widely used alum as a coagulant in water treatment may cause many disadvantage to human health and environment. Recent studies pointed out several serious health problems using alum such as Alzheimer's disease due to residual of aluminums in treated water (Flaten, 2001; Jodi et al., 2012). Exposure to high concentrations of alum in drinking water also can lead to serious health effects such as damage to the central nervous system, loss of memory, dementia and severe trembling (Lenntech, 2015). Besides that, the high cost to achieving the desired water

quality standard depend primarily on the cost and availability of the product as the product are often expensive and have to be imported. There is also the problem on pH of the treated water thus extra cost on lime are needed to buffer its effect and it has low efficiency in the coagulation of cold water (Muyibi, 2005). The production of sludge that are voluminous and non-biodegradable may lead to secondary environmental contamination problems. Therefore, the use of alum is still applied worldwide as chemical coagulants in water treatment and there is not much research that has been done regarding the use of fruit seeds in Malaysia in turbidity removal.

1.3 Research Question

1.3.1 Are fruit seeds an effective as natural coagulant in reducing turbidity of water?

1.3.2 Which is the best fruit seed as natural coagulant can be effectively in turbidity removal?

1.3.3 Is the optimum mass dosage of best fruit seed as natural coagulants in turbid water in turbidity removal is within the standard by The National Standard for Drinking Water Quality (NSDWQ)?

1.3.4 What is the time required for turbidity removal using the optimum mass dosage of the best fruit seed as natural coagulant using field samples?

1.4 Study Justification

As there is less research conducted on the use of natural coagulant in treating the turbidity of water especially by using fruit seeds in Malaysia, this study is needed to reveal and evaluate the effectiveness of fruit seeds as natural coagulants in turbidity removal of water. This will help to add, widen and diverse the knowledge for the issue related the use of chemical coagulant such as alum in water treatment. As a result of this study, the potential of several fruit seeds in turbidity removal will be assessed. This will determine which is the best fruit seeds as natural coagulants with optimum mass dosage in turbidity removal. This is very important because optimal dosage is determined where it gives the least turbid water reduction with the lowest mass dosage. The use of optimum mass dosage of best fruit seeds will be tested and determine whether the turbidity removal is within the standard required by The National Standard for Drinking Water Quality (NSDWQ) and time required for turbidity removal using field samples. This study is relevant because the use of fruit seeds as natural coagulants could benefit in various ways such as the sludge produced is biodegradable, it is virtually toxin-free, abundant, cheap and easily to obtain (Victoria, 2010). This will surely give an idea and new pathway to other researcher to conduct further studies by using other fruits seeds in Malaysia as natural coagulants in turbidity removal.

1.5 Research Objectives

1.5.1 General Objective

1.5.1.1 To determine the effectiveness of fruit seeds as natural coagulant in turbidity removal in water.

1.5.2 Specific Objectives

1.5.2.1 To determine the best fruit seed as a natural coagulant in turbidity removal.

1.5.2.2 To determine the optimum mass dosage of the best fruit seed as a natural coagulant in turbid water in turbidity removal is within the standard by National Standard for Drinking Water Quality (NSDWQ)

1.5.2.3 To select the required time needed for turbidity removal using the optimum mass dosage of the best fruit seed as a natural coagulant using field samples.

1.6 Hypothesis

1.6.1 There is a significant difference in optimum mass dosage of natural coagulant in turbid water in turbidity removal

1.7 Definition of Terms

1.7.1 Conceptual Definition

Alum

Alum is any of various double salts isomorphs with potassium aluminum sulfate. They are colorless, odorless, and exist as a white crystalline powder. Alums are generally soluble in hot water, and they can be readily precipitated from aqueous solutions to form large octahedral crystals (Helmenstine, 2017). Most widely used of Alum is a potassium aluminium as it can absorb suspended particles from water and thus a useful flocculating agent in water-purification plants (Encyclopedia Britannica, 2018).

Natural coagulant

Natural coagulants are mainly composed of polymer of natural origin that been extracted from plants (seed leaves and roots), algae and animals that been used on treating wastewater. These natural coagulants have high effectiveness in turbidity removal as it safe, cheaper and environmental friendly in term of water treatment (Kawamura, 1991).

Synthetic Turbid Water

Synthetic turbid water by using kaolin formulated to resemble the drinking water in order to determine the effectiveness of coagulants to treat drinking water at specific turbidity level.

Turbidity removal

Turbidity removal in this study reflects the level of turbidity that can be removed using natural coagulants from fruit seeds and alum. Turbidity is a measure degree of the cloudiness of water which caused by the presence of suspended solids that are generally invisible to naked eye This measurement act as an important key test to determine the quality of water as higher turbidity of water will appear cloudy while water with very low turbidity will appear clearly (Ndabigengesere & Narasiah, 1998).

1.7.2 Operational Definition

Alum

In water treatment, the use of alum as chemical coagulant in turbidity removal. The dosage of alum by using 50, 100, 150 and 200mg/L been tested in this study by using 1g of alum diluted with 1L of distilled water. The sample will undergo the process of coagulant by using synthetic water and be measured using turbiditimeter to determine the turbidity level.

Natural coagulants

In this study, the natural coagulant that been used is fruit seeds and the sample chosen includes Malaysian local fruits which are Tarap seed, Durian seed, Cat's eye seed, Date seed and Jackfruit seed as natural coagulants for water treatment of turbidity removal.

Synthetic turbid water

Preparation of synthetic turbid water by using 10 g of kaolin in 1L distilled water and the supernatant suspension of synthetic turbid water was added to the sample water to achieve the desired turbidity of 120 NTU just before coagulation using natural coagulants and alum.

Turbidity removal

The sample will be measured the turbidity level by using turbiditimeter and expressed in nephelometric turbidity units (NTU). Every turbidity removal for each natural coagulant and alum will be recorded for each testing dosage and mass for before, during and after coagulation in jar test procedure.

1.8 Conceptual Framework

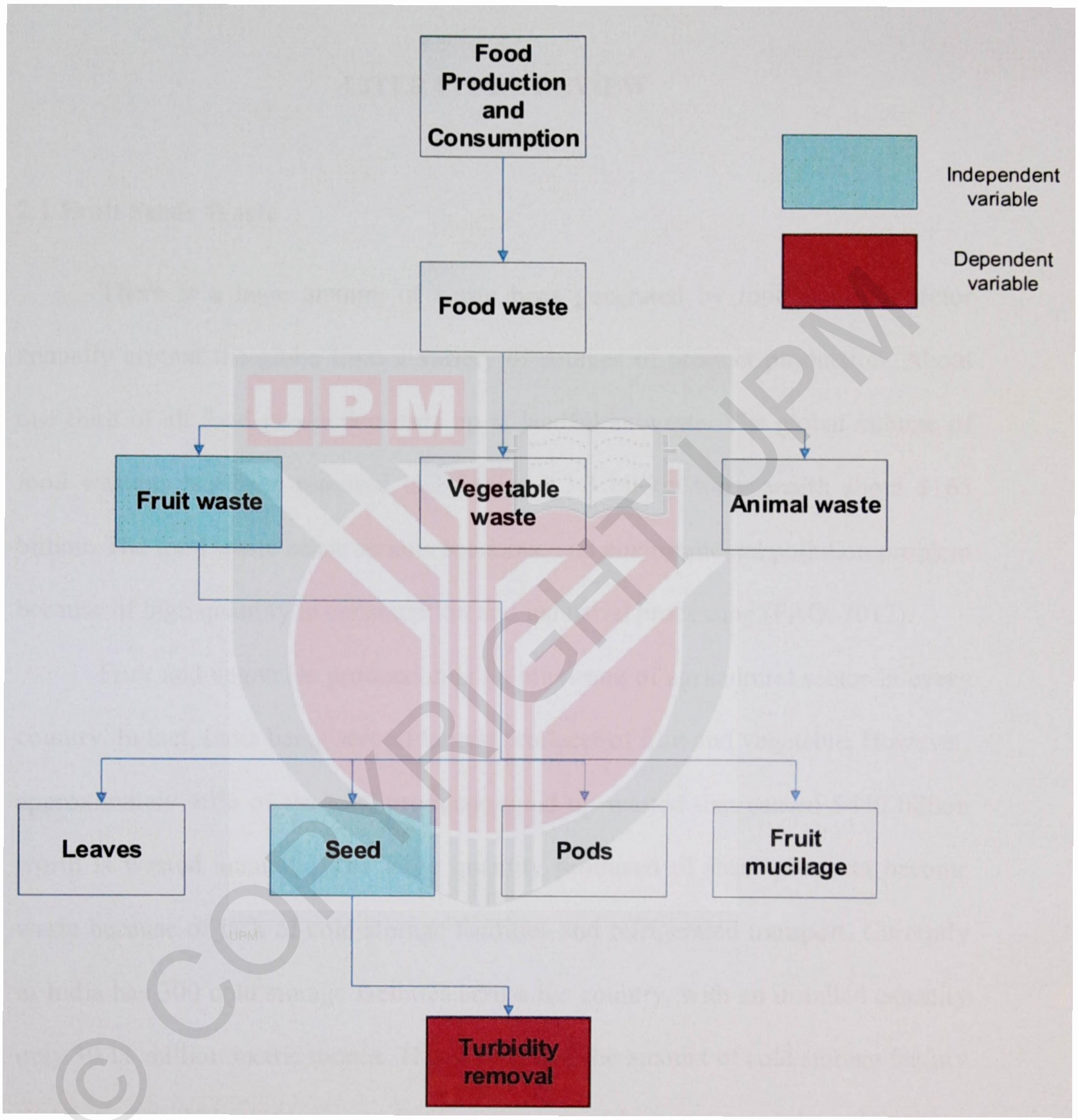


Figure 1: Conceptual framework of fruit seed as natural coagulant in turbidity removal of water.

`CHAPTER 2

LITERATURE REVIEW

2.1 Fruit Seeds Waste

There is a huge amount of waste been generated by food industry sector annually around the globe from a variety of sources of product production. About one third of all food production ends up at landfill as waste. The global volume of food wastage has been reported to be around 1.3 billion tones worth about $165 billion. The food waste cause serious economic and environmental pollution problem because of high quantity in consumption and industrial processing (FAO, 2012).

Fruit and vegetable production is an important of agricultural sector in every country. In fact, India being second largest producer of fruit and vegetable. However, approximately 40% of the total production end up wasted that caused $440 billion worth is wasted annually. The large quantity produced of these products become waste because of lack of cold storage facilities and refrigerated transport. Currently in India has 300 cold storage facilities across the country, with an installed capacity only 30.11 million metric tonnes. This is only half the amount of cold storage facility that India should have to prevent from excess loss of fruit waste and the cold storage should be installed capacity more than 61 million metric tonnes to prevent any loss of fruit (Jayashree Bhosale, 2013).

While in Malaysia, which is one of the country that having high population and fast economic growth due to production varieties of fruits and vegetable. Due to high consumption and industrial sector in processing of edible part of fruit include

peel and seed that been generated in high quantity. According to the statistic of Solid Waste Corporation of Malaysia (SWCorp) showed that in 2018, the disposal of food waste in Malaysia reached 3,000 metric tonnes daily that was still fit for consumption and the food waste recorded the total of 615,000 metric tonnes that should not have been discarded (Star Online, 2018). In addition, MARDI has conducted the research and showed that approximately 20 percent to 50 percent of food waste are come from fruits and vegetable. This shows that loss of half yield throughout the production of chain because of poor management and fail to follow the proper specification. In fact, the fruit seed waste in one of the main sources of municipal solid waste (MSW) and cause many environmental issue (Ibrahim et al., 2017).

2.2 Utilization of Fruit Seeds

Fruit seeds mainly content of high levels of protein, starch, calcium and thiamine. It also rich in energy, minerals, vitamin and dietary fiber and contains no cholesterol or saturated fats that making it a healthy fruit to savor (Burkill, 1997). The use of fruit seeds in many sectors and industry such as food, pharmaceutical and also cosmetic industry due to its content properties. One of the beneficial use of fruit seeds used as medicine. They can act as natural antioxidant that been used to reduce free radical damage to human such arthritis, ischemia, hemorrhagic shock and Parkinson diseases. The bioactive constituent that been found in fruit seeds that contain phenolic compounds and antioxidant properties (Ibrahim et al., 2017). The fruits contained of vitamin and minerals which are natural sources of antioxidant that responsible to give benefit to human health such as dates and grapes. According to Farzaei et al., (2013), the use of dates (*Phoenix dactylifera)* as wound healer via improvement of collagen function and also exhibited antioxidant properties in prevention of diseases capability.

Besides that, there are variety of food products made of from the fruit seeds such as flour that mainly been used in culinary operations. The utilization of fruit seeds such as jack fruit, potatoes, chest nut with the purpose in producing various flour for baked products of risen structure, and industrial product. The processing to make flour by ground and for baking process by blended it with wheat flour. For example, from jack fruit seeds (*Artocarpus integra*) and chest nut, due to its high carbohydrate content and other nutrients, they can be added to baked products for value addition without disrupting the functional properties of the final product (Ejiofor et al., 2014).

Lastly, fruit seeds also known as their beneficial content in industry sector such as cosmetic ingredient product by using Mango and Pineapples. Mango *(Mangifera indica Linn)* and pineapple (*Ananas comosus)* been used as a potential source for cosmetic product due the extract possessed effective tyrosinase inhibitory activity that can be use as whitening agent for cosmetic formulation and also been tested and proven that safe for human use (Maisuthisakul et al., 2009). Hence, the sources of these bioactive compound in fruit seed is beneficial to human health, environment and economic sectors.

Table 2.1: Utilization of fruit seed in product

Fruit seed	Product	Beneficial	References
Date Grape	Pharmaceutical	Wound healer	Farzaei et al., (2013)
Jack fruit Chest nut	Baked product	Flour	Ejiofor et al., (2014)
Mango Pineapple	Cosmetic product Tooth whitening	Whitening agent	Maisuthisakul et al., (2009)

2.3 Fruit Seed Waste as Natural Coagulant in Water Treatment.

Natural coagulant has many advantages over commonly used of chemical coagulant in water treatment due to their serious production of harmful sludge, costly and the effect to human health. Lately, natural coagulants are widely investigated because of the efficiency in turbidity removal, abundant source, low price, low toxicity, and environment friendly thus produce low residual sludge production. The use of natural coagulants is generally traditionally used in water purification in less developed communities such as in India, Sudan and Bangladesh since they are relatively cost effective compared to chemical coagulants. The economic factor especially in many developing countries to afford the highly cost of imported chemical coagulant for using in water and wastewater treatment (Ndabigengesere et al., 1995). In addition, natural coagulants are non-toxic and non-corrosive product and the usage of natural coagulants can reduce the production of toxic and non-biodegradable chemical sludge to the environment (Kawamura, 1991). Besides of reduce the sludge management, it also minimizes handling and treatment costs in waste water treatment compared to chemical coagulants. In addition, the uses of fruit waste natural coagulant in water treatment will increase the quality of treated water and also contributes to a sustainable water treatment and also longer the use of life. The natural characteristic obtained in the natural coagulants supposed to be harmless for human health compared to chemical coagulants (Bina et al, 2010).

2.3.1 Fruit Seed Waste Coagulation Mechanism

The natural coagulants that been used in wastewater treatments composed of microbial polysaccharides, starches, gelatin galactomannans, cellulose derivatives, chitosan, glues, and alginate. The studies by using natural fruit seeds which can potentially reduce the turbidity in various mechanism. In general, the process of treatment involved in these coagulants included of molecules bridging, charge neutralization, double layer compression, and sweep-floc mechanism (Renault et al., 2009). Among these process, adsorption and charge neutralization are regarded be the most vital processes act as coagulant in natural fruits. This process happens where the formation of hydrolyzed species of positive charge in the compound cause the adsorption occurs at the surface of this particle suspension and destabilizing it. This attraction happens due to interactions of ion exchange, coordination reaction, hydrogen bonds and covalent reactions (Libanius, 2008).

Adsorption and bridging mechanism occur when the polyelectrolyte of long chain polymer extending and capable in binding the colloids together. The efficiency of bridging improved when coagulants with larger molecular weights are used due to the extended polymeric chains. Natural polymers such as polysaccharides and proteins could also induce coagulation via bridging. According to Miller et al., (2008), the mucilage of cactus Opuntia ficus indica is an anionic polysaccharide has been proven in turbidity removal via adsorption and bridging mechanism.

Charge neutralization mechanism is the process involves the adsorption of an oppositely charged coagulant on the colloidal surface. The colloidal particles that been found in waste water are usually negatively charged. Thus, the attraction of positively charge of coagulant to the negative charge colloidal particle resulting in

charge neutralization mechanism (Ndabigengesere et. Al., 1995). The effectiveness of charge neutralization mechanism is depending on the coagulant dosage and the particle can cause restabilization once the optimum dosage is exceeded. According to Asrafuzzaman et al., (2011), the use of Moringa oleifera use charge neutralization mechanism for turbidity removal.

Double layer compression is depending on the addition of an 'indifferent' electrolyte in large quantities as the presence of high ionic solution would alter the overall ionic concentration. Thus, the colloidal particle will be surrounded by double layer and would be compressed to a certain extent so the repulsive energy barrier will be lowered. Then, this will encourage the binding of two molecules and subsequently aid in the formation of flocs. Furthermore, the presence of bivalent ions such as $Mg2^{+}$ and $Ca2^{+}$ in water can attributed and induce coagulation activities via the double-layer compression mechanism (Duan et al. 2009).

Lastly, the sweep-floc mechanism is the formation of coagulant precipitates by the addition of large coagulant dosage can lead to sweep coagulation. These particles could act as nucleation sites to facilitate the precipitation formation and the colloidal particles would be trap in the growing precipitate and been removed from the colloidal suspension. Therefore, sweep coagulation could give result with greater removal in coagulation compare with charge neutralization but when there are exceed amount of dosage coagulant required, the production of large amount of sludge may not be favorable at the end of the process coagulation using chemical coagulants such as alum. (Agarwal et al. 2001; Al-Samawi and Shokralla 1996).

2.4. Effective Turbidity Removal Using Natural Coagulant

There are numerous laboratory studies conducted by the researchers using natural coagulant in water treatment to determine the efficiencies to treat the turbid water. There are many natural coagulants that been use in the studies such as plants, legumes and fruit waste. Example of natural coagulant from plant are *Moringa oleifera, Cicer arietinum* seed while for legumes are *Phaseolous vulgaris* and *Arachis hypogea* while for fruit waste by using banana pith, orange peel in turbid water and the result obtained has high percentage of turbidity removal in water treatment that been shown in Table 2.2.

In a research done by using plant-based as natural coagulant. The Muyibi et al. (2002) reported that the turbidity removal up to 98% by using turbid water at optimum dosage of 200mg/L of using *Moringa oleifera* with the initial turbidity was 451 NTU reduced to 9 NTU. This study also supports by other researcher that use *Moringa oleifera* that achieved turbidity removal up to 88.06% for 50 NTU at optimum dosage of 150 mg/L and 99.80% for 450 NTU at dosage of 125 mg/L (Nkurunziza et. al., 2009). However, there are studies that shows the use of *Moringa oleifera* has been found to have low coagulation activity for low turbid water and high coagulation activity for high turbid water (Muyibi, S. A. and Evison L.M., 1995). Besides that, the use of *Cicer arietinum* has been used in water purification using turbid water and the results was found that 95.89% turbidity removal achieved by using dosage of 100mg/L for high, medium and low turbidity water (Asrafuzzaman et. al., 2011). Patil and Hugar (2015) reported that efficiency of reduction of turbidity by *Cicer arietinum* at initial turbidity of 289.5 NTU reduced to 78.33% with the optimum dosage of 0.1mg/500mL.

Next, the studies on the use of fruit waste such as watermelon seeds (*Citrullus Lanatus*) by Muhammad et al., (2015) by treating the medium turbid water with dosage of 0.1g/L at pH 7 reduce to the recommend World Health Organization (2017) water quality standard below 5NTU. This study also supports by other researcher that use optimum dosage of 2g/L had achieved turbidity removal up to 86.7% in the high turbid water range 1500 NTU been reduced 35 NTU (Sathish et al., 2018). From the research done conducted by Yang et al (2014), by using banana pith was able to remove turbidity, sulphates, nitrates lead, zinc, iron, copper and chromium removal up to more than 80% that can be achieved at optimal dosage of 0.1 kg/m^3 at the pH of 4. Besides that, there is another fruit waste using orange peel that had been conducted by Anju (2016) using dairy waste water to compare with alum. The initial turbidity of dairy waste was 260 NTU be reduced to 8 NTU using peel orange powder. However, the alum has higher removal efficiency that can remove 98% of turbidity, however this study shows that orange peel has the potential to be used as natural coagulant to treat water turbidity.

Lastly, the use of legumes as natural coagulant been studied by Muthuraman and Sasikala (2014) by using common bean (*Phaseolus vulgaris*) seed-derived coagulant in synthetic turbid water. The result shows that the turbidity removal up to 80% by using extraction of sodium chloride (NaCl) in 1mg/L at the pH of 7 compared to extraction by distilled water that can only reached 45% of removal in kaolin water. Besides that, there are many studies of legumes using peanut seed *(Arachis hypogea)* that has been proven by extraction of NaCl able to remove turbidity up to 93.2% in kaolin suspension due to high contain of globulin protein including arachin and coarachin (Birima et al., 2013). Therefore, comparison by

using natural coagulant in turbidity removal, *Moringa oleifera* possesses effective coagulant properties with the highest turbidity removal up to 98% that been proven from the past studies (Muyibi and Evison, 1995; Muyibi et al., 2002; Nkurunziza et. al., 2009). On top of that, *Moringa oleifera* have shown to be the one most effective primary coagulants for water treatment as it was identified the seed contain active agent coagulation which are dimeric cationic proteins of molecular weight of approximately 13 kilodaltons (kDa) that having an isoelectric point between 10 and 11 acting through the mechanism of charge neutralization and adsorption (Kwaambwa and Maikoker, 2007).

Table 2.2 Recent studies on natural coagulant for turbidity removal

Type of natural coagulant	**Natural coagulant**	**Optimal condition**		**Findings**	**Reference**
		pH	**Dosage**		
Plant	*Moringa oleifera* seed	7 -	200 mg/L 125 mg/L	Remove turbidity up to 98 % Remove trurbidity up to 99.80%	S. Muyibi et al., (2002) Nkurunziza et. al., (2009)
	Cicer arietinum seed	-	1 mg/500mL	Remove turbidity up to 95.89%	Asrafuzzaman et al., (2011). Patil & Hugar, (2015)
Fruit waste	Watermelon seeds	7 -	0.1h/L 2 g/L	Remove turbidity up to 86.7% from wastewater.	Muhammad et al, (2015) Sa.thish et al., (2018)

	Banana pith	4	0.1 kg/m^3	80 % turbidity removal, sulphates, nitrates lead, zinc , iron, copper and chromium removal	Yang et al., (2014)
	Orange peel	7.5	0.2 g/L	97% turbidity removal from dairy wastewater	Anju (2016)
Legumes	*Phaseolus vulgaris* (common bean)	7	1mg/L	80% turbidity removal from kaolin water by using extraction NaCl.	Muthuraman & Sasikala (2014)
	Arachis hypogea (Peanut seed)	-	20 mg/L	93.2% turbidity removal from kaolin water by using extraction of NaCl.	Birima et al., (2013)

2.5 Natural Coagulant and Alum to Health Effect

Natural coagulant has proven its effectiveness in the turbidity removal in water without cause adverse effect to human health and it is environmental friendly method used for water treatment. The application of natural coagulants is easily applied especially in rural areas which produce lesser volume of sludge due to their biodegradable nature of sludge. The use of natural coagulants by using fruit waste, plant and legumes that been conducted by many studies have concluded that they are no yield any toxic effect to human health when they were used for wastewater treatment (Bina et al. (2010); Nilanjana, (2005); Asrafuzzaman et al. (2011)). Besides that, there are issue related to the toxicity of the *J. curcas* seeds as a natural coagulant for the treatment of drinking water that potential of poison leaching into water (Pritchard et al., 2009). In addition, the use of Vigna mungo, Zea in water treatment will produce the smell but only small scale process.

Nowadays, the widely use of aluminum salts as primary coagulants in water and wastewater treatment due its effectiveness in turbidity removal. However, there are many recent studies that point out several serious effect of using aluminum salts to the neuropathic diseases, such as Alzheimer's disease and toxicity to other aquatic organism that may be consumed by human that associated with the residual aluminum in treated water. Therefore, many studies conducted to replace these chemical coagulant that does not generate any harmful product by using natural coagulants and polymer (Yang et al, 2014)

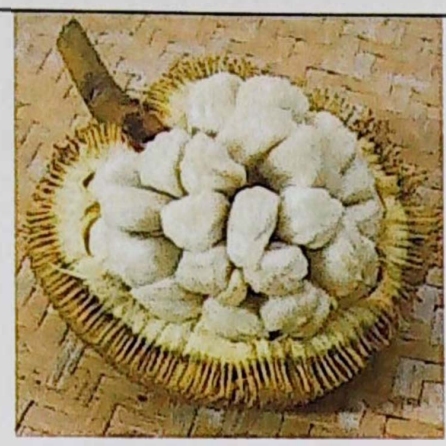
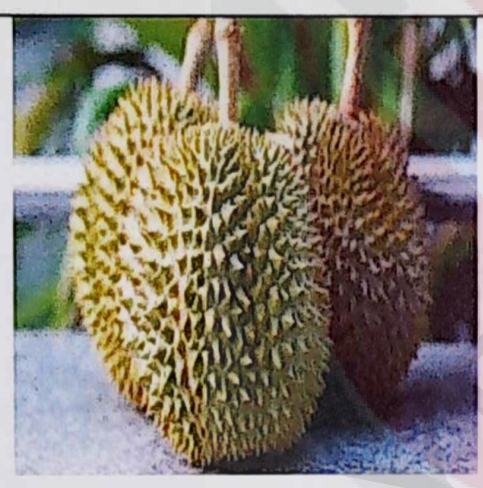
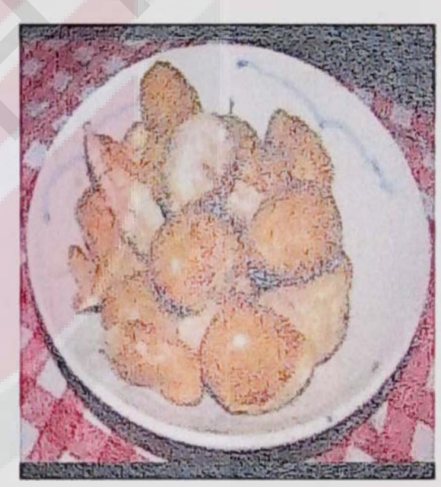
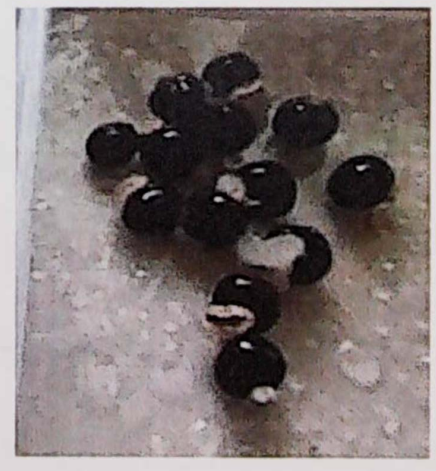
CHAPTER 3

METHODOLOGY

3.1 Fruit Seed Selection

The study was conducted in the laboratory Environmental Occupational Health in Faculty of Medicine and Science Health and Faculty of Engineering, UPM. Tarap seed *(Artocarpus odoratissimus)*, Durian seed (*Durio zibethinus)*, Cat's eye seed (*Euphoria malaiense*), Date seed (*Phoenix dactylifera)* and Jackfruit seed (*Artocarpus heterophyllus*) have been chosen in this study and obtained from local market in Seri Kembangan, Serdang. These are the picture of their seeds have been shown in Table 3.1.

Table 3.1: Seeds of local fruits chosen in this study.

Fruit	Fruit seed
 Tarap *(Artocarpus odoratissimus)*	
 Durian *(Durio zibethinus)*	
 Cat's Eye *(Euphoria malaiense)*	

 Date *(Phoenix dactylifera)*	
 Jackfruit *(Artocarpus heterophyllus)*	

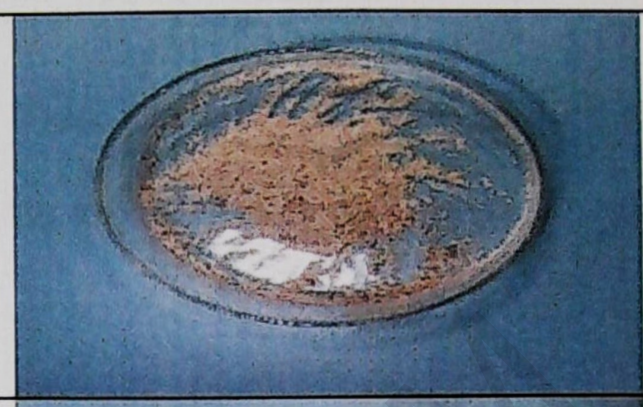
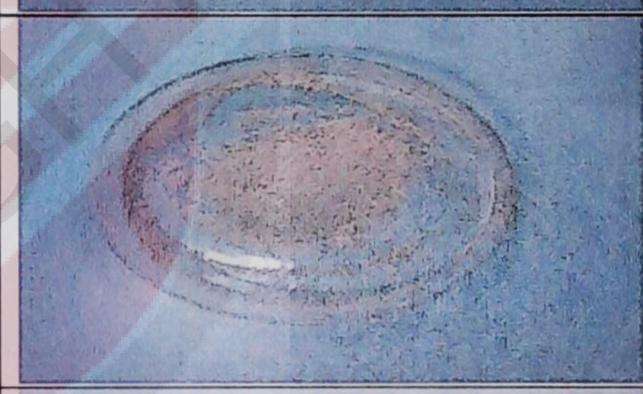
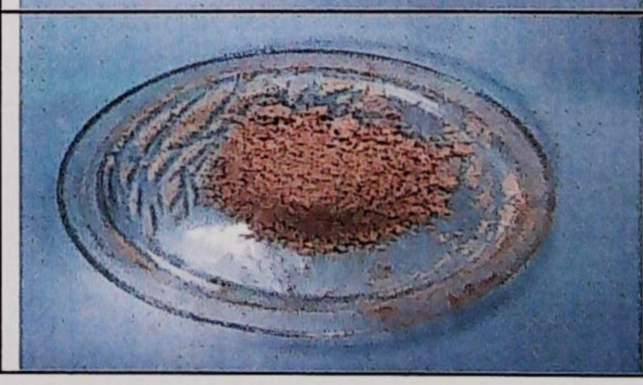
3.2 Steps Involved for Turbidity Removal

To ensure the data collection was reliable, the steps were taken as followed:

3.2.1 Preparation of Fruit Seed Powder.

The seeds were removed and kept for sun to dry before the seeds were ground to fine powder using Waring® Two-Speed Laboratory Blender. The ground powder had the oil extracted using methanol before dry it using oven at 90°C for 4 hours (Asrafuzzaman et al., 2011). Then, the powder was homogenized by using pastel and mortar before proceed to seed extraction for stock solution. These are the picture of fruit seed powder after homogenized shown in Table 3.2.

Table 3.2: **Fruit seeds powder**

Fruit seeds	Powder
Jack fruit *(Artocarpus heterophyllus)*	
Durian *(Durio zibethinus)*	
Cat's Eye *(Euphoria malaiense)*	
Date *(Phoenix dactylifera)*	
Tarap *(Artocarpus odoratissimus)*	

3.2.2 Preparation of Fruit Seed Extract Using NaCl.

The prepared powder from the fruit seed was weighed 10 g and was added to the appropriate volume needed by using NaCl. A mass of 1, 2 and 3% were used out for in this study by adding the amount of 1 g, 2 g, and 3 g of each fruit seed powder in 100 mL of NaCl. Then, the solutions were stirred using magnetic stirrer for 20 minutes, then the solution be filtered through a rugged filter paper (Whatmann No 42, 125mm) and obtained filtrates represented seed extracts of coagulation active components for stock solution as shown in Figure 2 (Ndabigengesere & Narasiah, 1998).

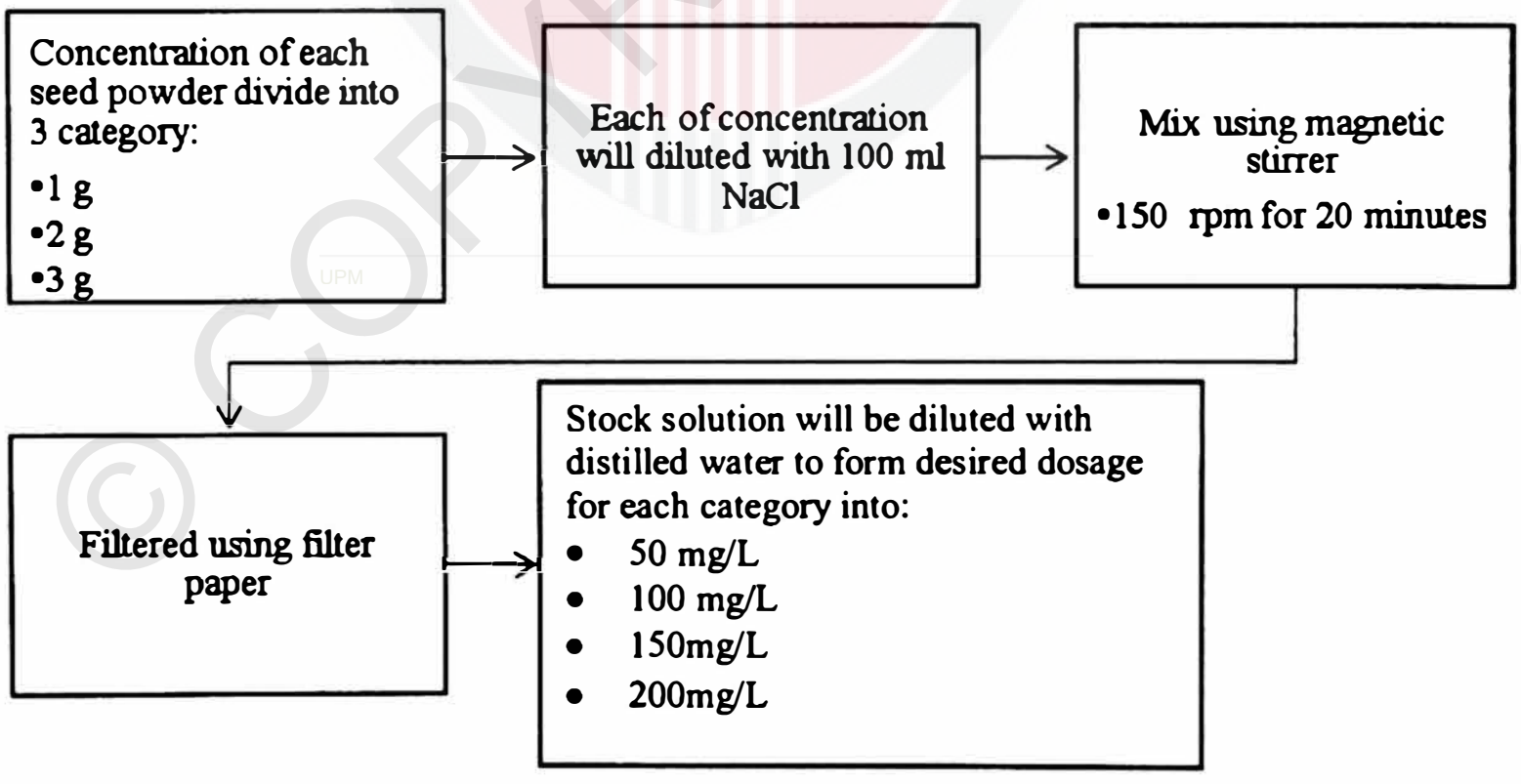


Figure 2: Extraction of fruit seed using NaCl solution

3.2.3 Preparation of Alum as Chemical Coagulant

Along with the preparation of fruit seed extract, aluminum sulphate [Al2(SO4)3.18H2O] was also prepared and used in the present study. The alum was prepared 1% solution of alum in tap water (1 g of alum in 1000 ml). The alum powder was totally soluble in the water. A fresh solution was prepared before conducting jar test experiment (Ndabigengesere & Narasiah, 1998).

3.2.4 Preparation of Synthetic Turbid Water

According to Asrafuzzaman et al., (2011) synthetic turbid water for coagulation tests was prepared by adding 30 g kaolin powder to 1000 ml of distilled water. Then, stirred the suspension for 1-hour to achieve uniform dispersion of kaolin particles, and then it was allowed to stand for 24-hour for completing hydration of the particles. This suspension was used as the stock suspension. The supernatant suspension of synthetic turbid water was added to the sample water to achieve the desired turbidity just before coagulation. The preparation of turbid water having for this experiment was 120 nephelometric turbidity units (NTU) and then was prepared by diluting of stock suspension to 200 ml distilled water.

3.2.5 Jar Test Operations

Lastly, conventional jar test apparatus was used in the experiments to coagulate sample of synthetic turbid water using some coagulants and this experiment was conducted at Faculty of Engineering, UPM. By using 200 ml of the synthetic turbid water samples was added into each of the 6 beakers and physicochemical (pH, turbidity, temperature) parameters were measured at 30, 60 and 90 minutes. Coagulants of varying mass were added in the beakers by using different doses (1g, 2g and 3g) of each fruit seeds powder were added to each of the 6 beakers simultaneously. The beakers were agitated in different rotating speeds, which consist of rapid mixing (250 rpm) for 1 minutes and slow mixing (35 rpm) for 90 minutes. Then, the suspensions were left to allow sedimentation for 60 minutes. After settling, 10 ml of the sample was taken from each beaker for turbidity, pH, and temperature measurement of supernatant. All tests were performed at an ambient temperature in the range of 26–32◦C and for turbid ranges 120 NTU.

Finally, turbidity removal percentage was calculated using the following equation (1):

$$Turbidity\ removal = \frac{TB - TS}{TB} X100\%$$

Equation (1)

, where TB represent the initial turbidity (NTU) value and TS represent final turbidity (NTU) value of water. Figure 3 below illustrates the turbidity removal process in this study.

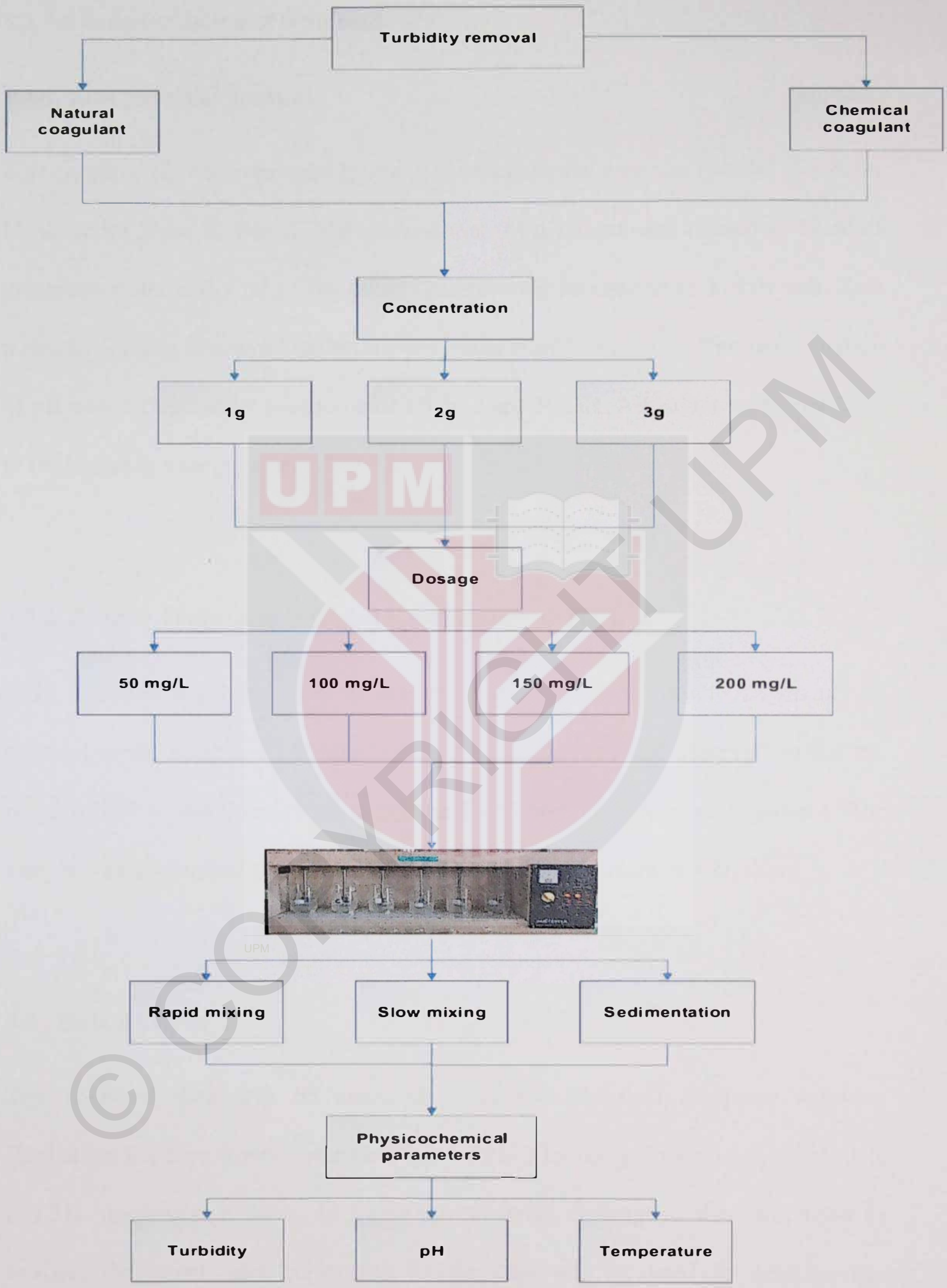


Figure 3: Illustrates the turbidity removal process.

3.3 Characterization of fruit seed

3.3.1. Zeta potential analysis

Zeta potential (ζ) was measured by using a Zeta potential analyzer (Model: Zetasizer Nano Series Nano-Z, Brand: Malvern). About 0.1 g sample was diluted in 10 ml of deionised water and 1 ml of the diluted sample was injected in to a flow cell. Zeta potential (ζ) was measured within the pH range from 2.0 to 10.0. The manipulation of pH was performed by addition of 0.1N HCl and NaOH. All values were measured in triplicates at a temperature of 25 °C.

3.3.2. Fourier Transform Infrared Spectroscopy (FTIR)

FTIR spectroscopy been used to determine the chemical characterization of the material in the sample. FTIR spectroscopy were analyzed and observed within the range of 400 - 4000 cm^{-1} with using the KBr pellet. The functional group of the sample was determined through the identification diverse mode of vibrations.

3.4 Data Analysis

The collected data will be analyzed using the statistical computer software (Statistical Package Service and Solution – SPSS) by using General Linear Models (GLM), univariate analysis. In Univariate analysis, descriptive date was used to analyze the mean, and percentage as the data will be used to describe the effectiveness of fruit seed in turbidity removal by using different mass, dosage and time duration, to determine the best fruit seed as natural coagulant in turbidity

removal, to determine optimum mass dosage of the best fruit seed as natural coagulant in turbid water in turbidity removal is within the standard by National Standard for Drinking Water Quality (NSDWQ) and the time required for optimum mass dosage of best fruit seed to remove turbidity using field sample.

3.5 Quality Assurance and Quality Control

To ensure data collection was reliable and valid, quality control on the instruments and procedures were taken as followed. The seed collected in good condition with showing no signs of discoloration, softening, or extreme desiccation were used. Besides that, fresh solutions were prepared daily and kept refrigerated to prevent any ageing effects (such as change in pH, viscosity, and coagulation activity). Solutions were shaken vigorously before use. The sample was mixed up using shaker at the same speed which is 220 rpm to avoid affecting result during diluting with NaCl for the extraction process. The sample was analyzed in duplicates to increase the accuracy and reduce the bias. Instruments that has been used were calibrated and were in good condition when collecting the samples, eliminate any possible error of data and give an accurate result during the sampling especially by using turbidimeter (Hach 2100AN) to measure the turbidity of water.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Effectiveness of Fruit Seed in Reduction of Turbidity.

The jar test operations using diff erent coagulants were carried out in diff erent mass ranges from 1g, 2g and 3g and dosage from 25 mg/L, 50 mg/L, 100mg/L, 150 mg/L and 200 mg/L been tested using synthetic turbid water. The efficiency of the extracts of jackfruit seeds, durian seeds, date seeds, cat's eye seeds and tarap seeds been used as natural coagulants for removal of water turbidity.

The dosage started from 25mg/L to 100mg/L for mass of 1g of each seeds corresponding five beakers. Turbidity was measured for every 30, 60 and 90 minutes. Table 4.1- 4.3 show the results of diff erent mass and dosages of coagulant treatment in jar test. From Table 4.1, the initial water turbidity by using synthetic kaolin water was 120 NTU. As the result shown below, the turbidity been reduced to 71.6, 68, 38.2 and 46.6 NTU corresponding to 25, 50, 75 and 100mg/L of jackfruit seed doses respectively. For durian seed, the turbidity reduced to 44.4, 43, 28.7 and 36.7 NTU respectively. Result for removal of turbidity using date seeds been reduced to 46.2, 34.8, 35.2 and 38.5 NTU. For cat's eye seeds with the same doses reduce turbidity to 58.7, 45, 41.3 and 43.9 NTU. Lastly, the turbidity been reduced to 49.1, 34.3, 20.6 and15.2 NTU by using tarap seeds.

For the mass of 2g with the dosage ranges from 50, 100, 150 and 200 mg/L were carried out and the turbidity been reduced to 64.8, 59.4, 50.7 and 47.2 NTU by using jackfruit seeds corresponding to the dosage of 50, 100, 150 and 200 mg/L. For durian seeds, the turbidity reduced to 48.6, 46.9, 43.4 and 41 NTU respectively. Result for removal of turbidity using date seeds been reduced to 48.7, 46.7, 45.1 and 43.9 NTU. For cat's eye seeds with the same doses reduce turbidity to 53.7, 50.3, 50.4 and 50.1 NTU. Lastly, the turbidity been reduced to 41.1, 34.5, 33.9 and 28.9 NTU by using tarap seeds.

For the mass of 3g with the dosage ranges from 100, 150 and 200 mg/L were carried out and the turbidity been reduced to 68.9, 61.7 and 51.6 NTU by using jackfruit seeds corresponding to the dosage of 100, 150 and 200 mg/L. For durian seeds, the turbidity reduced to 46.1, 37.9 and 34.4 NTU respectively. Result for removal of turbidity using date seeds been reduced to 49.5, 39.1 and 33.6 NTU. For cat's eye seeds with the same doses reduce turbidity to 50.1, 51.2 and 50.3 NTU. Lastly, the turbidity been reduced to 37.5, 28.8 and25.2 NTU by using tarap seeds.

There was greater influence of mass and dosage of fruit seeds to the turbidity removal. According to Kuppusamy et al. (2015), the fruit seeds has high polyphenols content compared to other edible part of the fruit and the potential benefit of fruit seeds as coagulant. Besides that, the results showed the capability of turbidity removal by fruit seeds increase as the mass and dosage increase. Therefore, the fruit seeds as natural coagulant showed their effectiveness in the reduction of water turbidity.

Based on the Table 4.2, the result shows the reduction of pH using various mass and dosage of fruit seeds coagulant. The pH is one of the most important parameters that may influence on coagulation activity because it depends on the charge of polyelectrolyte molecule (e.g. protein) for coagulation process (Sciban et al., 2009), The measurement was carried out and the initial pH of the water sample in this study was 8 the result after treatment been reduced ranged from 8 to 7.42. The use of fruit seeds as natural coagulant has no significant variation on pH of treated water and the pH is still within the range of World Health Organization (2017) standard which recommend limit from 6.5 to 8.5. Therefore, the use of fruit seeds dosage does not need any pH adjustment. Based on the Table 4.3, the temperature of this study was at 28 °C and the result after treat the water by using natural coagulant was slightly reduction of temperature to the lowest at 36.5 °C which could not alter the coagulation process.

Table 4.1: Reduction of turbidity using various mass and dosage of fruit seeds coagulant.

Mass (g)	Dosage (mg/L)	Time (minutes)	Initial turbidity (NTU)	Final Turbidity (NTU)					
				Jackfruit	Durian	Date	Cat's eye	Tarap	alum
1	25	30	120	82.8	58	66.4	64.3	64.7	63.8
		60	120	77.8	53.3	54.4	51.9	55.7	61.5
		90	120	71.6	44.4	46.2	58.7	49.1	45.1
	50	30	120	73.6	62.4	68.4	65.6	78	56.9
		60	120	70.8	54.1	56	57.1	54.2	51.4
		90	120	68	43	34.8	45	34.3	42
	75	30	120	52.2	50.1	48.7	54.2	38.9	54
		60	120	44	39.1	38.5	47.1	29.8	50.4
		90	120	38.2	28.7	35.2	41.3	20.6	38.4
	100	30	120	67.1	61.2	62.4	59.7	45	51.2
		60	120	54.4	51.3	50.5	52.3	23.2	50.1
		90	120	46.6	36.7	38.5	43.9	15.2	38.2
2	50	30	120	73.8	67.7	67.4	69.1	64	56.9
		60	120	67.4	55.2	56.2	63.9	52.2	51.4
		90	120	64.8	48.6	48.7	53.7	41.1	42
	100	30	120	72.7	73.5	75.6	72.6	62.1	51.2
		60	120	66.9	57.9	59.2	57.7	43.2	50.1
		90	120	59.4	46.9	46.7	50.3	34.8	38.2
	150	30	120	71.1	70.9	72.1	69.9	61.9	43.5
		60	120	65	59.8	59.1	58.2	57.8	24.2
		90	120	50.7	43.4	45.1	50.4	33.9	11.1
	200	30	120	67.6	66.9	65.9	69.4	61	34
		60	120	61.2	59	58.8	59.5	53.9	21.7
		90	120	47.2	41	43.9	50.1	28.9	8.8
3	100	30	120	78.2	71.9	80.8	77.6	67.2	51.2
		60	120	71.2	59.5	68.1	67.9	57	50.1
		90	120	68.9	46.1	49.5	50.1	37.5	38.2
	150	30	120	76.7	83.4	79.8	82.1	79	43.5
		60	120	71.4	50.1	55.1	58.1	51.2	24.2
		90	120	61.7	37.9	39.1	51.2	28.8	11.1
	200	30	120	78.1	71.3	72.9	72.3	61.6	34
		60	120	66.4	55.9	57	60	38.9	21.7
		90	120	51.6	34.4	33.6	50.3	25.2	8.8

Table 4.2: Reduction of pH using various mass and dosage of fruit seeds coagulant.

Mass (g)	Dosage (mg/L)	Time (minutes)	Initial pH	Final pH					
				Jack fruit	Durian	Date	Cat's eye	Tarap	alum
1	25	30	8	7.68	7.62	7.68	7.7	7.69	4.64
		60	8	7.68	7.62	7.67	7.63	7.67	4.61
		90	8	7.67	7.6	7.6	7.61	7.63	4.57
	50	30	8	7.59	7.53	7.55	7.66	7.62	4.47
		60	8	7.58	7.53	7.54	7.65	7.6	4.44
		90	8	7.58	7.51	7.54	7.62	7.59	4.4
	75	30	8	7.79	7.81	7.85	7.86	7.89	4.43
		60	8	7.73	7.73	7.83	7.82	7.85	4.39
		90	8	7.62	7.69	7.75	7.79	7.8	4.37
	100	30	8	7.64	7.61	7.55	7.78	7.69	4.43
		60	8	7.59	7.59	7.55	7.66	7.61	4.31
		90	8	7.59	7.58	7.5	7.63	7.53	4.29
2	50	30	8	7.7	7.62	7.63	7.7	7.72	4.47
		60	8	7.7	7.6	7.6	7.63	7.7	4.44
		90	8	7.67	7.6	7.58	7.61	7.63	4.4
	100	30	8	7.71	7.67	7.67	7.65	7.7	4.43
		60	8	7.7	7.67	7.67	7.64	7.7	4.31
		90	8	7.68	7.63	7.66	7.65	7.68	4.29
	150	30	8	7.61	7.52	7.63	7.6	7.59	4.24
		60	8	7.6	7.48	7.58	7.58	7.57	4.22
		90	8	7.42	7.48	7.52	7.57	7.55	4.16
	200	30	8	7.51	7.49	7.54	7.55	7.52	4.18
		60	8	7.49	7.46	7.53	7.51	7.52	4.14
		90	8	7.46	7.45	7.51	7.51	7.5	4.13
3	100	30	8	7.81	7.84	7.85	7.61	7.75	4.43
		60	8	7.11	7.81	7.81	7.81	7.74	4.31
		90	8	7.8	7.79	7.8	7.79	7.74	4.29
	150	30	8	7.98	7.97	8.01	8.01	7.99	4.24
		60	8	7.97	7.97	7.99	7.97	7.91	4.22
		90	8	7.91	7.92	7.96	7.95	7.94	4.16
	200	30	8	8.07	8.03	8.01	7.99	8.09	4.18
		60	8	8.02	7.97	7.96	7.94	8.01	4.14
		90	8	7.95	7.94	7.95	7.93	7.94	4.13

Table 4.3: Reduction of temperature using various mass and dosage of fruit seeds coagulant.

Mass (g)	Dosage (mg/L)	Time (minutes)	Initial temperature (°C)	Final temperature (°C)					
				Jack fruit	Durian	Date	Cat's eye	Tarap	alum
1	25	30	28	27	27.3	27	27.1	27.1	28.1
		60	28	26.9	27.1	26.8	27	26.9	27.9
		90	28	26.9	27	26.7	27	26.9	27.7
	50	30	28	28.2	28.3	28.2	28.3	28	28.3
		60	28	28.1	28.3	28.2	28.1	28	28
		90	28	28	28.2	28	28.1	27.9	27.9
	75	30	28	27.9	28.1	28.3	27	27.5	28.5
		60	28	27.7	27.9	28.1	26.9	27.5	28.4
		90	28	27.7	27.8	27.5	26.8	27.3	28.1
	100	30	28	28.1	28	27.8	27.8	27.3	28.5
		60	28	28	27.9	27.1	27.5	27.1	28.5
		90	28	27.6	27.7	27	27.5	27	28.3
2	50	30	28	27	27.3	27	27.1	27.1	28.3
		60	28	26.9	27.1	26.8	27	26.9	28
		90	28	26.9	27	26.7	27	26.9	27.9
	100	30	28	27.1	27.2	27	27.1	27	28.5
		60	28	27.1	27.1	26.8	26.9	27	28.5
		90	28	27.1	26.9	26.8	26.7	26.9	28.3
	150	30	28	26.9	27.3	27.3	27.7	27.8	28.6
		60	28	26.9	27.1	27.3	27.7	27.2	28.4
		90	28	26.7	26.9	26.9	26.7	26.8	28.3
	200	30	28	27.1	27.1	27.3	27.5	27.4	29.8
		60	28	27	27.1	27.1	27.1	27.3	29.5
		90	28	26.9	27	27	27.1	27	29
3	100	30	28	27.3	27.4	27.5	27.4	27.5	28.5
		60	28	27.3	27.3	27.5	27.4	27.4	28.5
		90	28	27.3	27.3	27.3	27.2	27.4	28.3
	150	30	28	27.2	27.3	27.3	27.4	27.3	28.6
		60	28	27.2	27.2	27.3	27.1	27	28.4
		90	28	26.9	27	27.3	27.1	27	28.3
	200	30	28	27.3	27.3	27.2	27.3	27.4	29.8
		60	28	27.3	27.2	27.1	27.2	27.3	29.5
		90	28	27	27.1	27.1	27.2	27.3	29

4.2 Best Fruit Seeds as Natural Coagulant in Turbidity Removal.

In this study, date seeds were selected as the best fruit seeds in turbidity removal. Based on the Table 4.4 shows the comparison of mass and dosage level using date seeds in turbidity removal. The mass of 1 g to 3 g and the dosage in the range of 25 - 200 mg/L on the synthetic turbid water by using kaolin were used with the initial turbidity at 120 NTU and determine the result in terms of turbidity removal percentage (%) by following equation (1):

$$Turbidity\ removal = \frac{TB - TS}{TB} X\ 100\% \quad (1)$$

, where TB represent the initial turbidity (NTU) value and TS represent final turbidity (NTU) value of water.

Based on the result, at 30 minutes, the highest turbidity removal were observed can remove 59.4% at mass of 1g with 75 mg/L of dosage while for 60 minutes, the removal were observed can reduce up to 67.9% at mass of 1g with dosage of 75 mg/L and lastly for 90 minutes, the highest turbidity removal were recorded at the mass and dosage level using 3g and 200 mg/L of date seed can reduce up to 72% of turbidity removal of water which is the highest turbidity removal by using various mass and dosage and the lowest turbidity removal is 32.70% at the mass of 3g and the dosage of 100mg/L. Thus, the amount needed to give the best percentage of turbidity removal based on the mass and dosage. Based on the study by Renault et al., (2009) the mechanism used by natural coagulant in turbidity removal by through adsorption and charge neutralization process that be the most vital process as coagulant. These processes occur from the formation of hydrolysed species of positive charge in the compound and cause the adsorption occurs at the

surface of this particle suspension and destabilizing it due to interactions of ion exchange, coordination reaction, hydrogen bonds and covalent reactions. (Libanius, 2008). There are several researches reported that at initially, as the dosage of the coagulant increase, the percentage removal of turbidity will increase. But after a certain dose, there will show a decreasing trend in turbidity removal percentage with the increase of coagulant dose (Miller et al., 2008). This phenomenon happen due to the optimal dose of coagulant in suspension can causes larger amount of solid to aggregate and settle. However, when there is amount that exceed the optimal dose of coagulant, it would not increase turbidity removal but will cause the aggregated particles to disperse in the suspension and disturb particle to settling.

Table 4.4: Statistical summary of mass and dosage level in turbidity removal using date seeds.

Mass (g)	Dosage (mg/L)	Time (minutes)	Turbidity removal percentage (%)	
			Mean	Standard Deviation (SD)
1	25	30	44.7	8.45
		60	54.7	
		90	61.5	
	50	30	43	14.16
		60	53.3	
		90	71	
	75	30	59.4	5.89
		60	67.9	
		90	70.7	
	100	30	48	9.95
		60	57.9	
		90	67.9	
2	50	30	43.8	7.86
		60	53.2	
		90	59.4	
	100	30	37	12.09
		60	50.7	
		90	61.1	
	150	30	39.9	11.25
		60	50.8	
		90	62.4	
	200	30	45.1	9.34
		60	51	
		90	63.4	
3	100	30	32.7	13.13
		60	43.3	
		90	58.8	
	150	30	33.5	17.01
		60	54.1	
		90	67.4	
	200	30	39.3	16.45
		60	52.5	
		90	72	

4.3 The Optimum Mass Dosage of the Best Fruit Seeds as Natural Coagulant in Turbid Water in Turbidity Removal is Within the Standard by National Standard for Drinking Water Quality (NSDWQ).

Based on the Table 4.5, the comparison of optimum mass dosage between the alum and date seeds in turbidity removal using kaolin water. The optimal dosage, which is the minimum dosage corresponding to the lowest residual turbidity. For this study, it was found that the date seeds has the optimum mass dosage in turbidity removal with the mass of 2.34g and 121.25 mg/L. In this case, by using the optimum mass dosage of date seeds as the best natural coagulant has been tested in synthetic turbid water at 120 NTU. The date seeds can reduce up to 97% of turbidity removal at 24-hour settling time to achieve the standard water quality by using optimum dosage mass of date seeds in synthetic turbid water.

As the result shown, the measurement of physicochemical show decrease after the coagulation and flocculation process as the time increase. Based on Figure 4, the result shown by using alum, the decrease of turbidity from 120 NTU to 4.07 NTU required 12-hour to achieved standard water quality while for alum by using optimum mass dosage reduce the turbidity from 120 NTU to 3.56 NTU for 24-hour time needed. The turbidity that been set by National Standard for Drinking Water Quality (NSDWQ) must be less than 5 NTU for human consumption. Besides that, the optimum mass dosage of best fruit seeds as natural coagulant shows significant difference in turbidity removal that gives value 0.025 ($p<0.05$). Therefore, the optimum of mass dosage influenced the turbidity removal due to their abilities and efficacy of natural coagulant by using date seeds able to achieve water quality standard through coagulation and flocculation process by using synthetic turbid

water. Besides that, date seeds could achieve the recommended pH value after treated. The initial turbid water with the pH of 8.11 been reduced to pH of 7.49. According to WHO (2017), the pH range suitable of drinking water for human consumption is between 6.5 and 8.5. Therefore, the water treated by date seeds fall within the recommended pH range.

Table 4.5: The optimum mass dosage of the best natural coagulant in turbid water in turbidity removal is within the standard by National Standard for Drinking Water Quality (NSDWQ).

Time (Hour)	Turbidity (NTU) alum	Turbidity (NTU) Date	pH alum	pH date	Temperature (°C)
0	120	120	8.11	8.11	26
4	26.65	40.2	7.26	7.82	26
8	10	18.32	7.22	7.67	26
12	4.07	8.66	7.17	7.64	26
16		6.75		7.63	26
20		5.6		7.61	26
24		3.56		7.49	26

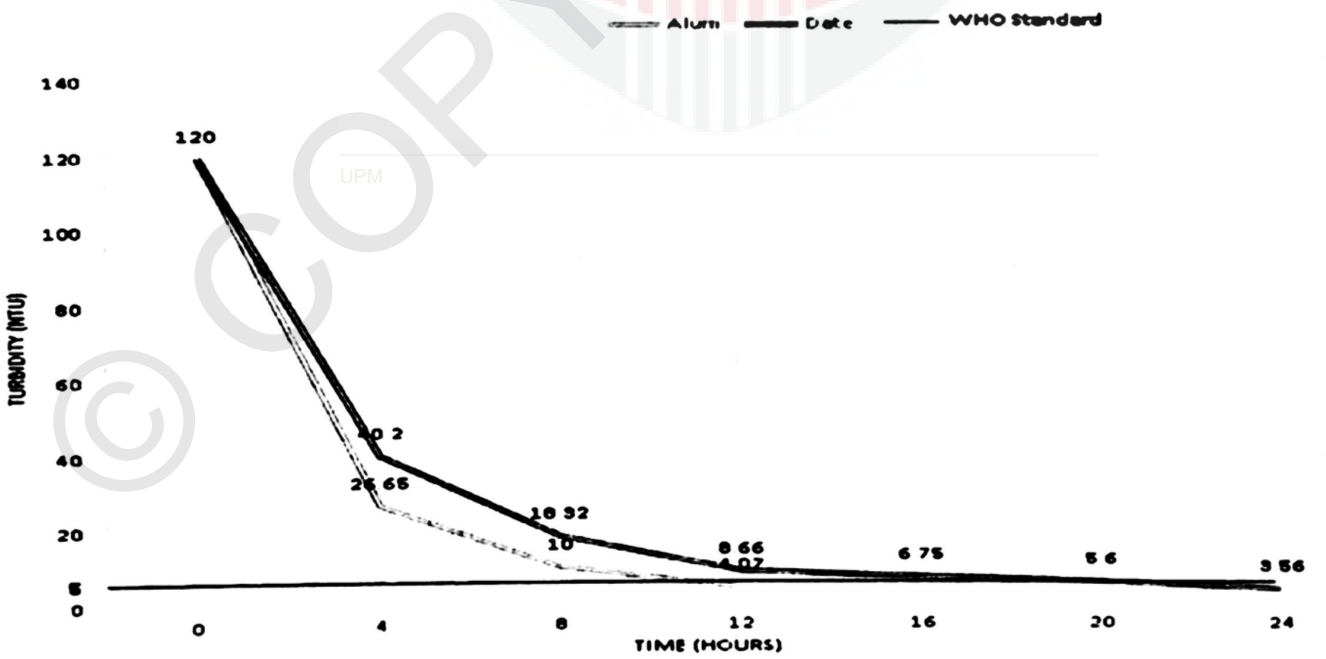


Figure 4: Reduction of turbidity using date seeds and alum before and after treatment using synthetic turbid water (Kaolin).

4.4 Time Required for Optimum Mass Dosage of the Best Fruit Seeds as Natural Coagulant in Turbidity Removal Using Field Sample.

Table 4.6 shows the result of the needed time required for optimum mass dosage of the best natural coagulant and alum in turbidity removal using field sample. The pH of the water samples in this study ranged from 7 to 7.7 and temperature at 26 ℃ by using field sample taken from the lake at college 17, UPM and been tested by using optimum mass dosage of date seeds and alum. For this study, most of the physicochemical of reading show decrease as the time increase.

The optimum mass dosage of date seeds by using 2.34 g with the dosage of 121.25 mg/L was conducted using field sample from the lake at college 17, UPM. Based on the Figure 5, the initial turbidity of field sample is 79.6 NTU and the optimum mass dosage of date seeds reduced the turbidity to 29.92 NTU at 96-hour which it took longer time from the alum which only took 48-hour at 3.86 NTU that achieve water quality standard. The result shown that the highest percentage of turbidity removal is 62% at the 96-hour by using optimum mass dosage of date seeds. However, the turbidity was not achieved the standard of water quality below than 5 NTU and it required longer time to reduce. According to Ndabigengesere et. Al., (1995), this happen because the use of natural coagulants in water treatment may increase the organic load in waters and resulting in the possibility for undesired and increased microbial activity thus increase the biological oxygen demand (BOD) in the water. Thus, this factor responsible for the optimum fruit seedss not achieving the water quality standard due to their present that could affect the reduction of turbidity (Okuda et al., 2001).

Table 4.6: Time required for optimum mass dosage of the best natural coagulant in turbidity removal suing field sample.

Time (Hour)	Turbidity (NTU) alum	Turbidity (NTU) Date	pH alum	pH date	Temperature (°C)
0	79.6	79.6	7.62	7.62	26
24	9.46	50.52	7.42	7.1	26
48	3.96	39.02	7.29	7.07	26
72		33.16		7.03	26
96		29.92		7	26

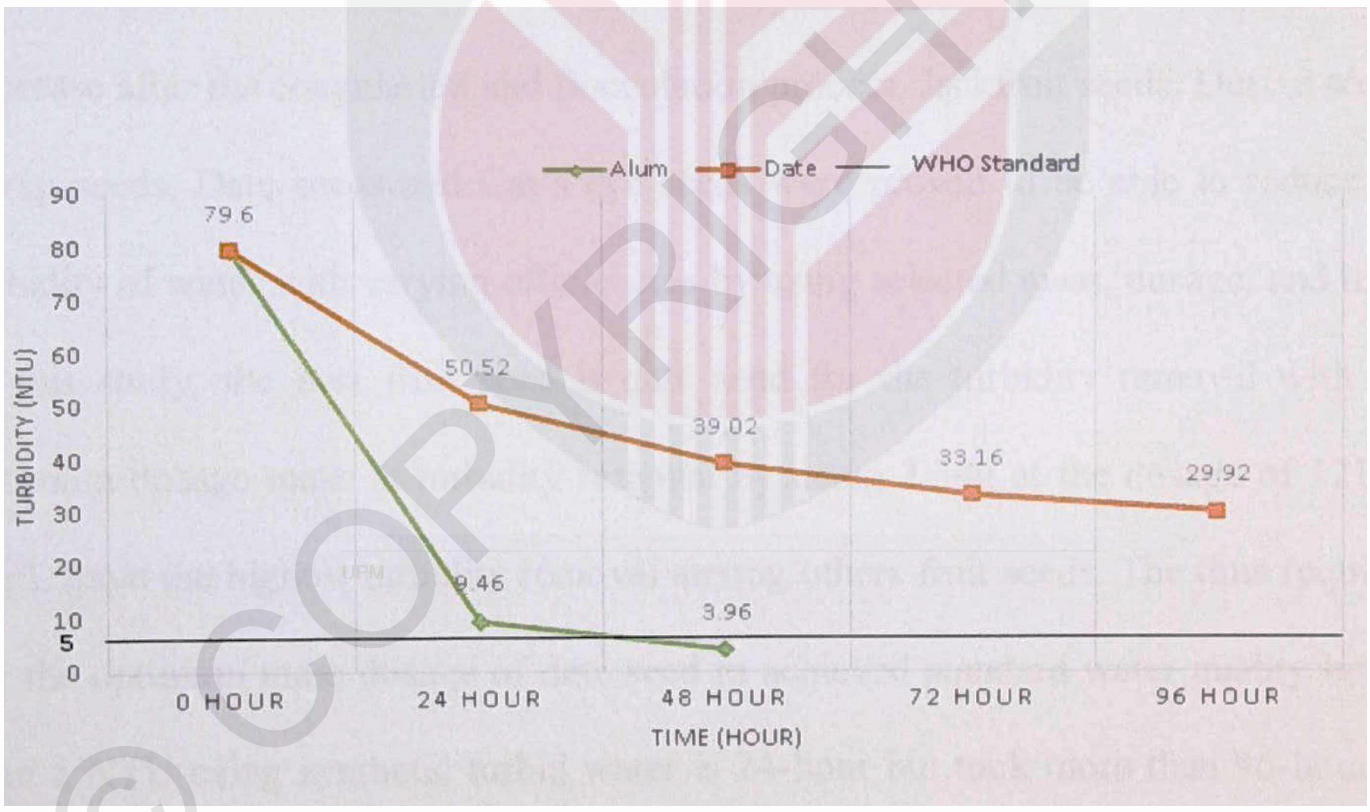


Figure 5: Reduction of turbidity by using date seed and alum before and after treatment using field sample.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

For the last decade, there are many efforts by researcher been made to improve method of treating water by using natural coagulants. In this study, treating turbid water have been conducted by using selected fruit seeds waste to determine the effectiveness in turbidity removal. Most of the physicochemical reading show decrease after the coagulation and flocculation process. Jackfruit seeds, Durian seeds, Tarap seeds, Date seeds and Cat's eye seeds were proven to be able to reduce the turbidity of water with varying efficiencies by using selected mass, dosage, and time. In this study, the best fruit seed is date seed for the turbidity removal with the optimum dosage mass in turbidity removal by using 2.34g at the dosage of 121.25 mg/L gave the highest turbidity removal among others fruit seeds. The time required for the optimum mass dosage of date seed to achieved standard water quality below than 5 NTU using synthetic turbid water is 24-hour but took more than 96-hour by using field sample water due to the use of natural coagulants in water treatment may increase the organic load in waters and resulting in the possibility for undesired and increased microbial activity thus increase the biological oxygen demand (BOD) in the water. Therefore, it can be concluded that fruit seeds as natural coagulants give a lot of advantages of being, low cost, abundant, native and efficient for water treatment.

5.2 Recommendations

As recommendation, the exploitation of naturally available resources of fruit as coagulant remained at its infancy with little knowledge on their respective potential in Malaysia. Furthermore, utilization of fruit seed waste as coagulants aids can be considered in combination of fruit seed with chemical coagulants in turbidity removal of water thus also effective in terms of cost and environmentally friendly and speed up coagulation-flocculation activities in turbidity removal. Besides that, include more physiochemical parameter in the study such as BOD, COD and total suspended solid (TSS) which more relevant in determines the water quality and conduct in different water quality and contaminants from different localities

5.3 Study Limitation

There are several limitations of this study that should be considered to improve on further research. Firstly, the period of time to conduct this study is too short and time constraint. Although, this study only conducted in a small size of fruit seeds, the required time for the settling time need longer period of time to get better result. Besides that, the equipment of conducting the jar test is limit and only available at other faculty that cause time constraint and not able to stay longer after working hour.

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APPENDIX

Table 4.1: Reduction of turbidity using various concentration and dosage of fruit seed coagulant.

Concentration (g)	Dosage (mg/L)	Time (minutes)	Initial turbidity (NTU)	Final Turbidity (NTU)					
				Jackfruit	Durian	Date	Cat's eye	Tarap	alum
1	25	30	120	82.8	58	66.4	64.3	64.7	63.8
		60	120	77.8	53.3	54.4	51.9	55.7	61.5
		90	120	71.6	44.4	46.2	58.7	49.1	45.1
	50	30	120	73.6	62.4	68.4	65.6	78	56.9
		60	120	70.8	54.1	56	57.1	54.2	51.4
		90	120	68	43	34.8	45	34.3	42
	75	30	120	52.2	50.1	48.7	54.2	38.9	54
		60	120	44	39.1	38.5	47.1	29.8	50.4
		90	120	38.2	28.7	35.2	41.3	20.6	38.4
	100	30	120	67.1	61.2	62.4	59.7	45	51.2
		60	120	54.4	51.3	50.5	52.3	23.2	50.1
		90	120	46.6	36.7	38.5	43.9	15.2	38.2
2	50	30	120	73.8	67.7	67.4	69.1	64	56.9
		60	120	67.4	55.2	56.2	63.9	52.2	51.4
		90	120	64.8	48.6	48.7	53.7	41.1	42
	100	30	120	72.7	73.5	75.6	72.6	62.1	51.2
		60	120	66.9	57.9	59.2	57.7	43.2	50.1
		90	120	59.4	46.9	46.7	50.3	34.8	38.2
	150	30	120	71.1	70.9	72.1	69.9	61.9	43.5
		60	120	65	59.8	59.1	58.2	57.8	24.2
		90	120	50.7	43.4	45.1	50.4	33.9	11.1
	200	30	120	67.6	66.9	65.9	69.4	61	34
		60	120	61.2	59	58.8	59.5	53.9	21.7
		90	120	47.2	41	43.9	50.1	28.9	8.8
3	100	30	120	78.2	71.9	80.8	77.6	67.2	51.2
		60	120	71.2	59.5	68.1	67.9	57	50.1
		90	120	68.9	46.1	49.5	50.1	37.5	38.2
	150	30	120	76.7	83.4	79.8	82.1	79	43.5
		60	120	71.4	50.1	55.1	58.1	51.2	24.2
		90	120	61.7	37.9	39.1	51.2	28.8	11.1
	200	30	120	78.1	71.3	72.9	72.3	61.6	34
		60	120	66.4	55.9	57	60	38.9	21.7
		90	120	51.6	34.4	33.6	50.3	25.2	8.8

Table 4.2: Reduction of pH using various concentration and dosage of fruit seed coagulant.

Concentration (g)	Dosage (mg/L)	Time (minutes)	Initial pH	Final pH					
				Jack fruit	Durian	Date	Cat's eye	Tarap	alum
1	25	30	8	7.68	7.62	7.68	7.7	7.69	4.64
		60	8	7.68	7.62	7.67	7.63	7.67	4.61
		90	8	7.67	7.6	7.6	7.61	7.63	4.57
	50	30	8	7.59	7.53	7.55	7.66	7.62	4.47
		60	8	7.58	7.53	7.54	7.65	7.6	4.44
		90	8	7.58	7.51	7.54	7.62	7.59	4.4
	75	30	8	7.79	7.81	7.85	7.86	7.89	4.43
		60	8	7.73	7.73	7.83	7.82	7.85	4.39
		90	8	7.62	7.69	7.75	7.79	7.8	4.37
	100	30	8	7.64	7.61	7.55	7.78	7.69	4.43
		60	8	7.59	7.59	7.55	7.66	7.61	4.31
		90	8	7.59	7.58	7.5	7.63	7.53	4.29
2	50	30	8	7.7	7.62	7.63	7.7	7.72	4.47
		60	8	7.7	7.6	7.6	7.63	7.7	4.44
		90	8	7.67	7.6	7.58	7.61	7.63	4.4
	100	30	8	7.71	7.67	7.67	7.65	7.7	4.43
		60	8	7.7	7.67	7.67	7.64	7.7	4.31
		90	8	7.68	7.63	7.66	7.65	7.68	4.29
	150	30	8	7.61	7.52	7.63	7.6	7.59	4.24
		60	8	7.6	7.48	7.58	7.58	7.57	4.22
		90	8	7.42	7.48	7.52	7.57	7.55	4.16
	200	30	8	7.51	7.49	7.54	7.55	7.52	4.18
		60	8	7.49	7.46	7.53	7.51	7.52	4.14
		90	8	7.46	7.45	7.51	7.51	7.5	4.13
3	100	30	8	7.81	7.84	7.85	7.61	7.75	4.43
		60	8	7.11	7.81	7.81	7.81	7.74	4.31
		90	8	7.8	7.79	7.8	7.79	7.74	4.29
	150	30	8	7.98	7.97	8.01	8.01	7.99	4.24
		60	8	7.97	7.97	7.99	7.97	7.91	4.22
		90	8	7.91	7.92	7.96	7.95	7.94	4.16
	200	30	8	8.07	8.03	8.01	7.99	8.09	4.18
		60	8	8.02	7.97	7.96	7.94	8.01	4.14
		90	8	7.95	7.94	7.95	7.93	7.94	4.13

Table 4.3: Reduction of temperature using various concentration and dosage of fruit seed coagulant.

Concentration (g)	Dosage (mg/L)	Time (minutes)	Initial temperature (°C)	Final temperature (°C) Jack fruit	Durian	Date	Cat's eye	Tarap	alum
1	25	30	28	27	27.3	27	27.1	27.1	28.1
		60	28	26.9	27.1	26.8	27	26.9	27.9
		90	28	26.9	27	26.7	27	26.9	27.7
	50	30	28	28.2	28.3	28.2	28.3	28	28.3
		60	28	28.1	28.3	28.2	28.1	28	28
		90	28	28	28.2	28	28.1	27.9	27.9
	75	30	28	27.9	28.1	28.3	27	27.5	28.5
		60	28	27.7	27.9	28.1	26.9	27.5	28.4
		90	28	27.7	27.8	27.5	26.8	27.3	28.1
	100	30	28	28.1	28	27.8	27.8	27.3	28.5
		60	28	28	27.9	27.1	27.5	27.1	28.5
		90	28	27.6	27.7	27	27.5	27	28.3
2	50	30	28	27	27.3	27	27.1	27.1	28.3
		60	28	26.9	27.1	26.8	27	26.9	28
		90	28	26.9	27	26.7	27	26.9	27.9
	100	30	28	27.1	27.2	27	27.1	27	28.5
		60	28	27.1	27.1	26.8	26.9	27	28.5
		90	28	27.1	26.9	26.8	26.7	26.9	28.3
	150	30	28	26.9	27.3	27.3	27.7	27.8	28.6
		60	28	26.9	27.1	27.3	27.7	27.2	28.4
		90	28	26.7	26.9	26.9	26.7	26.8	28.3
	200	30	28	27.1	27.1	27.3	27.5	27.4	29.8
		60	28	27	27.1	27.1	27.1	27.3	29.5
		90	28	26.9	27	27	27.1	27	29
3	100	30	28	27.3	27.4	27.5	27.4	27.5	28.5
		60	28	27.3	27.3	27.5	27.4	27.4	28.5
		90	28	27.3	27.3	27.3	27.2	27.4	28.3
	150	30	28	27.2	27.3	27.3	27.4	27.3	28.6
		60	28	27.2	27.2	27.3	27.1	27	28.4
		90	28	26.9	27	27.3	27.1	27	28.3
	200	30	28	27.3	27.3	27.2	27.3	27.4	29.8
		60	28	27.3	27.2	27.1	27.2	27.3	29.5
		90	28	27	27.1	27.1	27.2	27.3	29