A COMPARISON STUDY OF BIOPOLYMER WITH ALUM IN THE TREATMENT OF WATER

MOHAMAD HAFIDZ BIN MOHD LAZI

CIVIL ENGINEERING

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by

Mohamad Hafidz Bin Mohd Lazi

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32610, Bandar Seri Iskandar,

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Student ID

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Approved by,

____

(Dr. Ho Yeek Chia)

UNIVERSITI TEKNOLOGI PETRONAS
BANDAR SERI ISKANDAR, PERAK
SEPTEMBER 2016

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MOHAMAD HAFIDZ BIN MOHD LAZI

ABSTRACT

There are various types of water treatment plants operating all around the world. Basically, conventional water treatment used coagulation and flocculation process in order to remove colour and the turbidity of the water. There are various type of coagulants and flocculants which are natural, chemical and polymers. Nowadays, wastewater treatment by natural polymers is being increasingly advocated. In this study, commercial polygalacturonic acid is used as biopolymer in water treatment process to evaluate the treatment efficacy in order to compare with alum. The characterization analyses are required for better understanding of the biopolymer.

ACKNOWLEDGEMENTS

First and Foremost, I would like to thank Allah for this huge blessing He given me in order to finish this assignment. Because of this, I have successfully completed the interim report for Final Year Project (FYP).

In undergoing this project, I would like to express my sincere gratitude to my supervisor, Dr Ho Yeek Chia for giving me this golden chance to work and gain experience under her guidance for my FYP 1 and FYP 2. Besides, I would like to thank all the environmental laboratory technicians, who continuously provides a valuable guidance for me in doing my experiment. This cannot be done without the support from them. Thank you also to my parents and my friends for by giving moral support in order for me to complete the project.

Next, I would like to express my deepest appreciation to Universiti Teknologi Petronas (UTP) for establishing this course. From this, students are exposed to the research environment besides are capable to learn in depth about certain topic in their programme.

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CHAPTER 1

INTRODUCTION

1.1 Water

In general, water is a good solvent for a large variety of substances, and is an essential component for all organisms as well as being necessary for most biological processes. 70% of human body is made up of water thus continuous access to sufficient amounts of safe water is crucial for human health and socioeconomic development (Kulinkina et al., 2016). However, the availability of global water and its consequences has drawn a few concerns during the last decades and being described as “global water crisis” (Cain & Gleick, 2005), global “water scarcity” (United Nations, 2013) or even “water wars” (Shiva, 2002). Rapid developments have tainted the quality of drinking water sources in Malaysia (Ab Razak, Praveena, Aris, & Hashim, 2015).

1.2 Water Treatment

There are various types of water treatment plants operating all around the world. Most of them are practically using conventional water treatment system while only a small number of them are using advanced technologies such as Actiflo Clarification System, Ultra Membrane Filtration, Dissolved Air Floatation (DAF) and Ozone (Air Kelantan Sdn. Bhd. (AKSB),2013). Basically, conventional water treatment is divided into three stages: (1) pre-treatment, (2) pre-chlorination, and (3) post-treatment.

Pre-treatment stage includes filtration and aeration process to remove particles such as sands, colour, odour and taste. Next, the purpose of pre-chlorination phase is to remove smaller particles by pre-chlorination, coagulation (use alum), flocculation (use polymer), sedimentation and filtration (rapid sand gravity) process. Lastly, the post-treatment phase involves disinfection, post lime, fluoride and balancing reservoir to remove bacteria and stabilize water hardness. Chlorination process is being replaced by using ozone technology as disinfection (Ab Razak et al., 2015).

1.3 Drinking Water Quality

Water which is intended for domestic purposes must be free from chemical substances and microorganisms in amounts which would provide a threat to human health is generally accepted. Supplies of drinking water should not only be safe and free from threats to human health, but it is also should be as aesthetically attractive as possible. Hence, it is essential to ensure the absence of turbidity, colour and disagreeable or detectable tastes and odour in the water supplies.

Some countries in the world would have established a standards of quality of water and have developed a certain degree of uniformity in methods of analysis and in the expression of the results of such analyses which are applicable to the respective areas. However, there are countries which are lack official or recognized standards of water quality and have no official procedures to analyse the quality and safety of the water.

In collaboration with the Member States and number of experts, the World Health Organization has conducted a study in order to produce technical guidance for regulations on water quality control. The details of chemical and physical requirements can be described as follows:

Table 1.1: Chemical and Physcial Requirements

Aspect	Permissible	Excessive
Total solids	500 mg/L	1500 mg/L
Colour	5 units	50 units

Turbidity	5 units	25 units
Taste	Unobjectionable	-
Odour	Unobjectionable	-
Iron (Fe)	0.3 mg/L	1.0 mg/L
Manganese (Mn)	0.1 mg/L	0.5 mg/L
Copper (Cu)	1.0 mg/L	1.5 mg/L
Zinc (Zn)	5.0 mg/L	15 mg/L
Calcium (Ca)	75 mg/L	200 mg/L
Magnesium	50 mg/L	150 mg/L
Sulphate (SO_4)	200 mg/L	400 mg/L
Chloride (Cl)	200 mg/L	600 mg/L
pH range	7.0 – 8.5	Less than 6.5 or greater than 9.2
Magnesium + Sodium Sulphate	500 mg/L	1000 mg/L
Phenolic Substances (as phenol)	0.001 mg/L	0.002 mg/L

Note: Retrieved from International Standards for Drinking-Water. Copyright 1958 by World Health Organization.

1.4 Problem Statement

Alum is widely used as a coagulant in coagulation and flocculation in water treatment plant. Unfortunately, there are few drawbacks identified when using alum as a coagulant in water treatment plant such as:

a) Consumption of water treated by alum can affect human health.
b) Large volume of sludge is produced.
c) pH reduction since alum react with natural alkalinity in water.
d) Low coagulation efficiency in cold water.
e) Ecotoxilogical impacts when introduced into as post-treatment sludge.
f) High cost because of optimal implementation of alum requires technical skill and training.

The main highlight of using alum as a coagulant during water treatment process; it causes intermediate hazardous to human health as their monomer is neurotoxic and carcinogenic – cause cancer. The prolonged exposure to water with high residual aluminium content is linked to serious health issues, such as the development of Alzheimer's disease and senile dementia. This is being discussed by Wang, Chen, Wang, Yuan, and Yu (2011).

1.5 Objective

There are two main objective of the research which are:

a) To apply biopolymer in kaolin/river water to evaluate the treatment efficacy and compare with alum.
b) To analyse the characterization of the biopolymers.

1.6 Scope of Study

This study covers laboratory experiment that is conducted as a simulation of coagulation and flocculation process in water treatment systems. Scope of analysis of the data gained from the result of the experiment will cover the following analysis:

a) Turbidity.
b) Colour.
c) pH.
d) Biopolymer.
e) Alum.

Besides that, this study characterize biopolymer by using Fourier Transform Infrared Spectroscopy (FTIR). However, there is no toxicological test included for the biopolymers produced.

CHAPTER 2

LITERATURE REVIEW

2.1 Coagulation-flocculation process

Coagulation–flocculation is widely used for wastewater treatment due to its efficiency and involves a simple operation (Kim, 2016). In these processes, the colloidal material in the wastewater is being destabilize by adding the inorganic coagulants and synthetic or natural polymers and cause the small particles to agglomerate into larger settleable aggregates and can be removed easily (Stephenson and Duff, 1996). The coagulation-flocculation process can be used as a pre-treatment prior to biological treatment in order to enhance the biodegradability of the wastewater during the biological treatment and also is a proven technique when used with sedimentation process for the treatment of high suspended solids wastewater especially those formed by colloidal matters (Kim, 2016).

2.2 Coagulant

Coagulation is a process where coagulants are used to neutralise the dispersed colloidal particles charges in order to force the particle to attract each other and agglomerate. There are two types of coagulant that being used which are natural coagulant and chemical-based coagulant. Between those two, the application of natural coagulants have long been acknowledged in traditional water purification which was evident from various ancient records cited by (Bratby, 2006; Dorea, 2006). Natural coagulants are largely non-toxic, eco-friendly and results in less sludge volume in some instances (Ndabigengesere, Narasiah, & Talbot, 1995).

2.3 Flocculant

Flocculants are added to assist the progress of settling of suspended particles in a solution. Flocculants facilitate the accumulation process between particles and, thus, form larger floccules. They tend to settle down due to gravitational force. Flocculants also try to bridge the molecules forming clumps. For example, an anionic flocculant will react with a positively charge polymer and will adsorb those particles. This may cause destabilization due to charge neutralization or bridging. Flocculants are added slowly and mixed gently during the flocculation process. Hence, small flocs can agglomerate into larger particles. Recently, coagulation-flocculation or flocculation processes have also been broadly used for the treatment of pulp mill wastewater. In such studies, various polymers have been tested as a flocculant in the flocculation process such as polyaluminium chloride (PAC), chitosan, polymeric phosphate-aluminium chloride, cationic and anionic polyacrylamides (PAMs) and polydiallyldimethylammonium chloride (polyDADMAC), and various levels of removal efficiency for turbidity and lignin have been obtained (Razali, Ahmad, Ahmad, & Ariffin, 2011; Renault et al., 2009; Wong, Teng, Ahmad, Zuhairi, & Najafpour, 2006; Zheng et al., 2011). There are also organic synthetic polymer flocculants which is more familiar polyacrylamide available in the market; offering a wider selection of chemical coagulants to cater for the diverse requirements of the individual water treatment plants (Bolto & Gregory, 2007).

2. 4 Biopolymer

Wastewater treatment by natural polymers is being increasingly advocated nowadays. The biopolymers which are being currently studied for industrial wastewater treatment are chitosan (Guibal and Roussy, 2007), vegetable tannin (Özacar and Şengil, 2003), *Cassia javahikai* seed gum (Sanghi et al., 2006b), okra gum (Agarwal et al., 2003) and *Ipomea dasysperma* seed gum (Sanghi et al., 2006a). These biopolymers are renewable resources and biodegradable. In the present study, three polysaccharides (biopolymers) have been used as flocculant for separation of pulp fibres. Their efficiency has been compared to alum, which is a known chemical flocculant. The selected biopolymers viz. Guar gum, Locust bean gum and Xanthan gum are non-toxic, biodegradable and widely available (Levy et al., 1995). Guar gum is also a sizing additive commonly used in paper industry (Whistler Roy, 1954).

CHAPTER 3

MATERIALS AND METHODS

3.1.Research Flowchart

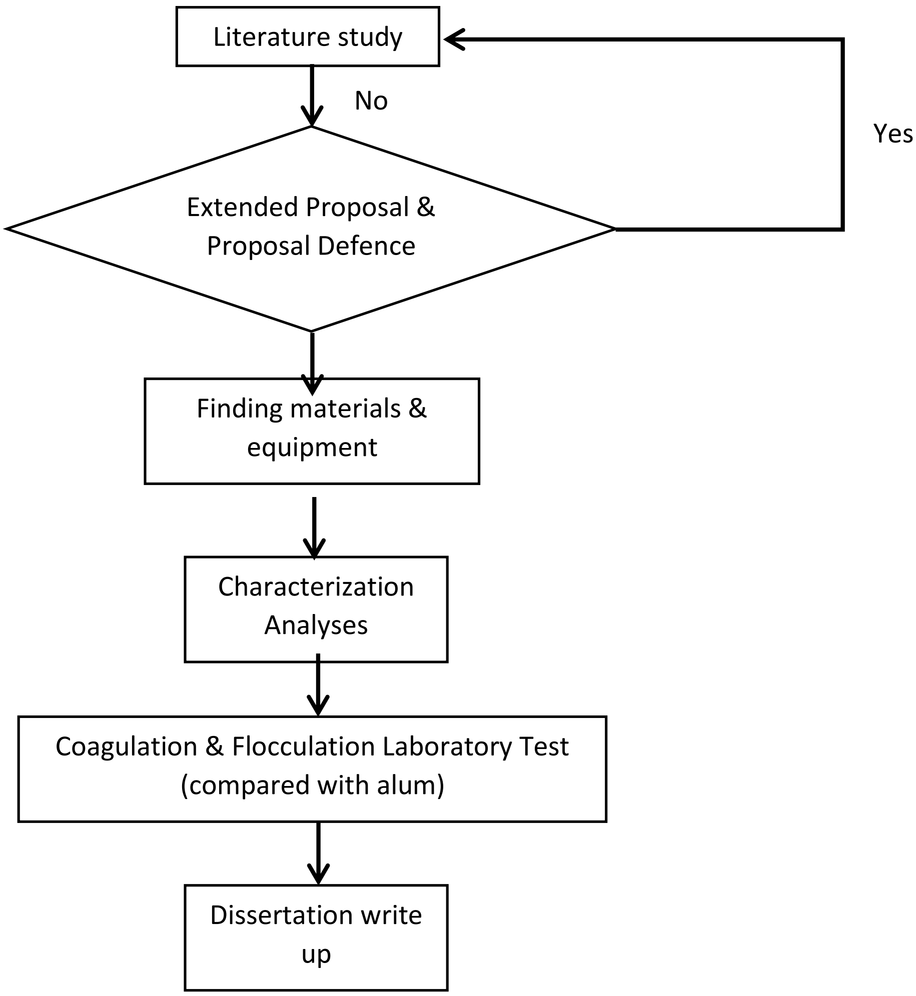

Figure 3.1: Research flowchart of FYP I and FYP 2.

3.2 Preparation of Alum

First, aluminium sulphate powder or are usually called as alum, $Al_2(SO_4)_3$, is taken from the laboratory. Subsequently, 1 g of alum powder is measured and put in the 250 mL of beaker. After that, the beaker is filled with distilled water and the solution is stirred using magnetic stirrer. The solution is poured from the beaker into 1 L of conical flask for dilution process. The beaker is filled again with distilled water and the solution is stirred using magnetic stirrer to make sure the all the alum is fully diluted and pour the solution into the conical flask. Repeat this step until all the powder is perfectly dissolved in the water and there is no undissolved powder of alum in the beaker. After that, the conical flask is filled with until the meniscus of the solution reach the mark on the conical flask. The solution in the conical flask is stirred by using magnetic stirrer until the solution is diluted and well mixed. The solution stored in glass bottle to avoid contamination.

3.3 Preparation of Polygalatrunic Acid

Firstly, polygalatrunic acid is taken from the laboratory. After that, 1 g of alum powder is measured and is put in the 250 mL of beaker. Then, the beaker is filled with distilled water and the solution is stirred using a magnetic stirrer. From here, the solution is poured into 1 L of conical flask in order for a dilution process to take place. The beaker is filled again with distilled water and the solution is stirred using magnetic stirrer to make sure the all the alum is fully diluted and pour the solution into the conical flask. This process is repeated until all the powder is totally dissolved in the water and there is no undissolved powder in the beaker. Subsequently, the conical flask is filled with distilled water until the meniscus of the solution reached the mark on the conical flask. The solution then is stirred using magnetic stirrer until it is diluted and well mixed in the conical flask. Lastly, the solution is stored in a glass bottle to avoid contamination.

3.3 Characterization Analyses

For characterization analyses, the suitable test that can be used towards the biopolymer is Fourier Transform Infrared Spectroscopy, also known as FTIR analyses. FTIR analyses is used to reveal the presence of different functional groups in the biopolymer sample by using Fourier transformed infrared (FTIR) spectrophotometer. In FTIR analyses, the samples are tested in the pellet form. The sample is placed on Potassium Bromide (KBr) plate to form a pellet. Then, the pellet is tested by Perkin Elmer Spectrum One under frequency range of 4000 cm^{-1} to 400 cm^{-1}.

3.4 Application of Coagulation-Flocculation

3.4.1 Application of Coagulation-Flocculation for Alum

Optimum Dosage

The water sample from the nearest river is taken and preserve in the cold room in order to avoid contamination. Then, the sample is taken out and left in the room temperature for a few hours before being used as the sample. The prepared coagulants and the apparatus needed is prepared for the experiment. 1 L of river water sample is poured into 1 L beakers and is placed in flocculator machine. The step is repeated for 5 different beakers to produce another 5 river water sample. Colour, turbidity, pH and temperature of the samples is measured and recorded before starting the experiment. After that, different dosage of coagulant is added for each beaker. The sample is stirred by using the flocculator at 120 rpm for 3 minutes for rapid mix process. After 3 minutes, the speed of the flocculator machines is reduced to 30 rpm for 20 minutes. After 20 minutes, flocculator machine is turned on and the samples is left for 5 minutes in order to allow the flocs to settle at the bottom part of the beakers. The upper part of the sample in each beaker is collected by using syringe. Then, measure and record the pH, colour, turbidity and temperature of the samples as the result of the experiment.

Optimum pH

The water sample from the nearest river is taken and preserve in the cold room in order to avoid contamination. Then, the sample is taken out and left in the room temperature for a few hours before being used as the sample. The prepared coagulants and the apparatus needed is prepared for the experiment1 L of river water sample is poured into 1 L beakers and is placed in flocculator machine. The step is repeated for 5 different beakers to produce another 5 river water sample. The pH of each sample is adjusted according to 4,5,6,7,8 and 9. Colour, turbidity and temperature of the samples is measured and recorded before starting the experiment. After that, similar dosage of coagulant is added for each beaker. The sample is stirred by using the flocculator at 120 rpm for 3 minutes for rapid mix process. After 3 minutes, the speed of the flocculator machines is reduced to 30 rpm for 20 minutes. After 20 minutes, flocculator machine is turned on and the samples is left for 5 minutes in order to allow the flocs to settle at the bottom part of the beakers. The upper part of the sample in each beaker is collected by using syringe. Then, measure and record the pH, colour, turbidity and temperature of the samples as the result of the experiment.

3.4.2 Application of Coagulation-Flocculation for Biopolymer

While conducting this research, it can be concluded that polygalatrunic acid is not effective to be use as coagulants since it has a low efficiency in removing colour and turbidity of the river water. Hence, it is decided to use the polygalatrunic acid as a flocculant along with alum as a coagulant.

Note: The result of polygalatrunic acid as coagulant are included in the Appendix A.

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Optimum Dosage

The water sample from the nearest river is taken and preserve in the cold room in order to avoid contamination. Then, the sample is taken out and left in the room temperature for a few hours before being used as the sample. The prepared coagulants, flocculants and the apparatus needed is prepared for the experiment. 1 L of river water sample is poured into 1 L beakers and is placed in flocculator machine. The step is repeated for 5 different beakers to produce another 5 river water sample. Colour, turbidity, pH and temperature of the samples is measured and recorded before starting the experiment. After that, constant dosage of coagulant is added for each beaker and the sample is stirred by using the flocculator at 120 rpm for 3 minutes for rapid mix process. After 3 minutes, different dosages of flocculant are added into each beaker and the speed of the flocculator machines is reduced to 30 rpm. The samples are stirred for 20 minutes. After 20 minutes, flocculator machine is turned off and the samples is left for 5 minutes in order to allow the flocs to settle at the bottom part of the beakers. The upper part of the sample in each beaker is collected by using syringe. Then, measure and record the pH, colour, turbidity and temperature of the samples as the result of the experiment.

Optimum pH

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CHAPTER 4: KEY MILESTONE AND GANTT CHART

4.1 Key Milestone

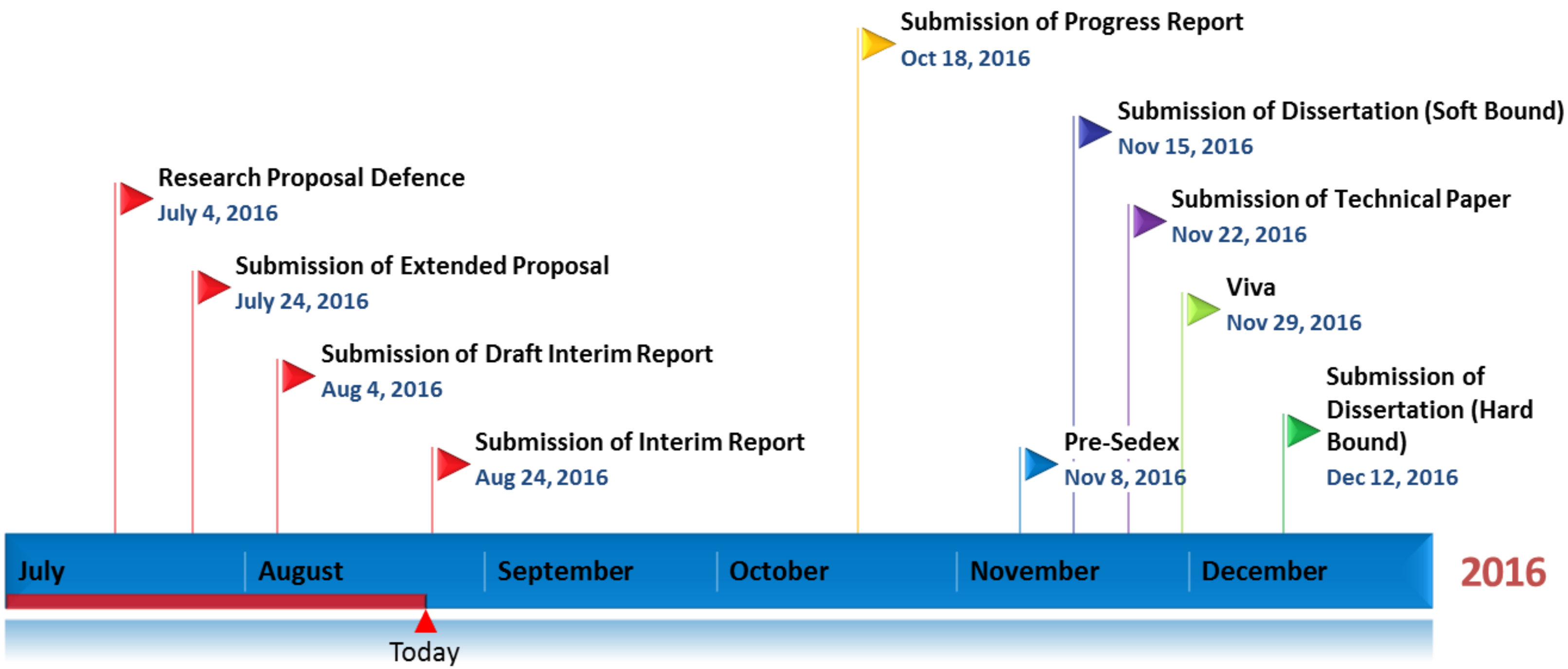

Figure 4.1 Key Milestone

Each of the milestones marks a significant progress for my Final Year Project I and Final Year Project II. The key milestone is achievable as being set.

4.2 GANTT Chart

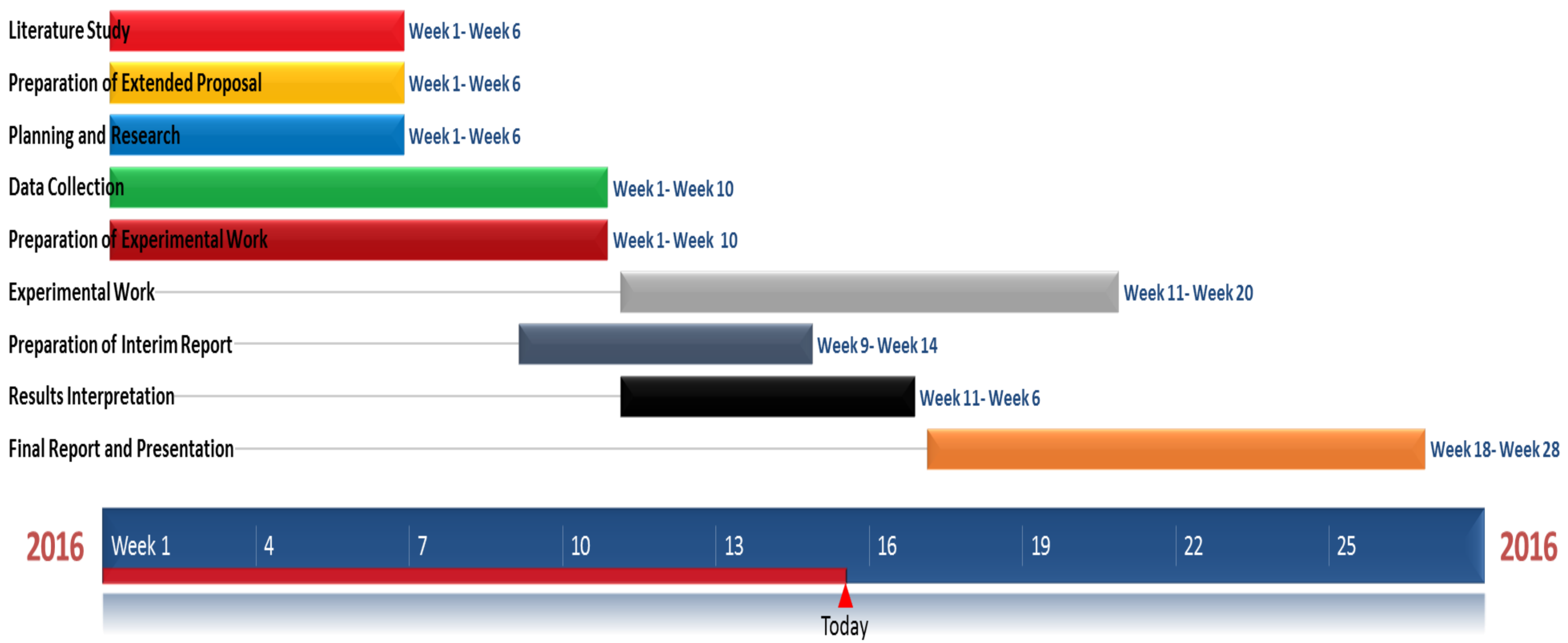

Figure 4.2 GANTT Chart

CHAPTER 5

RESULT AND DISCUSSION

5.1 Result of Optimum Dosage of Alum

Below is the result of the jar test (optimum dosage) conducted by using alum as the coagulant.

Table 5.1: Result of jar test (optimum dosage) of alum

Dosage of Alum (mg/L)	Colour Removal Efficiency (%)	Turbidity Removal Efficiency (%)
1	-5.18	-12.78
2	-4.17	-11.28
3	-7.43	3.76
4	0.79	-4.51
5	7.92	6.02
6	5.07	11.28
7	8.56	10.80
8	13.34	18.75
9	24.01	30.68
10	65.32	68.47
11	82.70	83.52
12	95.77	95.61
13	97.17	96.76
14	97.25	97.10
15	97.05	97.00
16	96.66	96.18
17	96.17	95.76
18	94.79	94.85

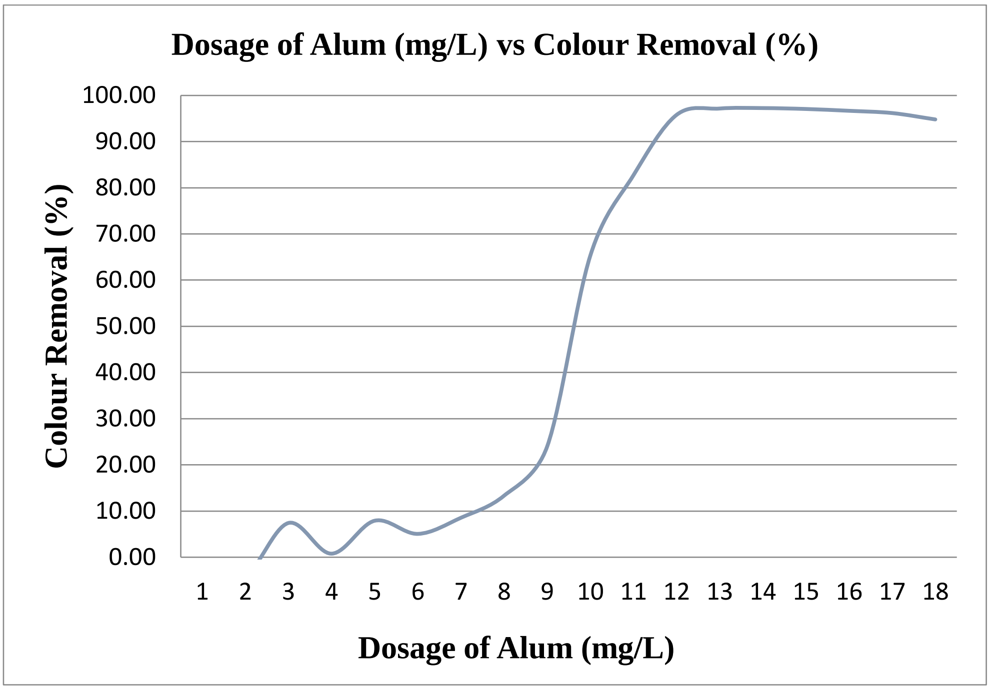

Figure 5.1: The graph of Dosage of Alum (mg/L) vs Colour Removal (%)

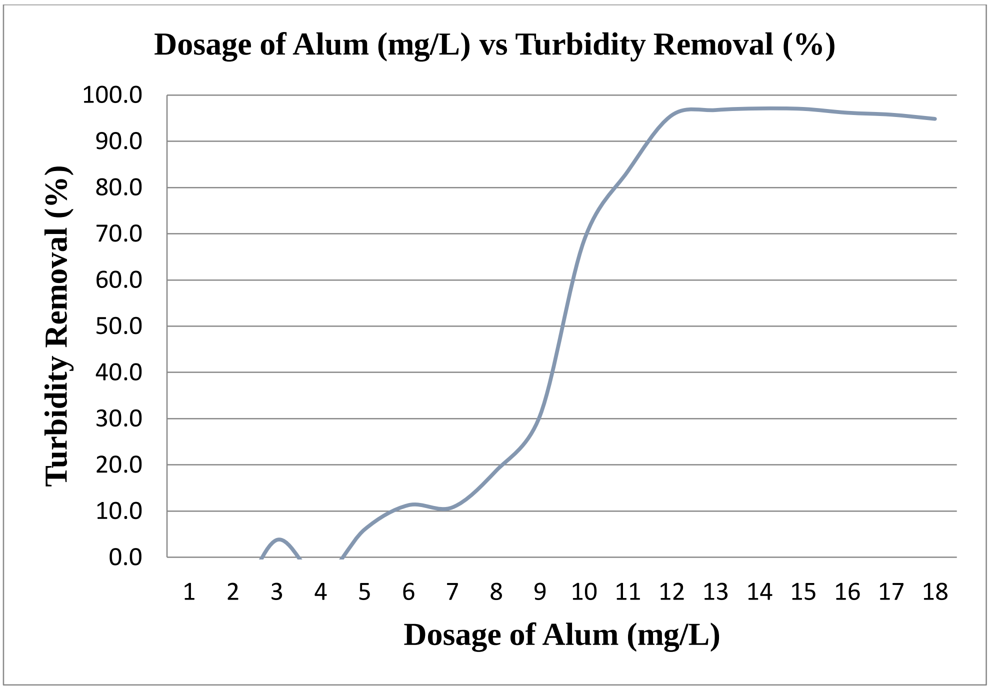

Figure 5.2: The graph of Dosage of Alum (mg/L) vs Turbidity Removal (%)

Discussion:

Based on the graph 5.1, the colour removal efficiency of dosage 1 mg/L to 7 mg/L is very low. This happened due to insufficient dosage of alum in the sample. Whereas for dosage 8 mg/L to 13 mg/L, the colour removal efficiency increase directly proportional to dosage of alum. This happened due to increasing dosage of alum being apply to the sample. While for dosage from 13 mg/L to 14 mg/L, the graph shown a slightly increment of colour removal efficiency before starting to decrease at the dosage of 14 mg/L to 18 mg/L. The increment occurred from dosage of 13mg/L to 14 mg/L showed that the dosage of alum is reaching state while the decrement occurred from dosage 14 mg/L to 18 mg/L showed that the dosage of alum is already overdosed.

Based on the graph 5.2, it could be shown that the turbidity removal efficiency of dosage 1 mg/L to 7 mg/L is very low. This is because the insufficient dosage of alum being applied to the sample. While for dosage 8 mg/L to 13 mg/L, it can be observed that the turbidity removal efficiency increase directly proportional to the dosage of alum.This happened due to increasing dosage of alum being applied to the sample. From dosage of 13 mg/L to 14 mg/L, there is a slight increment of turbidity removal efficiency. This is because the dosage of alum applied in the sample is reaching optimum dosage. Whereas from dosage of alum from 14 mg/L to 18 mg/L, there is a slight decrement occurred in turbidity removal efficiency. This happened due an excessive dosage of alum being applied to the sample.

Based on the observation above, it can be concluded that the optimum dosage of alum is 14 mg/L. As a proof, the portrayed graph shown the highest colour removal efficiency and highest turbidity removal efficiency at the dosage of alum of 14mg/L.

5.2 Result of Optimum pH of Alum

Below is the result of the jar test (optimum pH) conducted by using alum as the coagulant.

Table 5.2: The result of jar test (Optimum pH) of alum

pH	Turbidity Removal Efficiency (%)	Turbidity Removal Efficiency (%)
4	89.37	91.35
5	96.54	96.44
6	97.94	97.81
7	97.61	97.73
8	73.87	78.23
9	40.64	50.70

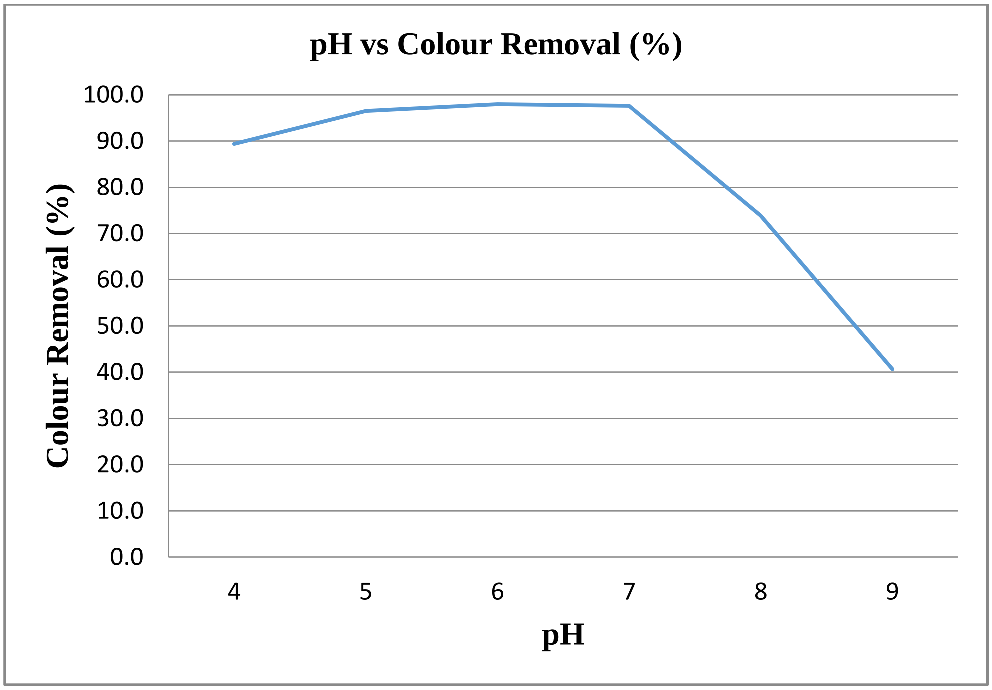

Figure 5.3: The graph of pH vs Colour Removal (%)

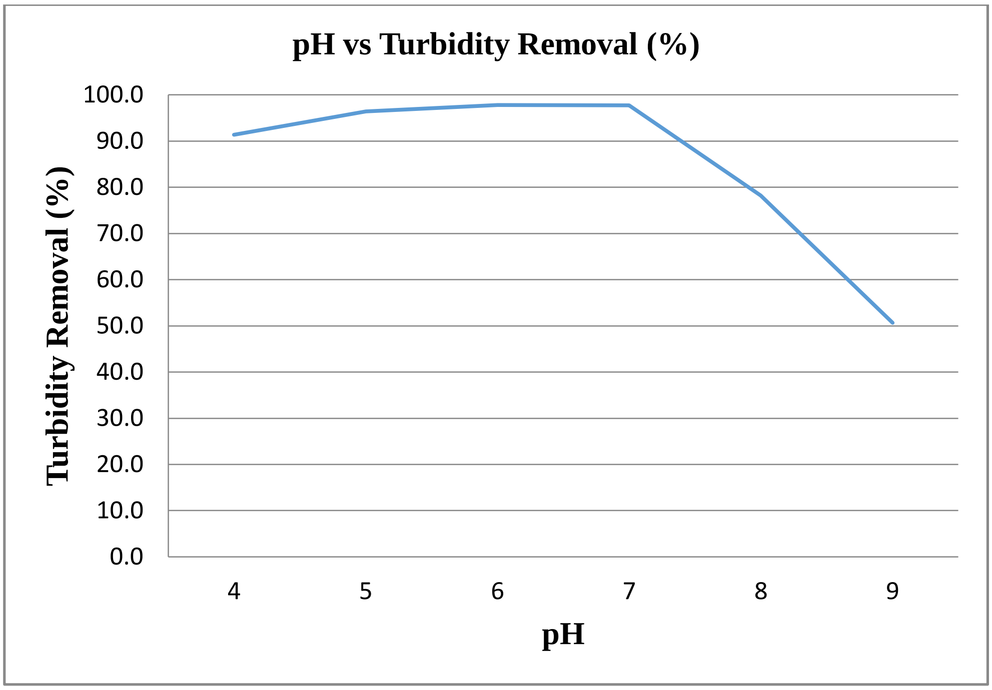

Figure 5.4: The graph of pH vs Turbidity Removal (%)

Discussion:

Based on the graph 5.3, the colour removal efficiency is increasing from pH 4 to pH 7 before falling rapidly from pH 7 to pH 9.

Based on the graph 5.4, the turbidity removal efficiency is rising from pH 4 to pH 7 before it fall dramatically from pH 7 to pH 9.

Based on the result above, it can be concluded that the optimum pH for alum is 6. This result also proves that alum is not effective in pH 7 and above.

5.3 Result of Dosage Adjustment of Biopolymer

Below is the result of the jar test (Dosage adjustment) conducted by using different dosage of biopolymer as flocculant, used along with 10 mg/L of alum as coagulant at natural pH of the sample which is around pH 6.

Table 5.3: Result of jar test (dosage adjustment) of biopolymer.

Dosage of Biopolymer (mg/L)	Colour Removal Efficiency (%)	Turbidity Removal Efficiency (%)
0.1	93.61	98.97
0.5	88.51	98.39
1	89.09	98.36
5	88.51	98.23
10	91.03	98.64
20	87.22	98.08

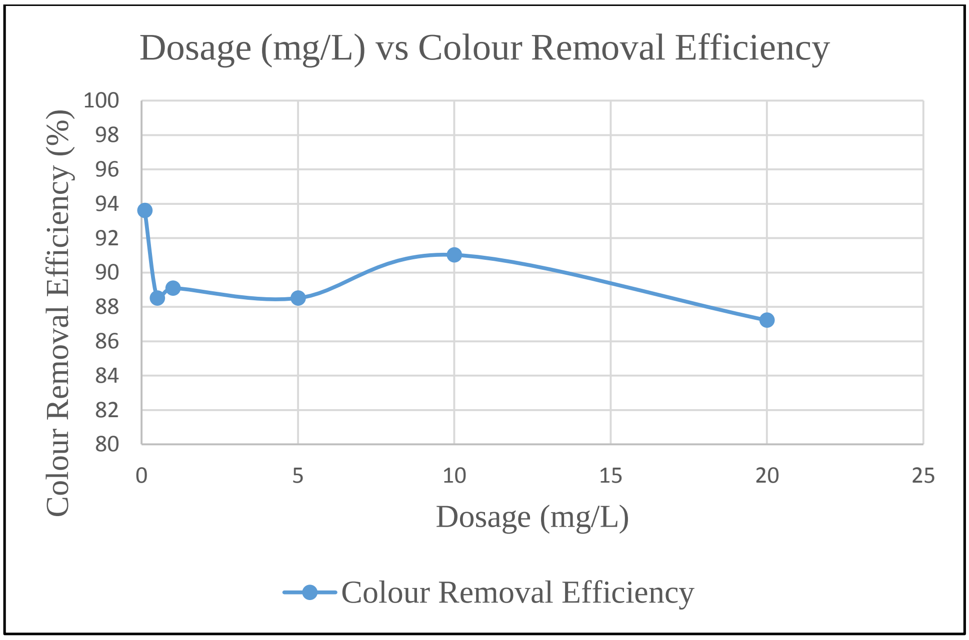

Figure 5.5: The graph of Dosage of Biopolymer (mg/L) vs Colour Removal Efficiency (%)

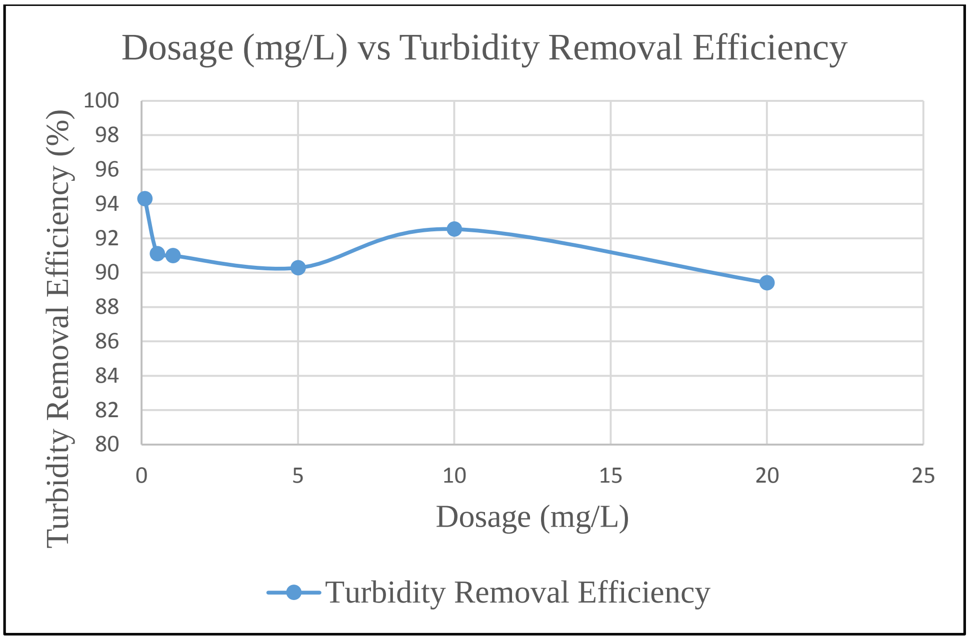

Figure 5.6: The graph of Dosage of Biopolymer (mg/L) vs Turbidity Removal Efficiency (%)

Discussion:

Based on the graph 5.5, it can be observed that at the dosage of 0.1 mg/L, the colour removal efficiency is the highest. The reading then decreases for dosage of 5 mg/L before increasing again at dosage of 1mg/L. For dosage of 5 mg/L, the colour removal efficiency shows a slightly decrease compared to dosage 1 mg/L. Whereas for dosage 10 mg/L, the colour removal efficiency shows a big increment before starting to decrease rapidly at the dosage of 20 mg/L. This happened due to the overdosed of the biopolymer.

Based on the graph 5.6, it can be observed that the dosage of 0.1 mg/L has highest turbidity removal efficiency is the highest. The graph also shows a slight decrement from dosage of 0.1 mg/L until dosage of 5 mg/L before starting to increase again at dosage of 10 mg/L. However, the turbidity removal efficiency shows a bigger decrement from dosage 10 mg/L to 20 mg/L.

5.4 Result of pH Adjustment for Biopolymer

Below is the result of the jar test (Optimum pH) conducted by using 0.5 mg/L of dosage of biopolymer as flocculant, used along with 10 mg/L of alum as coagulant.

Table 5.4: The result of jar test (Optimum pH) of biopolymer

pH	Turbidity Removal Efficiency (%)	Turbidity Removal Efficiency (%)
4	71.10	81.49
5	88.88	92.65
6	69.00	80.12
7	68.82	79.36
8	34.83	55.82
9	22.88	45.78

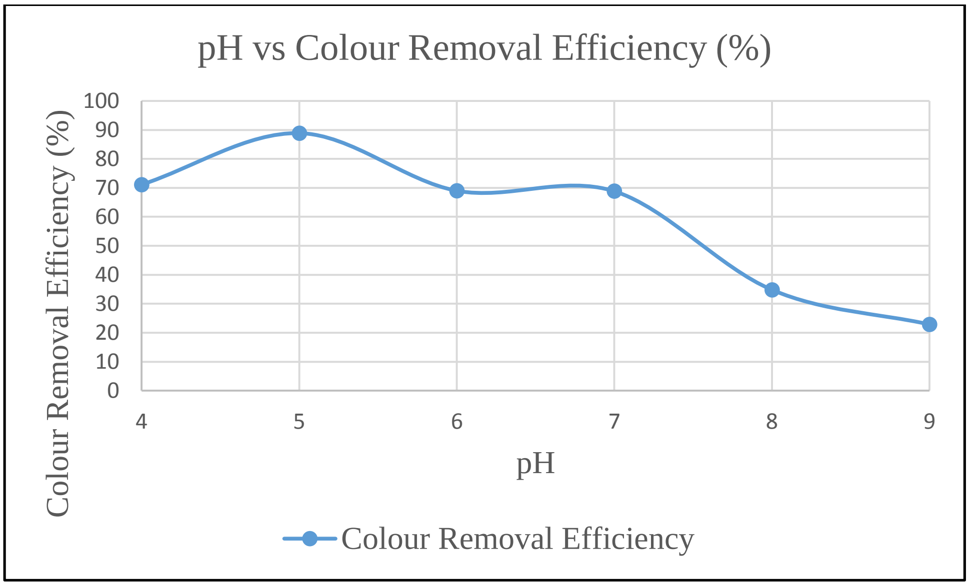

Figure 5.7: Graph of pH vs Colour Removal Efficiency (%)

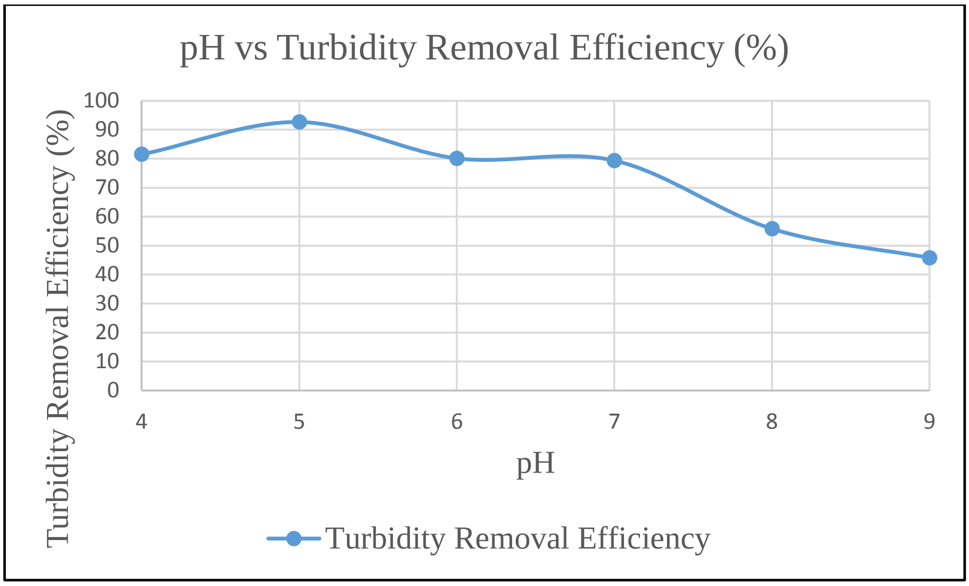

Figure 5.8: Graph of pH vs Turbidity Removal Efficiency (%)

Discussion:

Based on the graph 5.7 and 5.8, it can be observed that the colour removal efficiency increase from pH 4 to pH 5 as well as turbidity removal efficiency, before showing a rapid decrement from pH 5 to dosage 6. While for pH 6 to pH 7, the colour removal efficiency and turbidity removal efficiency only shows a slight decrement compared to pH 5 to pH 6. Then colour removal efficiency and turbidity removal efficiency start to decrease rapidly from pH 7 until pH 9.

With the increase of pH over the optimum pH, the percent removal of turbidity and colour decreased. Optimum removal efficiency was observed at pH 5.0 with 92.65% turbidity removal and 88.88% colour removal. This reading shows the optimum pH for the biopolymer to react is pH 5. Optimum efficiency at pH 5.0 is due to metal ion precipitation in hydroxide form. Usually, the change in pH do not affect the efficiency of the natural polymer (A Mishra, Agarwal, Bajpai, Rajani, & Mishra, 2002).

5.5 Result of Optimum Dosage and Optimum pH for Biopolymer

Below is the result of the jar test (Optimum Dosage) conducted by using different dosage of biopolymer as flocculant, used along with 10 mg/L of alum as coagulant at optimum pH for biopolymer which is around pH 5.

Table 5.3: Result of jar test (dosage adjustment) of biopolymer.

Dosage of Biopolymer (mg/L)	Colour Removal Efficiency (%)	Turbidity Removal Efficiency (%)
0.1	93.12	95.39
0.2	91.29	91.94
0.3	92.93	95.49
0.4	94.19	96.36
0.5	92.49	95.03
0.6	92.42	95.13

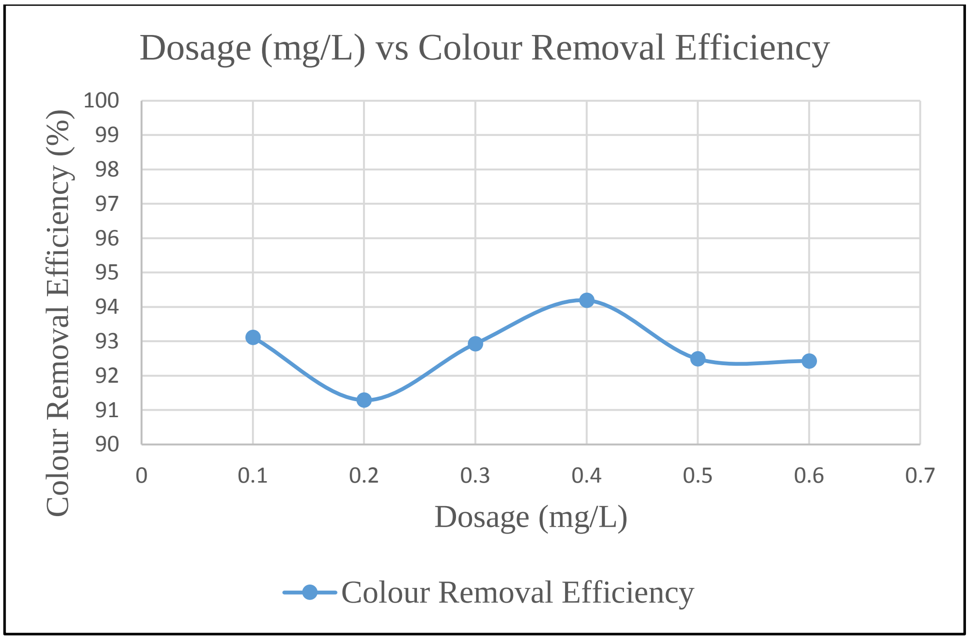

Figure 5.9: The graph of Dosage of Biopolymer (mg/L) vs Colour Removal Efficiency (%)

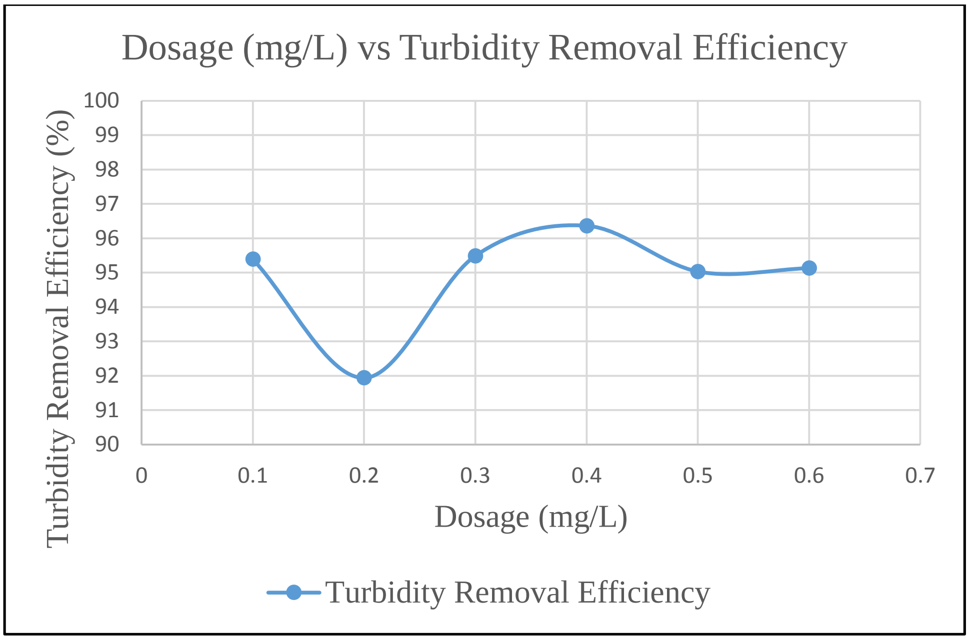

Figure 5.10: The graph of Dosage of Biopolymer (mg/L) vs Turbidity Removal Efficiency (%)

Discussion:

Based on the graph 5.9 and 5.10, it can be observed that the colour removal efficiency decreases from dosage of 0.1 mg/L to dosage 0.2 mg/L as well and the turbidity removal efficiency before showing a rapid increment from 0.2 mg/L until 0.5 mg/L. Then, the colour removal efficiency and turbidity removal efficiency start to decrease rapidly from dosage of 0.4 mg/L to 0.5 before slightly increasing at 0.6 mg/L dosage of biopolymer compared to 0.5 dosage of biopolymer. This happened due to the overdosed at dosage of 0.5 mg/L.

Based on the graphs, it can be concluded that optimum removal efficiency was observed at dosage 0.4 mg/L with 96.36% turbidity removal and 94.19 % colour removal. This reading shows the optimum dosage for the biopolymer is 0.4 mg/L.

Bridging function of the polymer bridging plays a great role in flocculation process. Hence, the higher the dosage of the flocculant, the more likely the aggregation between colliding particles. An over-optimum quantity of flocculant causes the aggregated particles to redisperse and disturbs particle settling (Anuradha Mishra & Bajpai, 2005).

5.6 Characterization Analysis

FTIR Analysis

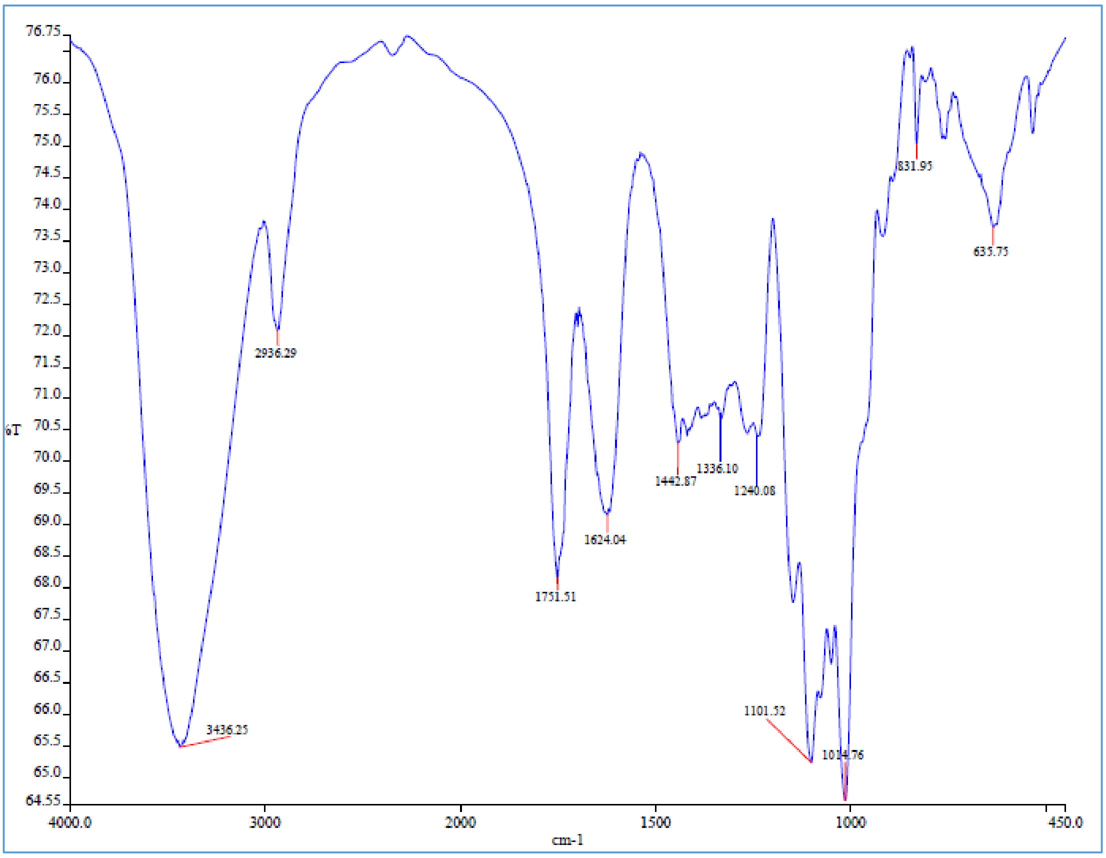

Figure 5.9: Graph of FTIR Analysis Result (%)

In the polymeric form of galacturonic acid, the OH− concentration in the solution affects the quantity of available COO^- adsorption site. This is shown by the equation below (Yin, 2010).

$$R{-}COO^{1-} + H^2O \rightleftharpoons R{-}COOH + OH^{1-}$$

The major functional groups present in polygalatronic acid were identified by using infrared spectroscopy. The FT-IR spectrum of polygalatronic shown above allows assigning characteristics compatible with polysaccharide substances. The absorption peaks around 1200–950 cm^{-1} are considered characteristic polysaccharide bands. Hence, it could be indicated that the presence of −C−O− bonding of alcohol, ether, etc., assigned to the vibration of axial deformation of the C−O of alcohol and the vibration of axial deformation of O−C−O systems (de Jesus, Cruz, Pacífico, & Silva, 2013).

The adsorption peaks in the region of 2930 cm^{-1} indicate the C−H asymmetric stretching related to aromatic rings. Whereas at the peaks of 1630 cm^{-1} refers to stretching of the C=O (carboxylic acid carbonyl) bond, while the angular deformation on the OH bonding plane occurs at 1420 cm^{-1}. At 1240 cm^{-1}, to C−O stretching in complex polysaccharides at the peak of 1051 cm^{-1} refers to the stretching of the C−O−C group in polysaccharides. The bigger band in the region of 3200–360 cm^{-1} with a sharp peak in the region near 3400 cm^{-1} is characteristic of stretching and deformations of the hydroxyl groups (−OH). These groups serve as active sites for the attachment between colloidal particles (Lima, Cabral, Neto, Tavares, & Pierucci, 2012).

CHAPTER 7: CONCLUSION AND WAY FORWARD

Water treatment by coagulation and flocculation using only chemical coagulant (Alum) efficiently removed 97.94% of turbidity and 97.81% of colour of the water in its optimum state which is at the dosage of 14 mg/L in pH 6.

Based on the result, the optimum condition of the polygalatrunic acid as flocculant is at the dosage of 0.4 mg/L in pH 5, with help of 10 mg/L of alum as coagulant. Water treatment by coagulation and flocculation which using chemical coagulant (Alum) and biopolymer (polygalatrunic acid) as flocculant has efficiently removed 94.19% of colour and 96.36% of turbidity of the water sample in its optimum state. This proves that polygalatrunic acid has a great potential flocculant. conclusion, the expected result for this project is the biopolymer that will be extracted from plant can be a good coagulant and flocculant in water treatment process.

All objectives of the project can be achieved through the research flowchart proposed by the authors.

As conducting the study, it is recommended to use the pre-treatment effluent as the water sample for a constant initial condition of the sample.

The obtained result might have some inaccuracy and errors. Hence, the experiment should be conducted according to the correct procedures and techniques. By ensuring all apparatus and equipment in excellent condition could increase the accuracy of the results. It is also advisable to avoid any contamination towards any chemicals used in order to obtain a good result.

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APPENDICES

APPENDIX A:

Below is the result of the jar test (dosage adjustment) which using biopolymer (galatrunic acid) as coagulant.

Dosage of Biopolymer (mg/L)	Colour Removal Efficiency (%)	Turbidity Removal Efficiency (%)
1	-0.12	1.44
5	6.15	10.79
10	7.42	9.35
20	8.58	12.95
50	7.54	10.07
75	9.68	11.71
100	11.22	13.96
200	16.22	19.37
300	12.31	26.01
400	11.30	28.72
500	6.62	26.01

Below is the result of the jar test (pH adjustment) which using biopolymer (galatrunic acid) as coagulant.

pH	Colour Removal Efficiency (%)	Turbidity Removal Efficiency (%)
4	-27.36	-8.94
5	-26.29	-4.88
6	-25.68	-3.25
7	-140.88	-48.78
8	-31.16	-8.94
9	-36.47	-9.76