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Academic Session : 2015/2016

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Date: 30 JUNE 2016 Date: 30 JUNE 2016

COAGULATION AND [illegible] ATED BAUXITE WATER AT SUNGAI PE [illegible] LYSACCHARIDE BIOCOAGULANT

NURSYAFIRAH BINTI ROSLI

Report submitted in fulfilment of the requirements for the award of the degree of Bachelor of Civil Engineering with (Hons)

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

2016

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this report and in my opinion, this report is adequate in terms of scope and quality for the award of the degree in B. ENGINEERING (HONS.) CIVIL ENGINEERING in Universiti Malaysia Pahang.

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STUDENT'S DECLARATION

I hereby declare that the work in this report entitled " Coagulation and Flocculation of Contaminated Bauxite Water at Sungai Pengorak by using Linear Polysaccharide Biocoagulant" is the result of my own research except quotation and summaries which have been duly acknowledged. The report has not been accepted for any degree is not concurrently submitted for any award of other degree.

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Dedicated to my loving parents and family,

supervisor and friends.

ACKNOWLEDGEMENTS

I am particularly grateful for the assistance given by my supervisor, Dr Mohd Yuhyi bin Mohd Tadza for his valuable and constructive suggestion during the early planning and development of this research work. He gave lots of advice and guidance throughout this research and also in writing this thesis. With his helped, it simplifies the process of this research. Any errors and mistakes made during the research and thesis writing were corrected by his helped. All of that was not only for the research and thesis but also for the future career.

I would like to express my sincere to technical staff of the Civil Engineering Department at UMP, the Environmental Laboratorty which is Puan Norazimah binti Abdul Aziz, Encik Mohd Qori bin Mohd Nor and Encik Ahmad Suhaimi bin Embong for their assistance in the laboratory and giving me endless guidance when carrying out the experiment for this research.

Besides that, I also would like express my sincere thanks also to my labmates Tan Yee Ling and Iffah Farzana for the valuable help during the experiments process.

Last but not least, appreciation and gratitude to my loving parents and family for encouragement, moral support and love. Patience and help from both of them does helped me completing this research and thesis writing successfully. No words can describe how thankful I am for them for always be on my side and helped me through the journey following my dreams.

ABSTRACT

Bauxite is a naturally occurring, heterogeneous weathering product composed primarily of one or more aluminium hydroxide minerals, plus various mixture of silica (Si_2), iron oxide (Fe_2O_3), Titania (Ti_2) and other impurities in minor or trace amounts (Shaffer and Patterson et al, 1983) . Aluminium toxicity in soils is particularly harmful because it causes shallow rooting, drought susceptibility, and deficient nutrients input. Bauxite forms a major resource of aluminium in Kuantan, Pahang. The objective of this research work is to investigate the potential and effectiveness of Linear Polysaccharide as biocoagulant to coagulate and flocculate the bauxite contaminated river at Sungai Penggorak, Kuantan, Pahang. Sample water river from Sungai Penggorak are been collected. Nine parameter are determined which is ph, Total Dissolved Solid (TDS), Dissolved Oxygen (DO), Turbidity, Colour, Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Ammonia Nitrate (AN). Then, it treated using conventional of coagulation and flocculation method by using Linear Polysaccharides as biocoagulant. The water quality condition are measured on its classes which is Class I, II, III, IV or VI by using Water Quality Index (WQI), Interim National Water Quality Standard (INWQS) and National Drinking Water (NDWQS). The selection of and optimum dosages of, pH and hydraulic retention time (HRT) are determined experimentally by using conventional Jar Test. The results indicated that the optimum dose which is 1 g/L was sufficient to improve the water quality parameter to safe level at pH 7. The results was followed the drinkable standards of (WQI), (INQWS) and (NDWQS) from Class IV to Class I which is tested at optimum conditions.

ABSTRAK

Bauxite ialah produk semula jadi heterogen luluhawa terdiri terutamanya daripada satu atau lebih mineral aluminium hidroksida, ditambah dengan pelbagai campuran silika (SI_2) besi oksida (Fe_2O_3) Titania (Ti2) dan kekotoran lain dalam kecil atau mengesan jumlah (Shaffer dan Patterson et al, 1983). Ketoksikan aluminium dalam tanah amat berbahaya kerana ia menyebabkan perakaran cetek, kemarau kerentanan, dan nutrien kekurangan input (Kabata-Pendias dan Mukherjee, 2014). Bauxite membentuk sumber utama aluminium di Kuantan, Pahang. Objektif penyelidikan ini adalah untuk menyelidik potensi dan keberkesanan Linear Polisakarida sebagai biocoagulant untuk membeku dan flokulate sungai tercemar bauksit di Sungai Penggorak, Kuantan, Pahang. Sampel air sungai dari Sungai Penggorak sedang dikumpulkan. Sembilan parameter ditentukan ialah ph, jumlah terlarut pepejal (TDS), terlarut Oxygen (DO), kekeruhan, warna, jumlah pepejal terampai (TSS), Biochemical Oxygen Demand (BOD) permintaan oksigen Kimia (COD) dan ammonia nitrat (AN). Kemudian, ia dirawat menggunakan konvensional pembekuan dan kaedah pemberbukuan dengan menggunakan Linear Polisakarida sebagai biocoagulant. Keadaan kualiti air diukur pada kelas yang merupakan kelas I, II, III, IV atau VI dengan menggunakan Indeks Kualiti Air (WQI), Standard Interim Kualiti Air Kebangsaan (INWQS) dan Air Minuman Kebangsaan (NDWQS). Pemilihan dos yang optimum, ph dan masa tahanan hidraulik (HRT) ditentukan secara uji kaji dengan menggunakan Ujian Jar bukannya secara kuantitatif dengan formula. Melalui keputusan, didapati optimum dos sebanyak 1 g/L adalah mencukupi bagi merawat air dan dengan menggunakan pH 7. Kualiti air bertambah baik untuk piawaian yang boleh diminum oleh (WQI), (INWQS) dan (NDWQS) dari Kelas IV kepada Kelas I yang diuji pada keadaan optimum.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Bauxite is a naturally occurring, heterogeneous weathering product composed primarily of one or more aluminium hydroxide minerals, plus various mixture of silica (Si_2), iron oxide (Fe_2O_3), Titania (Ti_2) and other impurities in minor or trace amounts (Shaffer and Patterson et al, 1983). (Hyslop, 2012) classified the end of product of the process is a slurry of aluminate ions which separated by filtration from the mixture of basic iron and silicon oxides, commonly knows as 'red mud'. Overflow of toxic "red mud" created serious pollution to nearby Pengorak river and beach. Bauxite mining damages forests, pollutes waterways, and encroaches on agriculture land often displacing small farmers (Mimi Sheller , 2014).

Due to the advent of increasing human populations, the range requirements for water has increased with higher demands for higher water quality. Water pollution due to the deforestation and destruction of watersheds due to industrial and residential development have aggravated the problem soil erosion and river siltation (Akhtar, 2002). The source of most of these contaminants is sewage from human habitations and industries, although this is not exclusive and there are other sources. The water sources most likely to be affected are surface waters by sewage effluent and diffuse agriculture inputs (Tortajada, 2013). The effect of pollution does not remain at the place where it is polluted but travels several kilo meters radius from the point of discharge (Amankwah Emmanuel, 2013). From bauxite mining, aluminium toxicity in soils is particularly harmful because it causes shallow rooting, drought susceptibility, and deficient nutrients input (Kabata-Pendias and Mukherjee, 2014).

The use of conventional treatment like alum based coagulant will inevitably increase the concentrations of aluminium in the water, hence would not be advisable. An alternatives approach using non-aluminium, non-chemical based coagulant could minimised this effect. In this study, Pengorak river contaminated raw water was collected and treated with polysaccharide based biocoagulant. As a treatment, linear polysaccharide biocoagulant are one of the coagulant to treat the pollution water. Linear Polysaccharide or knows as Chitosan (N-acetyl-D-glucosamine) is a cationic biodegradable biopolymer produced by the extensive deacetylation of chitin obtained from shrimp shell wastes (Ahmad and Sumathi, et al Hameed,2006). Linear Polysaccharide Biocoagulant has been recommended as a suitable coagulant resources material because of its excellent properties such as biodegradability, biocompability, adsorption properly, flocculating ability, polyelectrolisity and its possibilities of regeneration in number of applications (Ahmad and et al Hameed,2006).

1.2 PROBLEM STATEMENT

Water quality of rivers, stream and lakes are one of the most common issues in Malaysia. Government, private company and publics are aware about the future rivers conditions.

Water quality river of Sungai Pengorak, Kuantan, Pahang has contaminated by the bauxite activities and has been chosen for the study of the quality because of its importance and functions to the societies. They used this river as water sources due to rapid development and urbanization process around the area. Kuantan's residents are at risk of metal poisoning from bauxite mining in the state. Toxic run-off from bauxite mines and processing plants are seeping into rivers that provide the main water supply. Digging at bauxite sites causes irreparable damage to topsoil and the environment. When red sludge from the mining process is dumped on the ground, toxic chemicals seep into the underground water table when it rains, which in turn contaminates main water sources. The effects of red sludge can be clearly polluted during rainy season especially on monsoon seasons.

Therefore, it is important to study the level of pollution in the river and determine the causes of pollution in order to recommend suitable solutions for this problem. Besides, the polluted river will influence the look, colour and the smell of the river. Clean water supply is needed to protect health of consumer and preserving the environment of the ecosystem of river.

1.3 OBJECTIVE

The objective of this study are as following:

1) To determine the water quality parameters of Sungai Pengorak, Kuantan based on Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD5), Chemical Oxygen Demand (COD), Total Suspended Solids (SS), Ammonia Nitrogen (AN), Total Dissolve Solid (TDS), Turbidity and pH.

2) To classify the quality of Sungai Pengorak, Kuantan based on Water Quality Index (WQI), Interim National Water Quality Index (INWQS) and National Drinking Water Quality Index (NDWQS).

3) To determine the optimal dosage and effectiveness of Linear Polysaccharide Biocoagulant needed for contaminated bauxite water treatment.

1.4 SCOPE OF STUDY

Scope of this study are as follows:

1) The scopes of this study are to determine the water quality at Sungai Pengorak, Kuantan, Pahang.
2) Laboratory test are conduct by using Jar Test to identify the effectiveness of optimum dosage.
3) Analysis the water river quality based on method which is known as coagulation and flocculation methods.
4) Testing the water quality parameters based on the Water Quality Index (WQI), National Water Quality Index (NWQS) and National Drinking Water Quality Index (NDWQS).

1.5 SIGNIFICANT OF STUDY

The significant of this study are :

1) To know the level of water quality at Sungai Pengorak, Kuantan caused by the discharge from the human activities of digging bauxite.

2) Further actions can be imply to improve the level of quality water and method can be able to treat or improve the polluted point sources.

3) The data obtained from this research can be used as a reference for further researches.

1.6 THESIS LAYOUT

This thesis consists of 5 concept line chapters:

Chapter 2: This chapter present the literature review related to the study. This chapter includes bauxite contamination water, the treatment for contaminated bauxite water by using linear polysaccharide biocoagulant, coagulation and flocculation process, water quality measurements which Water Quality Index (WQI), Interim National Water Quality (INWQS) and National Drinking Water Quality Standard (NDWQS).

Chapter 3: This chapter explains the methodologies adopted in this study. This chapter covers the material used for the water treatment process, water quality parameters, water quality analysis, the preparation of coagulant, jar test method which is to find the optimum dosage, pH and hydraulic retention time (HRT) and coagulation and flocculation processes of raw water.

Chapter 4: Further discussions were explained in this chapter. The result of initial water quality and it optimal dosage, pH and hydraulic retention time (HRT). The water quality of bauxite contaminated after treatment by using linear polysaccharide biocoagulant based on water quality of Water Quality Index (WQI), Interim National Water Quality (INWQS) and National Drinking Water Quality Standard (NDWQS).

Chapter 5: The last chapter refers to the conclusion and recommendation of the research.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND

The very valuable and quality freshwater resources for human is rivers. The convenience and distribution of freshwater of river may give effect on social life and economic. Major river water are commonly uses as water supply, municipal waste disposal and supplies, irrigation of agriculture lands and also as aesthetical value of the country. Furthermore, due to rapid development and growing population, the demand for clean and portable water has increased extremely. Not only humans are need the freshwater but the aquatic life that live in water need as their habitat needs the freshwater and as the same time give the protein source for humans life. Regulation and diversion of river water can have deleterious effect on invertebrates and marine fish in coastal waters (Maitland and Morgan, 1997).

Water pollution is caused mainly by the discharged of untreated or inadequately treated sewage, industrial effluent and waste-water runoff from households. The absence or deficiency of sewage and refuse collection services causes water courses become grossly polluted (Brebbia & Antunes do Carmo, 2006). Polluted water can spread diseases amongst people who use it for washing, cooking or bathing. There is a risk of contamination to ground water, water supplies from wells and agriculture users (Brebbia & Antunes do Carmo, 2006). Most plant nutrients and other chemicals in the water come directly from rainfall that has fallen on the catchment and accumulated a variety of ions there. The clearing of forests increases the runoff of surface water and the rate of soil erosion, with subsequent silting and nutrients increases in the waters draining such areas. Thus, human activities within the catchment can have a direct effect on river water quality by exposing soils to rainfall and by adding fertilizers and other chemicals, which may be washed into the river, often via drains and ditches (Maitland and Morgan, 1997).

Thus, it is vital that every effort from all agencies should be made to protect and conserve water resources especially river are saved from been contaminated by others humans activity that affect the quality of the rivers. Several agencies have been established to manage various aspects of inland water including the enforcement of related laws, one of which is the Department of Environment, under the Ministry of Natural Resources and Environment. The pollution control strategy is implemented through the two principal tasks of river pollution prevention and a water quality programme (Mustafa, Maizatun, 2011).

2.2 CONTAMINATED OF BAUXITE WATER

Bauxite is an aluminium ore from which aluminium products are made. However, the extraction process releases large amounts of hazardous wastes such as arsenic, beryllium, cadmium, lead, manganese, chromium, nickel, mercury and naturally-occurring radioactive materials. Digging activity at bauxite sites causes irreparable damage to topsoil and the environment. When red sludge from the mining process is dumped on the ground, toxic chemicals seep into the underground water table when it rains, which in turn contaminates main water sources. There are only two sources of water that supply in the remaining 99 percent of the total demand which is raw water from natural surface and subsurface sources and rainfall (Donaldson and Raahauge, 2013) .

Andrews et al, 2001 thought that the river receives bauxite processing waste in the upper reached from the nearby bauxite processing plant. Pollution derived from mining activities affects mainly surface water and potentially groundwater. Toxic compounds and metal salts are likely to leach into extraction waters, concentrating in sediments and eventually discharged into streams and rivers. The generation of highly alkaline red mud and associated contaminants represents the most significant risk to downstream surface and groundwater sources (Smajgl and Ward, 2013). Among the effluent from a bauxite plant, the largest and most toxic is red mud. For every one tonne of aluminium produces 1.2 tonnes of red mud is generated. Aluminium ions are generally considered to be toxic to aquatic life but are known to form organic and inorganic complexes and the solubility of aluminium and toxicity to organisms is generally considered to increase once pH exceeds 7.0 (Abel, 1996). Further the land locked in storage of red mud is bound to become barren (Sharma, 2001). The effect of pollution does not remain at the place where it is polluted but travels several kilo meters radius from the point of discharge (Amankwah Emmanuel, 2013). Overflow of toxic "red mud" created serious pollution to nearby Penggorak river and beach (Mohamad Shofi Mat Isa,2016).

The effect of mining bauxite of long-term uptake of aluminium is implicated in the aetiology of neurological disorders such as Alzheimer syndrome (Polizzi et al , 2002). The World Health Organization (WHO 1996) indicates that an excess aluminium seems to cause softening of bone. Research has established that malnutrition and unsafe drinking water can escalate diseases in developing countries (Amankwah Emmanuel, 2013). Rehabilitation should take place to reduce the soil runoff during the rainy season. Authorities should look into improving ground cover vegetation to control run-off and erosion. With the emerging threat of climate change, water availability and accessibility is going to be a key issue in the next couple of years thus the need for government, NGOs, environmentalist and all stakeholders to take interest protect and preserve all our water bodies for the present and future generations.

2.3 TREATMENT

Linear polysaccharide biocoagulant are one of the coagulant to treat the pollution water. A polysaccharides a cellulose in an organic compound consisting of a linear of several hundred or thousand glucose units (Kim, 2013). As renewable raw materials, polysaccharides already play an important role as alternatives to fossil raw materials due to their generally non-toxic nature. Polysaccharides are large organic molecules that occur in a variety of natural sources. (Brostow, 2009). Linear polysaccharide or knows as Chitosan (N-acetyl-D-glucosamine) is a cationic biodegradable biopolymer produced by the extensive deacetylation of chitin obtained from shrimp shell wastes (Ahmad, Sumathi, et al Hameed,2006).

Chitin and its derivative form chitosan are the second most abundant polymer in nature coming from crystalline microfibrils forming structural components. This biopolymer that originates from exoskeletons of shellfish like crabs and shrimps has the ability to fix a great range of heavy metals and radio-nuclides (Guibal, 2004; Muzzarelli, 2011). Chitin was first isolated by Braconnot (1811) as fungine and later, in 1823, Odier discovered it in insects and named as chitin. Currently, chitin is mostly produced from shrimp and crab shells as they are dumped as waste product from seafood industry. These shells contain 30-50% calcium carbonate, 30-40% protein and the rest 20- 30% is chitin in dry mass (Johnson and Peniston, 1982).

Chitosan has versatile physical and chemical properties, cationic nature, biodegradability, compatibility, antimicrobial activity and non-toxicity, it has an extensive wide range of applications including food processing, cosmetics, biotechnology, agriculture, fiber formation, pharmaceuticals, medical application, paper production, wastewater and drinking water treatment with other different applications (Ravi Kumar, 1999; Li *et al.*, 1997; Brine *et al.*, 1992; Bahmani *et al.*, 2000; Hudson and Smith, 1998; Momin, 2008). Chitosan has been used for various application such as coagulation of colloidal particles, as a coagulant of suspended solids in food processing plants, peatland treatment chelator of heavy metal and flocculation of food emulsion waste and river silt (Ahmad, Sumathi, et al Hameed,2006). Chitosan could coagulate negatively charged material with its positively charged funtional group to give neutrality (Ahmad, Sumathi, et al Hameed,2006).

2.4 COAGULATION AND FLOCCULATION

Surface waters with turbidity resulting from colloidal particles cannot be clarified without special treatment (Peavy et al, 1985). Coagulation method is widely used in water and wastewater treatments and well known for its capability of destabilizing and aggregating colloids (Ahmad et al., 2006). Coagulation involves the addition of a chemical coagulant for the purpose of conditioning the suspended, colloidal, and dissolved matter for the subsequent processing by flocculation or to create conditions that will allow for the subsequent removal of particulate and dissolved matter (Crittenden et al, 2012). The process is used to enhance the degree of removal of total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), bacterial population in primary settling facilities, as well as to improve the performance of secondary treatment processes (Tchobanoglous and Burton, 1991).

Chemical coagulation is usually accomplished by the addition of trivalent metallic salts such as Aluminium sulphate $Al_2(SO_4)_3$ or Ferric Chloride $FeCl_3$. These include ionic layer compression, adsorption and charge net tralization, entrapment in a flocculent mass, and adsorption and interparticle bridging (Peavy et al, 1985). The colloidal suspensions occur by neutralizing the electric forces that keep the suspended particles separated and the process formed the aggregates small and loosely bound and their sedimentation velocities are relatively low (Brostow, 2009). In conventional wastewater treatment systems, coagulants such as aluminium chloride, ferrous sulphate, ferric chloride and hydrated lime are the most widely used. The Maringa Oleifera seeds used as a coagulant in this study were obtained from Seremban in Malaysia. The seed wings and coat removed and the kernel was ground to fine powder using dry mill attachment of a Moulinex domestic, food blender, oil was extracted first from the powder (Muyibi et Al , 2001). This is because of their effectiveness, cheap, easy to handle and availability (Ahmad et al., 2006).

Flocculation is the physical process of bringing the destabilized particles in contact to form larger flocs that can be more easily removed from suspension. Flocculation is almost always used in conjunction with and preceded by coagulation. The process is generally accomplished by slow mixing of the destabilized suspension to provide an opportunity for the particles to come into contact with one another and bridge together (Semerjian and Ayoub, 2001). In this case, the large volumes of suspended particles which is red mud in bauxite water are eventually deposited as flocs in regions of low turbulence (Andrews, 2001). These mechanisms are very important in forming flocs of residue oil and suspended solid which could be easily settled and finally removed.

More complete information on the performance of flocculation processes can be obtained by direct measurement of floc size distribution. Laser light scattering and diffraction methods are well suited to such measurements, which can be carried out using standard, commercial equipment (Dobias and Hansjoachim, 2005). Flocculation activity may be explained by the electrostatic patch charge mechanisms. Positively charged proteins bind to parts of the surface of the negatively charged particles. This leads to the formation of negatively and positively charged particles surfaces. Due to particle collisions and formation of flocs take place (Gassesschmidt, 1995). In fact, flocculation is possible without significant changes in the particle surface charges (Brostow, 2009).

2.5 WATER QUALITY

Freshwater ecosystems are one of the important assets in the environment based on their immense biological diversity. The high economic value possessed by this ecosystem makes its suitable for aquaculture activity, as a source of food for sustaining food security, recreation, nature tourism and as genetic resources (Alkarkhi et al.2009). Water quality refers to the physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose (Aggarwal and Dr. Arora, 2012) . The World Health Organization estimates that 378 about 3.4 million people died every year from waterborne disease including cholera, typhoid fever, hepatitis A and cancer due to the lack of access to safe drinking water an adequate sanitation (Water Quality and Health Council 2003). Malaysia is one of the popular on going developing countries in South East Asia and the major water demand comes from agriculture, industry as well as domestic sector (DOE 2007).

The physiochemical analyses of water samples were performed using standard analytical methods according to procedures outlined in the Standard Methods for the Examination of Water and Wastewater (APHA) (Aggarwal and Dr. Arora, 2012). Water quality parameters were tested at different of the river are pH, Temperature, Turbidity, Dissolves Oxygen (DO), Hardness, Total solids, nation of Dissolve solids, Suspended Solids, Alkalinity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) (Fukushi et al., 2010).

2.5.1 Water Quality Index (WQI)

Water quality index is important to be measured in order to determine health of the river before consuming or safe to use in other purposes. In order to develop these water quality indexes, several parameters have to be considered. The Department of Environment (DOE) used Water Quality Index (WQI) to evaluate the status of the river water quality. A Water Quality Index (WQI) describes quality value to an aggregate set of measured parameters. It usually consists of sub-index values assigned to each pre-identified parameter by comparing its measurement with a parameter-specific rating curve, optionally weighted, and combined into the final index. The purpose of a WQI is to summarise large amounts of water quality data for a specific river into simple terms (Engr. Zaki Zainudin, 2010).

Six parameters were chosen for the WQI are Dissolved Oxygen (DO), Biochemical OxygenDemand (BOD5), Chemical Oxygen Demand (COD), Suspended Solids (SS), Ammoniacal Nitrogen (AN) and pH. Calculations are performed not on the parameters themselves but on their sub-indices. The sub-indices are named SIDO, SIBOD, SICOD, SIAN, SISS and SIPH.

Table 2.0 : DOE Water Quality Index Classification 2010

Parameters	Unit	Classes				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
Biochemical Oxygen Demand (BOD5)	mg/l	< 1	1-3	3-6	6-12	>12
Chemical Oxygen Demand (COD)	mg/l	< 10	10-25	25-50	50-100	>100
Dissolved Oxygen	mg/l	> 7	5-7	3-5	1-3	< 1
pH	mg/l	> 7	6-7	5-6	< 5	> 5
Total Suspended Solids (TSS)	mg/l	< 25	25-50	50-10	150-300	> 300
Water Quality Index (WQI)	mg/l	< 92.7	76.5-92.7	51.9-76.5	31.0-51.9	>31.0

Table 2.1 : Water Classes and Use

CLASS	USES
Class I	Conservation of natural environment. Water Supply I - Practically no treatment necessary. Fishery I - Very sensitive aquatic species.
Class IIA	Water Supply II - Conventional treatment. Fishery II - Sensitive aquatic species.
Class IIB	Class IIB Recreational use body contact.
Class III	Water Supply III - Extensive treatment required. Fishery III - Common,of economic value and tolerant species livestock drinking.
Class IV	Irrigation
Class V	None of the above.

Table 2.2 : DOE Water Quality Classification Based On Water Quality Index 2010

SUB INDEX AND WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	SLIGHTLY POLLUTED	POLLUTED
Biochemical Oxygen Demand (BOD)	91 - 100	80 - 90	0 - 79
Ammonia Nitrogen(NH3-N)	92 - 100	71 - 91	0 - 70
Suspended Solids(SS)	76 - 100	70 - 75	0 - 69
Water Quality Index(WQI)	81 - 100	60 - 80	0 - 59

WQI FORMULA AND CALCULATION:

WQI = (0.22* SIDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16 * SISS) + (0.12 * SipH)

Where:

SIDO = SubIndex DO (% saturtlon)

SIBOD = SubIndex BOD

SICOD = SubIndex COD

SIAN = SubIndex NH3-N

SISS = SubIndex SS

SipH = SubIndex pH

$0 \leq WQI \leq 100$

BEST FIT EQUATIONS FOR THE ESTIMATION OF VARIOUS SUBINDEX VALUES:

- Subindex for DO (in % saturation)

  SIDO = 0 for $x \leq 8$

  SIDO = 100 for $x \geq 92$

  SIDO = -0.395 + 0.030x2

  - 0.00020x3 for $8 < x < 92$

- Subindex for BOD

  SIBOD = 100.4 - 4.23x for $x \leq 5$

  SIBOD = 108 * exp(-0.055x) - 0.1x for $x > 5$

- Subindex for COD

$$SICOD = -1.33x + 99.1 \text{ for } x \leq 20$$

$$SICOD = 103 * \exp(-0.0157x) - 0.04x \text{ for } x > 20$$

- Subindex for NH3-N

$$SIAN = 100.5 - 105x \text{ for } x \leq 0.3$$

$$SIAN = 94 * \exp(-0.573x) - 5 * I\, x - 2\, I \text{ for } 0.3 < x < 4$$

$$SIAN = 0 \text{ for } x \geq 4$$

- Subindex for SS

$$SISS = 97.5 * \exp(-0.00676x) + 0.05x \text{ for } x \leq 100$$

$$SISS = 71 * \exp(-0.0061x) - 0.015x \text{ for } 100 < x < 1000$$

$$SISS = 0 \text{ for } x \geq 1000$$

- Subindex for pH

$$SIpH = 17.2 - 17.2x + 5.02x\ 2 \text{ for } x < 5.5$$

$$SIpH = -242 + 95.5x - 6.67x\ 2 \text{ for } 5.5 \leq x < 7$$

$$SIpH = -181 + 82.4x - 6.05x\ 2 \text{ for } 7 \leq x < 8.75$$

$$SIpH = 536 - 77.0x + 2.76x\ 2 \text{ for } x \geq 8.75$$

2.5.2 Interim National Water Quality Standards For Malaysia (INWQS)

Water quality data collected from monitored rivers are compared with the Water Quality Index (WQI) and the Interim National Water Quality Standard for Malaysia to determine their status which is clean, slightly polluted, or polluted and to classify them accordingly as Class I, II, III, IV, or V, which is an annual rating system (Grafton et al., 2015).

Table 2.3 : National Water Quality Standard for Malaysia 2010

PARAMETERS	UNIT	CLASSES					
		I	IIA	IIB	III	IV	V
Ammonia Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	›2.7
BOD	mg/l	1	3	3	6	12	›12
COD	mg/l	10	25	25	50	100	›100
DO	mg/l	7	5-7	5-7	3-5	‹3	‹1
pH		6.5-8.5	6-9	6-9	5-9	5-9	-
Colour	TCU	15	150	150	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature (C)	°C	-	Normal +2°C	[] @	Normal +2°C	-	-
Turbidity (NTU)	NTU	5	50	50	-	-	-

Notes:

N : No visible floatable materials or debris or No objectionable odour, or No objectionable taste

* : Related parameters, only one recommended for use

** : Geometric mean

A : maximum not to be exceeded

Table 2.4 : Water Classes and Uses

CLASS	USES
Class I	Conservation of natural environment. Water Supply I - Practically no treatment necessary. Fishery I - Very sensitive aquatic species.
Class IIA	Water Supply II - Conventional treatment. Fishery II - Sensitive aquatic species.
Class IIB	Class IIB Recreational use body contact.
Class III	Water Supply III - Extensive treatment required. Fishery III - Common,of economic value and tolerant species;livestock drinking.
Class IV	Irrigation
Class V	None of the above.

2.5.3 National Drinking Water Quality Standards (NDWQS)

The National Guideline for Drinking Water Standard 2001 (NGDWS) issued by the Ministry of Health will be used as the premise for the second indicator, which measures the performance of water utilities in relation to drinking water quality (Ministry of Health, 2008). The National Drinking Water Standard (NGDWS) identifies five physical parameters for measuring water quality standards which is residual chlorine, faecal coliform, E.coli, turbidity, and pH (Ching Thoo Kim, 2012).

Table 2.5 : Mandatory Water Quality Standards

Compliance Parameters	Mandatory Standards
Residual Chlorine	0.1 ml/l
Faecal Coliform	absent
E.Coli	Absent in 100ml sample
Turbidity	5 nephelometric turbidity units
pH	6.5-8.5

Table 2.6 : Drinking water quality standard 2010

Parameter	Group	RECOMMENDED RAW WATER QUALITY Acceptable Value (mg/litre (unless otherwise stated))	DRINKING WATER QUALITY STANDARDS Maximum Acceptable Value (mg/litre (unless otherwise stated))
Total Coliform	1	5000 MPN / 100 ml	0 in 100 ml
E.coli	1	5000 MPN / 100 m	0 in 100 m
Turbidity	1	1000 NTU	5 NTU
Color	1	300 TCU	15 TCU
pH	1	5.5 - 9.0	6.5 - 9.0
Free Residual Chlorine	1	-	0.2 - 5.0
Temperature	1	-	-
Total Dissolved Solids	2	1500	1000
Chloride	2	250	250
Ammonia	2	1.5	1.5
Aluminium	2	-	0.2
Chemical Oxygen Demand	2	10	-
Biological Oxygen Demand	2	6	-
Total indicative dose	5	-	

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will about the procedures in obtaining and analysing the data so the objectives of this research can be achieved. The research involved few steps that need to be considered. Firstly, classify water class based on water quality parameters by using Standard Method for the Examination of Water and Wastewater (APHA)(21st Edition) which is pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), and Ammoniacal-Nitrogen (NH3-N). Then, the water quality analysis are used to determine the initial quality of water based on class I, II, III IV or V of Water Quality Index (WQI), Interim National Water Quality Standard (INWQS) and National Drinking Water (NDWQS). After that, preparation of Linear Polysaccharides Biocoagulant that will be used to treat the contaminated water. Then, the jar test are conduct by using the optimum value of pH, dose and hydraulic retention time (HRT). The process of coagulation and flocculation are happen during the jar test. Then, the water quality of effluent treatment are test by using Standard Method for the Examination of Water and Wastewater (APHA)(21st Edition) as initial water quality parameters before. The classes of water treatment which is Water Quality Index (WQI), Interim National Water Quality Standard (INWQS) and National Drinking Water (NDWQS) analysis based on class I, II, III IV or V are determined.

3.2 LOCATION OF SAMPLING

The Figure 4.1 below show the location of Sungai Pengorak, Kuantan, Pahang. Sungai Pengorak is a stream and is located in Pahang, Malaysia. The estimate terrain elevation above sea level is 17 metres and the Latitude is 3°58'0.12" and Longitude is 103°24'16.92".

Figure 3.1 : Aerial Map of Sungai Pengorak, Kuantan, Pahang.

3.3 MATERIALS

3.3.1 Preparation Before Sampling

Containers that are used for samplings must be well prepared. They need to be clean and free from particles to minimize error in test results. The bottles need to be rinsed with distilled water so they will not contain any dirt or sediments from previous samples remain in the bottles. Also, bottles need to be well label with numbers, dates and locations to prevent the test results to be mix up. The apparatus that are used must be in good condition and containers volume needed in tests must be estimated

3.3.2 Sampling

The sample of contaminated by bauxite water are collect at Sungai Pengorak, Kuantan, Pahang. The process of obtaining samples must be standardized. For example, the samples taken from the river should be taken at the same level of water depth and avoid touching the river's basement. This can prevent the particles from the river's basement to be collected with the samples. In obtaining the water samples, there are a few precaution steps that must be taken into account. The sampling period should not be too long and the samples need to be sent to the laboratory to be tested immediately for initial results. So this can ensure the result to have minimum errors. The concentration of DO can decrease after a long period of time. Thus this can affect the result's accuracy.

Figure 3.2 : Sungai Pengorak, Kuantan, Pahang

3.4 WATER QUALITY PARAMETERS

Water quality parameters are to test initial water quality of this contaminated bauxite water. This test must be conducted in laboratory by using Standard Method for the Examination of Water and Wastewater (APHA). The water quality parameters include pH, temperature, dissolve oxygen (DO), biochemical demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), Ammonia Nitrogen (AN), turbidity and total dissolve solid (TDS). The Table 3.1 below shows the parameter and equipment that have been used in the tested for water quality by using the Standard Method for the Examination of Water and Wastewater (APHA).

Table 3.1 : Standard Method and Equipment for the Examination of Water and Wastewater (APHA)(21st Edition).

Parameter	Equipment
pH	APHA 4500H+
Colour (PtCo)	Method 8155 (DR/2500)
Turbidity (NTU)	Method 8155
Dissolved Oxygen, DO (mg/L)	Method 5210B
Total Dissolved Solids, TDS (mg/L)	APHA 4500H+
Total Suspended Solids, TSS (mg/L)	APHA 2005
Biochemical Oxygen Demand, BOD_5 (mg/L)	Method 5210B
Chemical Oxygen Demand, COD (mg/L)	Method 8000 (COD LR : 435)(DR/2500)
Ammonia Nitrogen, AN (mg/L)	Method 8155 (DR/2500)
Aluminium	Method 8012

3.4.1 pH and Dissolve Oxygen (DO)

The pH of the an effluent or water sample is important in almost all phases of drinking water and wastewater treatment. In water treatment, the pH role is to ensure the proper chemical treatment of disinfection as well as corrosion control (Weiner et. Al 2003). Aquatic organisms are sensitive to pH changes. The pH of a water body may be change due to acid of drainage surrounded of it, unregulated acids or bases in industrial effluents or atmospheric acid conditions. So, it will affect the reading of the pH conditions.

The parameters that can be obtained without conducting laboratory test are dissolved oxygen (DO) and pH. The test is done by directly inserting the probe of electronic instruments into the water. The probe is to be fully immerged near the centre of the river to get more accurate readings. The probes needed to be rinse with distilled water so can prevent residues to be trapped at the probes. Electronic instruments for testing pH are pH meter (Consort Model C536) and testing DO is by using DO meter (YSI Model 55). Tests procedures are based on Standard Method American Public Health Association (APHA).

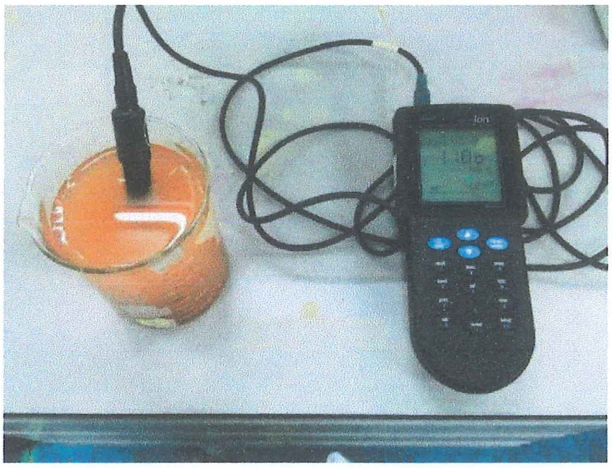

Figure 3.3 : YSI Professional Plus handheld multi-parameter meter

3.4.2 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is usually defined as the amount of oxygen required by bacteria while stabilising decomposable organic which means that the organic matter can serve food for the bacteria and energy is derive from its oxidation. (BOD) test is carried out based on the Standard Method APHA 5210-B. The purpose of this test is to measure the oxygen demand by micro-organism during biodegrade process.

The BOD test is done by filling the sample into air tight 350 mL BOD bottle and let for incubation at 200C for 5 days. The 5 day BOD is primarily composed of carbonaceous oxygen demand and to know the amount of oxygen consumes by microorganisms during the five days of the degradation process also known as BOD_5. The DO values which have been taken in-situ are set as baseline if the samples need to do dilution process. The testing of sample sometimes required dilution if the level of pollution is too high. For this contaminated bauxite water, need a dilution process because the water are more polluted and cannot be read by the machine. To measure initial DO and after incubation of the sample it using YSI 5100. After 5 days incubator in, remove the sample from incubator until it reach room temperature.

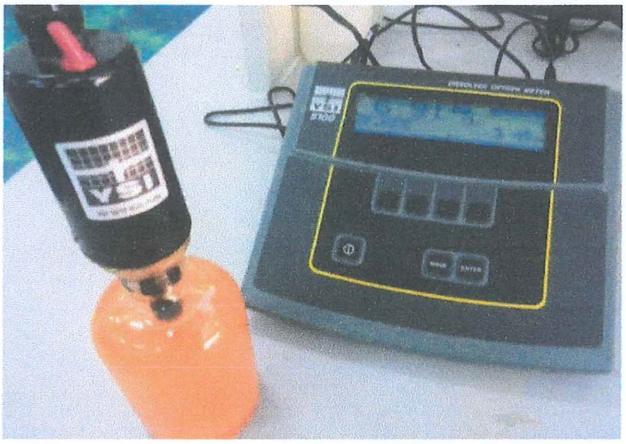

Figure 3.4 : YSI 5100

The formula to determine the BOD_5 is as follows:

- $P = V_s / (V_s + V_{dw})$
- $BOD_5 = (DO_1 - DO_5) / P$

Where :

BOD_5 = Biological Oxygen Demand at 5 days, mg/L

V_s = Volume of sample

V_{dw} = Volume of dilution water

DO_1 = Dissolved Oxygen of the diluted sample about 15 minute after preparation, mg/L

DO_5 = Dissolved Oxygen od diluted sample after 5 days incubation at 20^0C, mg/L

P = Decimal volumetric fraction of sample used

3.4.3 Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) test is carried out based on the Standard Method APHA 5220-C. The purpose of COD test is to measure the presence of pollutant in the sample by means of determining amount of oxygen needed in the reaction of oxidation and reduction. Each COD vial contains mercuric sulphate that will eliminate chloride interference up to the level specified. The type of vial are using for this raw water are low range which is the result must in the range of 3mg/L-150mg/L.

The sample are collect in glass bottle and test the biologically active sample as soon as possible. The sample are treat with sulphuric acid about 2ml per liter. Samples are heat with COD reactor until reach temperature of 150^0C for half an hour and after that heat the sample of raw water with vial and control sample contain mixture of vial and distilled water for two hours and cold it for an hour. Then, the results are test by using Spectrophotometer HACH DR 5000. It use reagent of COD of lower range and the programme to be store are 430.

Figure 3.5 : Sample are heated

Figure 3.6: Spectrophotometer HACH DR 5000

3.4.4 Total Suspended Solids

Total Suspended Solids (TSS) include all particles suspended in water which will not pass through a filter. TSS test is carried out based on the Standard Method APHA 2540-D. The purpose of this test is to measure the amount of suspended solid which may contain particles, micro-organism and others. To measure TSS, the water sample is filter glass fibre filter.. The glass microfiber disc is use to filter the water sample. A 100ml of sample are being filtered. The residue retained on the filter is dried in an oven at 105^{0}C for an hour. The increase in weight of the filter represents the total suspended solids. Then cooled it in desiccator and weight.

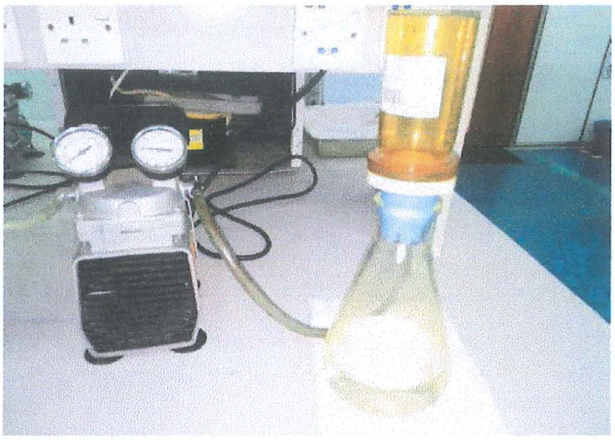

Figure 3.7 : 47 mm glass microanalysis filter holder (funnel, clamp and base)

The calculation for total suspended solid as follows :

$$SS = [(A-B) \times 1000] / C$$

Where :

A = weight of filter and dish + residue in mg

B = weight of filter and dish in mg

C = volume of sample filtered in mL

3.4.5 Ammonia Nitrogen

Ammonia Nitrogen (NH_3-N) test is carried out based on the Standard Method APHA 4500-NH_3-BC. The DR4000 Spectrophotometer is used and is set to HACH PROGRAM: 2400 N, Ammonia Nessler. The reagents used are Nessler reagent, mineral stabilizer, and polyvinyl alcohol as a dispersing agent. A control sample is set by using distilled water while reagents are mixed with samples. If the concentration of Ammonia is too high, dilution needs to be done.

Figure 3.8 : Spectrophotometer HACH DR 5000 used in this test

3.5 WATER QUALITY ANALYSIS

To evaluate water quality of Sungai Pengorak, Kuantan, Pahang are based on water quality analysis which is from Water Quality Index (WQI), Interim National Water Quality Standard (INWQS) and National Drinking Water Quality Standard (NDWQS). The result of the obtain are plotted in table for ease analyse. The source of the Water Quality Index (WQI) and Interim National Water Quality Standard (INWQS) are from official web site of Malaysia Standard Water Quality 2010. While for water quality analysis for National Drinking Water Quality Standard (NDWQS) are from Malaysia Standard Drinking Water Quality web site that can refer in reference.

The classification can help in determining the pollution level at Sungai Penggorak for initial water quality of raw water and after treatment quality water. The data collected may be used as a guideline for maintaining and monitoring the river's water quality and also to reduce the source of impact detected.

3.6 PREPARATION OF COAGULANT

The polysaccharide biocoagulant are prepared by mixing the 10g of linear polysaccharide which is knows as shrimp shell with 10mL of acetic acid and 980mL of distilled water. This was mix using stirrer machine for about 3 hours. Then, leave it for a day to it became like a jelly.

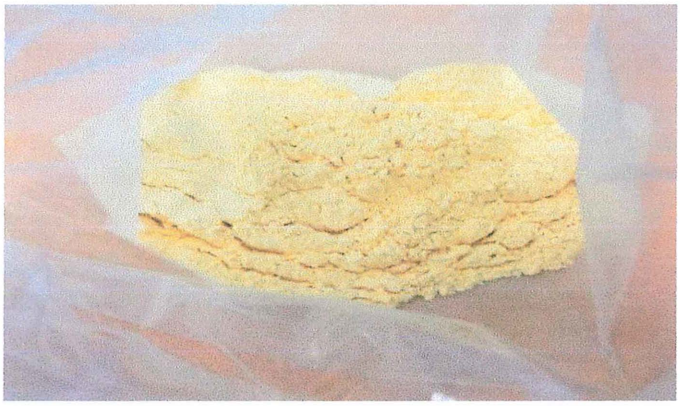

Figure 3.9 : Linear Polysaccharide Powder

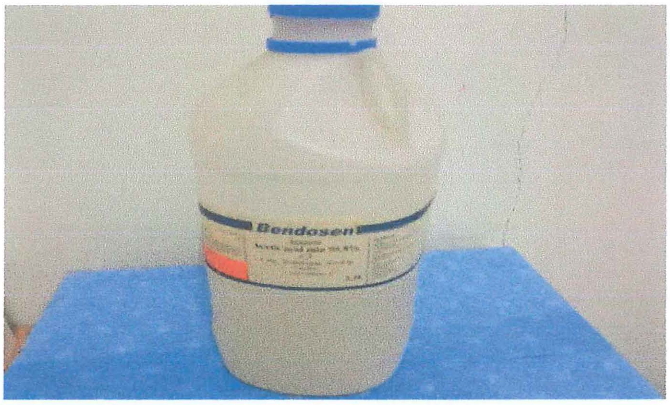

Figure 3.10 : 10% of Acetic Acid are used

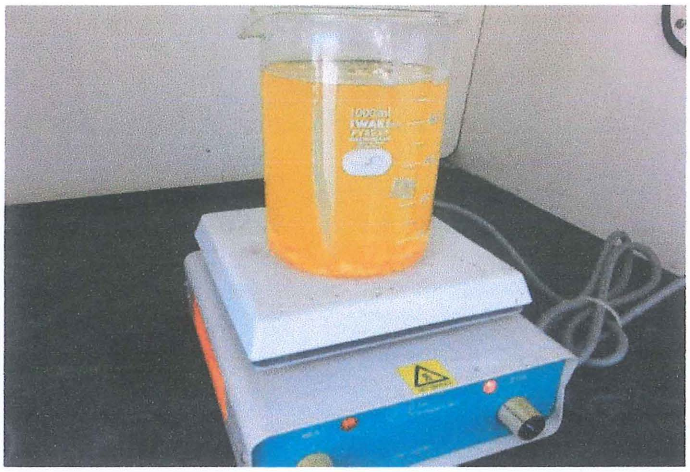

Figure 3.11: Linear Polysaccharide Biocoagulant mixed by using stirrer magnetic

3.7 JAR TEST

The selection and optimum dosage of coagulants are determined experimentally by the jar test instead if quantitatively by formula. The jar test must be performed on each water that is to be coagulated and must be repeated with each significant change in the quality of a given water.

The jar test is performed using a series of glass containers that hold at least 500mL and are of uniform size and shape. Normally, six jars are used with a stirring device that simultaneously mixes of contents of each jar with a uniform power input. Each of the six jars is filled to the 500mL mark with water whose turbidity, pH and alkalinity have been predetermined.

One jar is used as a control, while the remaining five are dosed with different amounts of coagulant at different pH values until the minimum values of residual turbidity are obtained. The mixture are mix for 30 minutes to aid in the formation of flocs with 70rpm of mixing rate (Ahmad et al,2005).

3.7.1 Effect of Dosage

The dosage needed by the synthetic coagulants were 10 times more than linear polysaccharide biocoagulant. Furthermore, linear polysaccharide biocoagulant proved to be a better coagulant even at lower dosage (A.L.Ahmad et al., 2006). It has a high charge density compared to the other coagulants and is a positively charged linear polyelectrolyte at acidic conditions.

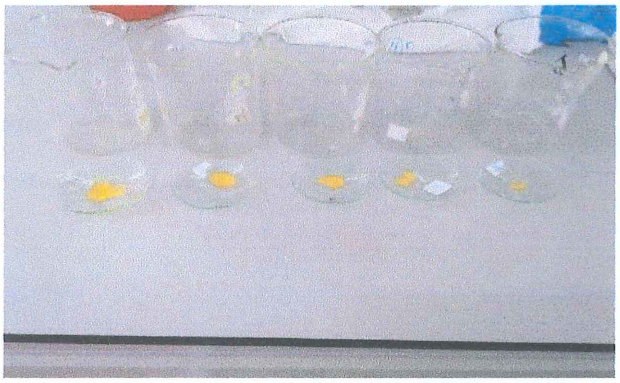

Figure 3.12 : Different dosage of Linear Polysaccharide Biocoagulant

3.7.2 Effect of Ph

Emulsion breaking is usually brought about by changing the sample pH value or inorganic coagulants. The effect of pH was conducted by adjusting the pH from 5-9 and using the optimum dosage of chitosan with 30 minutes of mixing time and 70 rpm of mixing rate (Ahmad et al,2005). The flocculation at high pH achieves efficient removal particles, colloids and certain dissolved materials present in the wastewater (9 January 2001). The sample was then let to settle for an hour. Compare the 5 different of pH with the lower turbidity. From the turbidity test vs pH graph will show the optimum pH of the test.

Figure 3.13 : Coagulation test at different pH

3.7.3 Hydraulic Retention Time (HRT)

Effect of sedimentation time was analysed at different sedimentation at optimum of dose and pH. Chitosan react faster to the residue oil compared to alum and PAC. It needs about 30 min of mixing at 70 rpm with 1.0g/l of chitosan (A.L.Ahmad et al., 2006). The time needed for the flocs to settlement is very important in removing the coagulated residue oil faster and more effective. The turbidity of the coagulated sample depends on the sedimentation effect. Chitosan promotes more faster aggregations of colloids.

3.8 COAGULATION AND FLOCCULATION PROCESSES

The positive charge of the coagulant neutralizes the negative charge of dissolved and suspended particles in the water. Once the charge is neutralized, the small suspended particles are capable of sticking together. The slightly larger particles, formed through this process and called microflocs, are not visible to the naked eye (Coagulation and Flocculation Process, 2005). When this reaction occurs, the particles bind together and coagulate and be knows as flocculation process. The larger particles known as flocs, are heavy and quickly settle to the bottom of the water supply. This settling process is called sedimentation (Safe Drinking Water Formulation, 2007).

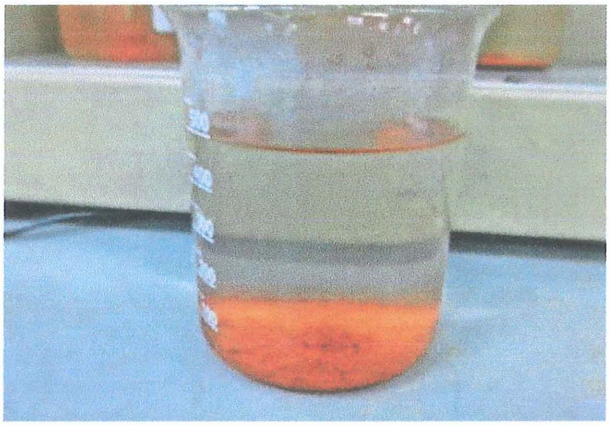

Figure 3.14: The bauxite flocs are settle to bottom

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

This chapter discusses about the results obtained in this study. The sample was taken on 10th of November 2015 where during that time is the monsoon seasons at Pahang Darul Makmur. During this time, the bauxite activities are popular in this area and most of the area are been polluted by the bauxite mining. Thus, the samples are kept in the container and taken to the laboratory to be tested for initial reading of water quality. The parameters are pH, Temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Turbidity and Ammoniacal Nitrogen (NH^3N).

The purpose to examine the water quality of Sungai Pengorak through Water Quality Index (WQI), Interim National Water Quality Standard(INWQS) and National Drinking Water Quality Standard (NDWQS) is to determine the classes of water quality of the river. Then, the optimum dose, pH and hydraulic retention time (HRT) are determined for the treatment of the water and to identify the effectiveness of Linear Polysaccharide Biocoagulant to the contaminated bauxite water.

4.2 INITIAL WATER QUALITY PARAMETER

The initial water quality parameter are determined to know the original water quality of the raw water. To determine the WQI, INWQS and NDWQS parameters such as pH, Turbidity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH_3N) Total Suspended Solids (SS) and Total Dissolved Solid (TDS) are used.

Table 4.1 : Initial Water Quality of Sungai Pengorak.

Parameters	Before treatment
pH and Temperature	7.37 @ 26.2°C
Colour	4334
Turbidity	1000
Dissolved Oxygen, DO	5.72
Total Dissolved Solids, TDS	1897
Total Suspended Solids, TSS	579
Biochemical Oxygen Demand, BOD_5	6.55
Chemical Oxygen Demand, COD	124
Ammonia Nitrogen, AN	1.43

- All parameters in mg/L except colour (PtCo) and turbidity (NTU)

The Biochemical Oxygen Demand, BOD5 (mg/L) initial water quality value are 6.55mg/L and Chemical Oxygen Demand, COD (mg/L) is 124 mg/L. Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are two different ways to measure how much oxygen the water will consume when it enters the recipient. In both cases the oxygen consuming substances are mainly of organic origin. These substances should be reduced to a minimum in the wastewater treatment plant.

While the Ammonia Nitrogen, AN is 1.43 mg/L. Excess nitrogen discharged into our waterways can contribute to eutrophication, the gradual change of water bodies into marshes, meadows and forests. It can also contribute to massive algae blooms leading to oxygen depletion in water and its associated problems.

4.3 OPTIMUM OF DOSAGE BY USING LINEAR POLYSACCHARIDE BIOCOAGULANT

The effect of coagulant dosage was analysed by varying the weight which is from 1 g/L to 5 g/L of Linear Polysaccharide Biocoagulant of dosage coagulant by using 30 minutes mixing time and 100 rpm of mixing rate. In Figure 4.2 shows the comparative of weight dosage which is by using Linear Polysaccharide Biocoagulant against result of turbidity after jar test process treatment.

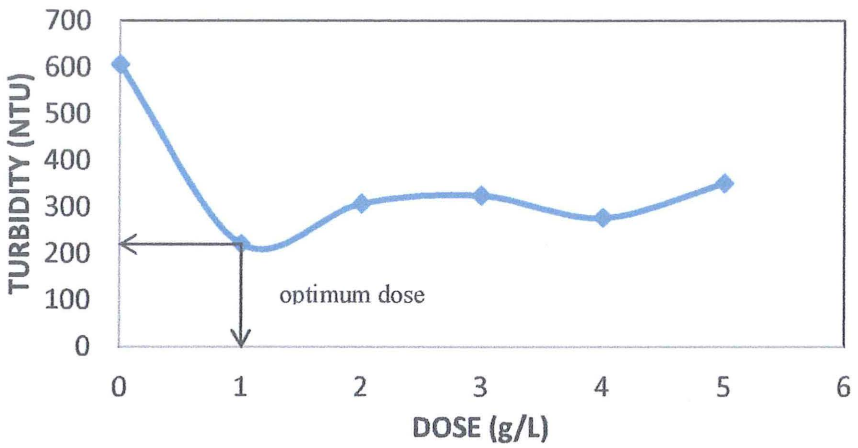

Figure 4.1 : Result of Optimum Dose

From the result, noticed that 1 g/L of Linear Polysaccharide was successfully needed to remove the contaminated bauxite water. Furthermore, from the results proved that Linear Polysaccharide Biocoagulant to be better coagulant ever by only using the optimum value which is 1 g/L. From the result shows that the optimum dose only 1 g/L which means it requires lower dosage to destabilize the raw water. The turbidity analysis results represents the suspended solid remove by using the optimum value of dose can reach the minimum value of suspended solid which is 221 NTU. The flocs produced by the linear polysaccharide appear rapidly and grows very fast to form a larger size which can be easily sediment by using the coagulation and flocculation process. The flocs are fibrous and forms large entangled mass resembling cobwebs. Furthermore, from the Figure 4.2, it was also noticed that when applied dosage was higher than the optimum amount, the turbidity of the water value become increased. This proves that this Linear Polysaccharide biocoagulant is a successful coagulant to coagulate suspended solid in bauxite water by using optimum dose.

4.4 OPTIMUM OF pH

The pH adjustment was done to study the effectiveness of pH to the contaminated bauxite water. The effect of pH was conducted by adjusting the pH from pH 5-9 with the optimum dosage of Linear Polysaccharide Biocoagulant with 30 minutes of mixing time and 100 rpm of mixing rate. Then, the sample was then let to settle for 1 hour. The result of optimum pH against the turbidity as the Figure 4.3 below.

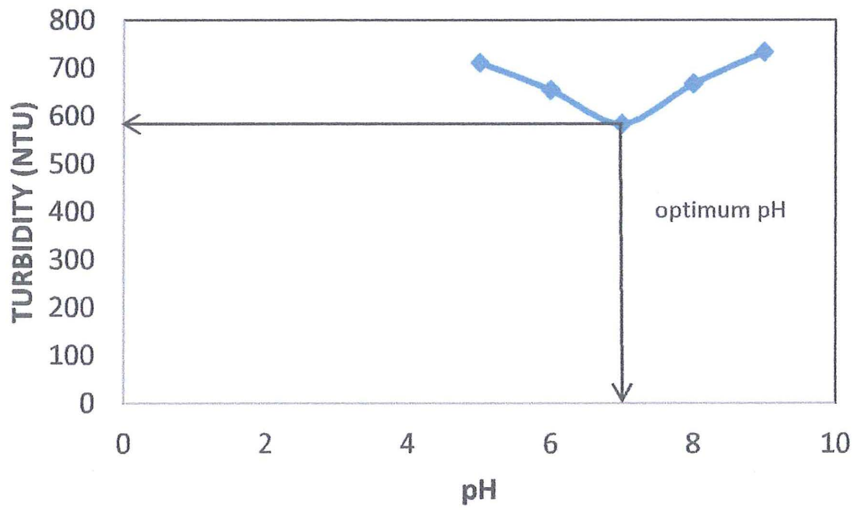

Figure 4.2 : Result of Optimum pH

In Figure 4.3 shows that the raw water of bauxite was very satisfying at the pH of 7. When the pH is adjust less or more than 7 the bauxite to remove from the water become poor compared to pH 7. The pH are considered as the normal range of water quality and produce the optimum value of turbidity with 584 NTU. From the pH results, shows that the coagulation and flocculation process by using Linear Polysaccharide Biocoagulant with optimum normal pH was an effective and health risk free treatment technique for contaminated bauxite water.

4.5 OPTIMUM HYDRAULIC RETENTION TIME (HRT)

The effect of sedimentation was analyzed at different sedimentation time at optimum dosage and optimum pH with 30 minutes of mixing time and 100 rpm of mixing rate. Figure 4.4 shows the settling time needed for the optimum value of turbidity produce against the optimum time.

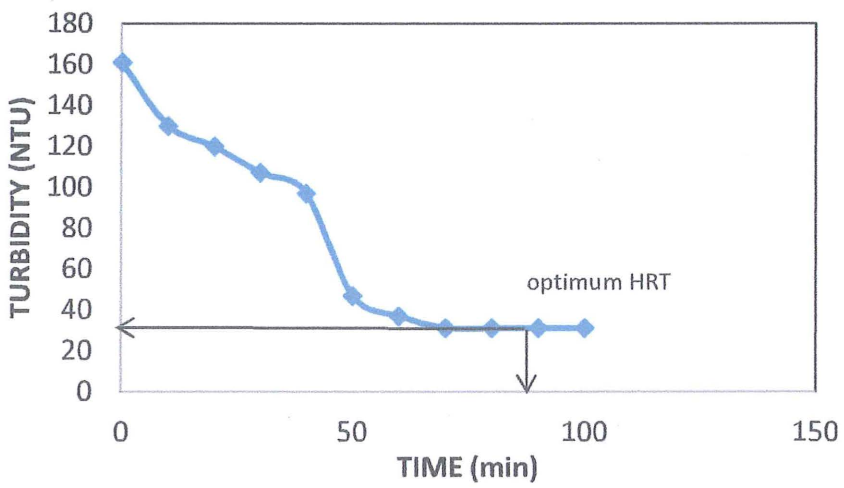

Figure 4.3 : Variation in turbidity with elapsed time

From the Figure 4.4 shows that the the first optimum value of HRT are at 70 minutes with the turbidity of 31.2NTU and are consistently until 100 minutes. The time needed for the flocs to settlement is very important in removing the coagulated residue oil faster and more effective. The turbidity of the coagulated sample depends on the sedimentation effect. Furthermore, from the Figure 4.4 shows that there are drastic reduction in suspended solid once the sample is left to settle for more than 1 hour. The suspended solid values are decreased as the flocs starts to settle to the bottom of the beaker and this effect are considerely affect by the gravitational force. The flocs formed by the Linear Polysaccharide Biocoagulant are larger and denser causing the suspended solid to settle fast.

4.6 WATER QUALITY

The quality of Sungai Pengorak that have been contaminated by bauxite activates was analyzed by using the Water Quality Index (WQI), Interim National Water Quality Standard(INWQS) and National Drinking Water Quality Standard (NDWQS) for initial water quality and final water quality after treatment by using Linear Polysaccharide Biocoagulant. The Water Quality Index (WQI), Interim National Water Quality Standard(INWQS) and National Drinking Water Quality Standard (NDWQS) are based on water quality parameter results which is pH, Temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Turbidity and Ammoniacal Nitrogen (NH^3N).

4.6.1 Water Quality Index (WQI)

Based on calculation below and analysis in Table 4.2, shows the results of contaminated bauxite water for the initial Water Quality Index (WQI) and after treatment.

Table 4.2 : Water quality standards of bauxite raw contaminated water before and after treatment

Water Quality Index	Before Treatment	After Treatment
Water Quality Index (WQI)	49.93 (Class IV)	97.65 (Class I)

From the Table 4.2, shows that the improved water quality to drinkable standards (WQI) from class IV to class I. Which is from the highly polluted because of contaminated bauxite water to clean and safe to be used.

4.6.2 Interim National Water Quality Standards For Malaysia (INWQS)

The Interim National Water Quality Standard for Malaysia to determine their status which is clean, slightly polluted, or polluted and to classify them accordingly as Class I, II, III, IV or V. The Table 4.3 shows the results of water quality parameter compared to the classes of Interim National Water Quality Standard (INWQS) before treatment and after treatment by using linear polysaccharide biocoagulant.

Table 4.3 : Results of Interim National Water Quality Standards For Malaysia (INWQS)

Parameters	Unit	Before Treatment	Classes	After Treatment	Classes
Ammonia Nitrogen	mg/L	1.43	IV	0.05	I
BOD	mg/L	6.55	III	1.4	I
COD	mg/L	124	IV	0	I
DO	mg/L	5.72	IV	7.01	I
pH and Temperature		7.37 @ 26.2°C	II	7.0 @ 26.7°C	I
Colour	PtCo	4334	IV	97	I
Total Dissolved Solid	mg/L	1897	IV	187	I
Total Suspended Solid	mg/L	579	V	0	I
Turbidity (NTU)	mg/L	1000	V	11.2	I

4.6.3 National Drinking Water Quality Standards (NDWQS)

The National Drinking Water Quality Standards (NDWQS) is to determine their status which is clean, slightly polluted, or polluted and to classify them accordingly as Class I, II, III, IV or V. The Table 4.4 shows the results of water quality parameter compared the water quality of the contaminated bauxite water before and after treatment by using linear polysaccharide biocoagulant.

Table 4.4 : Result of National Drinking Water Quality Standards (NDWQS)

Parameters	Unit	Before Treatment	Group	After Treatment	Group
Ammonia Nitrogen	mg/L	1.43	IV	0.05	I
BOD	mg/L	6.55	III	1.4	I
COD	mg/L	124	IV	0	I
DO	mg/L	5.72	IV	7.01	I
pH and Temperature		7.37 @ 26.2°C	II	7.0 @ 26.7°C	I
Colour	PtCo	4334	IV	97	I
Total Dissolved Solid	mg/L	1897	IV	187	I
Total Suspended Solid	mg/L	579	V	0	I

Turbidity (NTU)	mg/L	1000	V	11.2	I
Aluminium	mg/L	0.268	II	0	I

4.7 Final Water Quality

The water quality of the contaminated bauxite water after been treat by the linear polysaccharide biocoagulant are shown in Table 4.5. By using the optimum value of pH, dose and hydraulic retention time (HRT) the water quality of Sungai Pengorak are slightly improved from contaminated water to safe been used based on water quality parameter of Water Quality Index (WQI), Interim National Water Quality Standard (INWQS) and National Drinking Water Quality Standard (NDWQS).

Table 4.5 : Final Water Quality After Treatment

Parameters	Water after treatment
pH	7.0 @ 26.7°C
Colour (PtCo)	97
Turbidity (NTU)	11.2
Dissolved Oxygen, DO (mg/L)	7.01
Total Dissolved Solids, TDS (mg/L)	187
Total Suspended Solids, TSS (mg/L)	0
Biochemical Oxygen Demand, BOD_5 (mg/L)	1.4
Chemical Oxygen Demand, COD (mg/L)	0
Ammonia Nitrogen, AN (mg/L)	0.05

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The objective of the research have been achieved through the results that have collected. By using the Linear Polysaccharide Biocoagulant as the coagulant to this research which is it slightly changed the water quality which is from highly polluted to clean and save to be used. The results also significantly improves water quality of Sungai Pengorak that contaminated by bauxite and reduce the class of contaminated bauxite water based on Water Quality Index (WQI), Interim National Water Quality Index (INWQS) and National Drinking Water Quality Index (NDWQS) from Class IV to Class I. Then, by using only the optimum Linear Polysaccharide Biocoagulant it can slightly change the water quality which is Water Quality Index (WQI), Interim National Water Quality Index (INWQS) and National Drinking Water Quality Index (NDWQS) from Class IV to Class I.

5.2 RECOMMENDATION

Based on the analysis been done in Chapter 4 and the conclusion above, there are some recommendations can be done to improve the water quality of Sungai Pengorak.

i. Environmental Department should apply rules and regulation to prevent further damage to Sungai Pengorak and fines should be given to those who break the laws.
ii. Buffer zones of bauxite activities can be applied to prevent erosion and sediments to get into the Sungai Pengorak and near beach.
iii. Piping system can be built to convey effluents to other places which is more systematic with better treatment system instead of discharging effluents from STP directly into Sungai Pengorak.

The recommendations for future studies on river water quality classifications are by taking precaution steps to improve the accuracy of the data are as following:

i. The equipment and apparatus should be checked from time to time to minimize mistake when taking readings or data.
ii. More sets of data should be taken to achieve a more accurate data. For example 4 to 5 sets of data with extra research time.
iii. More parameters such as oil and grease, E-Coli and Nitrate should be considered because they will able to represent the condition of the river better. The parameters stated in water quality parameters, Water Quality Index (WQI), Interim National Water Quality Index (INWQS) and National Drinking Water Quality Index (NDWQS) are actually not enough for evaluating a river's water quality since there are many other factors affecting the water quality.

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APPENDICES

Water Quality Index (WQI) of Raw Water

- Sub Index for DO (In % saturation)

  DO = 72%

  SIDO = $-0.395 + 0.030x^2 - 0.00020x^3$ for $8<x<92$

  $= -0.395 + 0.030(72^2) - 0.00020(72^3)$

  = 80.48

- Sub Index for BOD

  BOD = 6.55 mg/L

  SIDOD = 108*exp(-0.055x) – 0.1 for x>5

  = 108*exp[-0.055(6.55)] – 0.1

  = 74.68

- Sub Index for COD

  COD = 124 mg/L

  SICOD = 103*exp (-0.0157x) – 0.04x for x> 20

  = 103*exp [-0.0157(124)] – 0.04(124)

  = 9.74

- Sub Index for (NH^3N)

  NH^3N = 1.43 mg/L

  SIAN = 94*exp (-0.573x) – 5*[x-2] for 0.3 <x< 4

  = 94*exp [-0.573(1.43)] – 5*[(1.43)-2]

  = 67.89

- Sub Index for SS

SS = 579 mg/L

SISS = 71* exp (-0.0061x) + 0.015 x   for 100 < x <1000

= 71* exp [-0.0061(579)] + 0.015(579)

= 10.73

- Sub Index of pH

pH = 7.37

SIpH = -181 + 82.4x – 6.05x^2 for 7 < x < 8.75

= -181 + 82.4(7.37) – 6.05$(7.37)^2$

= 97.67

WQI = (0.22* SIDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16* SISS) + (0.12 * SipH)

= [0.22*(80.48)] + [0.19*(74.68)] + [0.16*(9.74)] + [0.15*(67.89)] + [0.16 *(10.73)] + [0.12 *(97.67)]

= 49.93 (CLASS IV of WQI)

Water Quality Index (WQI) After Treatment

- Subindex for DO (in % saturation)

DO = 98.1%

SIDO = 100   for x > 92%

= 100

- Subindex for BOD

BOD = 1.40 mg/L

SIBOD = 100.4 - 4.23x   for x ≤ 5

= 100.4 – 4.23 (1.40)

= 94.5

- Subindex for COD

COD = 0 mg/L

SICOD = -1.33x + 99.1 for $x \leq 20$

= -1.33(0) + 99.1

= 99.1

- Sub Index for (NH^3N)

NH^3N = 0.05 mg/L

SIAN = 100.5 - 105x for $x \leq 0.3$

= 100.5 – 105(0.05)

= 95.25

- Subindex for SS

SS = 0

SISS = 97.5 * exp(-0.00676x) + 0.05x for $x \leq 100$

= 97.5 * exp[-0.00676(0)] + 0.05(0)

= 97.5

- Subindex for pH

pH = 7.0

SIpH = $-242 + 95.5x - 6.67x^2$ for $5.5 \leq x < 7$

= $-242 + 95.5(7.0) - 6.67(7.0)^2$

= 99.67

WQI = (0.22* SIDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16* SISS) + (0.12 * SipH)

= [0.22*(100)] + [0.19*(94.5)] + [0.16*(99.1)] + [0.15*(95.25)] + [0.16 *(97.5)] + [0.12 *(99.67)]

= 97.65 (Class I of WQI)