EFFECTIVENESS OF ACTIVATED CARBON FROM BAMBOO CHIPS FOR INDUSTRIAL WASTEWATER TREATMENT

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ABSTRAK

Sistem sungai yang mengelilingi kawasan perindustrian Gebeng telah mengalami tekanan berlebihan akibat daripada pertumbuhan pesat pengeluaran di kawasan itu, yang merangkumi pelbagai kilang dan aktiviti perlombongan. Berdasarkan efluen yang dibuang, aktiviti perindustrian berasaskan perlombongan petrokimia dan bauksit telah disenaraikan sebagai penyumbang kepada pencemaran bahan kimia dan logam berat dalam badan air. Logam berat, yang telah terkumpul dalam tanah untuk masa yang lama, berbahaya kepada ekosistem marin. Pencemaran air dengan sebatian organik dan bukan organik seperti logam dan racun perosak telah mendorong penyelidik untuk menambah baik kaedah penulenan dan pengekstrakan seperti penjerapan bahan pencemar menggunakan karbon teraktif. Matlamat kajian ini adalah untuk melihat keberkesanan karbon teraktif cip buluh dalam merawat air sisa tercemar dari kawasan perindustrian Gebeng. Parameter fizikal dan kimia air dianalisis untuk menilai tahap pencemaran awal, yang kemudiannya dibandingkan dengan tahap pencemaran selepas rawatan dengan tiga nisbah berbeza dan dua jenis suhu (400°C dan 500°C). pH, kekeruhan, jumlah pepejal terampai (TSS), permintaan oksigen biokimia (BOD), permintaan oksigen kimia (COD), serta logam berat zink (Zn) dan kuprum (Cu) (Cu) sedang diuji. 4 liter air sisa dirawat dengan 20 gram, 30 gram dan 40 gram karbon teraktif yang diperbuat daripada serpihan buluh dalam serbuk. Tahap pencemaran setiap parameter telah dikurangkan kepada kepekatan yang sangat rendah di bawah nilai standard yang dibenarkan selepas rawatan. Sampel air sisa telah habis BOD, COD dan kuprum. Ini menunjukkan bahawa karbon teraktif yang diperbuat daripada serpihan buluh boleh merawat air sisa tercemar dengan menyerap bahan pencemar. Akhirnya, penemuan kajian menunjukkan bahawa sisa cip buluh boleh ditukar kepada penjerap berkapasiti tinggi dan digunakan untuk merawat air sisa industri yang tercemar.

ABSTRACT

The river system surrounding the Gebeng industrial area has been overstressed as a result of the rapid growth of production in the area, which includes a variety of factories and mining activities. Based on the effluents discharged, industrial activities based on petrochemical and bauxite mining have been listed as a contributor to chemicals and heavy metals contamination in water bodies. Heavy metals, which have been accumulating in soil for a long time, are harmful to marine ecosystems. Contamination of water with organic and inorganic compounds such as metals and pesticides has prompted researchers to improve purification and extraction methods such as pollutant adsorption using activated carbon. The aim of this study was to see how effective bamboo chip activated carbon is at treating contaminated wastewater from the Gebeng industrial region. Water's physical and chemical parameters were analysed to assess the initial pollution level, which was then compared to the level of pollution after treatment by three different ratios and two types of temperature (400°C and 500 °C). pH, turbidity, total suspended solid (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), as well as zinc (Zn) and copper (Cu) heavy metals (Cu) is being test. 4 litres of wastewater were treated with 20-gram,30 gram and 40 grams of activated carbon made from bamboo chip in powdered. Each parameter's pollution level was reduced to a very low concentration below the permissible standard value after the treatment. The wastewater sample was totally depleted of BOD, COD and copper. This demonstrated that activated carbon made from bamboo chip can treat contaminated waste water by absorbing pollutants. Finally, the study's findings indicate that waste bamboo chip can be converted into a high-capacity adsorbent and used to treat contaminated industrial wastewater

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LIST OF SYMBOLS

^{o}C	Celcius / Degree

LIST OF ABBREVIATIONS

AC	Activated carbon
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DOE	Department of Environmental
TSS	Total Suspended Solids

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Wastewater is water that has had its physical, chemical, or biological properties altered by the application of such chemicals, rendering it unfit for certain uses such as drinking. Wastewater is the liquid waste discharged from homes, businesses, industries, and agriculture, and it also includes toxins as a result of the mixing of wastewater from various sources. Man's daily activities are largely dependent on water, and as a result, he discharges "waste" into the water. Body waste such as (faeces and urine), hair shampoo, hair, food scraps, fat, laundry powder, fabric conditioners, toilet paper, pesticides, detergent, household cleaners, dirt, and microorganisms (germs) are only a few of the things that can make people sick and damage the ecosystem. It is known that much of water supplied ends up as wastewater which makes its treatment very important. Wastewater is often pure water with a purity of more than 95%, and depending on the form and level of contamination, there are a variety of methods that can be used to clean it up. Wastewater treatment is the method and technology for removing the majority of pollutants present in wastewater in order to protect the environment and public health. Making waste water management as a subject that cannot be overlooked (Indranil Singh,2020). Wastewater management thus entails treating wastewater in a manner that protects the environment while also ensuring public health, economic, social, and political stability (Metcalf and Eddy, 2011).

Water contamination with organic and inorganic chemicals such as metals and pesticides has prompted researchers to create purification and extraction technologies, according to Renata S. D. Castro (2011). Several strategies for treating wastewater contaminated with organic and inorganic contaminants have been presented and developed. Solid materials such as alumina activated carbon and modified silica, for example, can be used to remove metal ions. Natural materials that are generally considered waste, such as bamboo chips, cane bagasse, and coconut shells, have also been tried to extract metals from water because they contain acid groups that aid in the process, such as carboxylic and phenolic groups.

Bamboo is a perennial giant woody grass belonging to the sub family Bamboo side of the family Graminae and takes only several months to grow and it matures within 3 to 4 years (Udeh,2018). Bamboos are abundant and widely distributed in Malaysia. Most of Malaysian bamboos grow gregariously, but in localized patches on river banks, in disturbed lowland forests, and on hillsides and ridge tops cited from (Appanah,1992). The populations are pure stands as well as mixed with other species in the forest. In general, bamboos were regarded as weeds in the context of Malaysian Forestry (Watson and Wyatt-Smith 1961; Chin 1977). Nevertheless, at present, it is ranked second to rattan in economic importance in Peninsular Malaysia among the minor or non-timber forest products (Aminuddin and Abd. Latiff 1991).

Chemical precipitation, chemical on oxidation, air stripping, and adsorption are some of the typical methods used to remove heavy metals from wastewater (Renou et al. 2008). This procedure is capable of removing 99% of pollutant from raw sewage. However, the treatment's total expense, including service, repair, and construction, is extremely high. Next, due to the high cost and to remain clean environmental, production of activated carbons from cheap and renewable precursors have been studied. Bamboo appears to be economically attractive because of its abundance, low cost, high carbon content, rapid growth and multiplication speed (Udeh,2018).

This research is being carried out to determine the level of wastewater contamination in the Gebeng industrial region as a result of industrial and mining activities, and to adapt an adsorption (carbon activation) approach to cleanse the water using bamboo chips.

1.2 Problem statement

Nowadays, in Malaysia, there are often pollution problems on rivers due to industrial and agricultural activities. Heavy metal pollutants are present in wastewater generated by industrial activities. Because most heavy metals do not degrade into nontoxic end products, their concentrations must be decreased to a tolerable level before they may be discharged into the environment. (Madhukar J. Phadtare,2015). At least 20 metals have been categorised as poisonous, and half of them are released in substantial quantities into the environment, posing serious threats to aquatic life. On 5 January 2016, MalaysiaKini and Berita Harian reported thousands of fishes were found dead alongside Tunggak River and the cause was suspected to be the pollution from bauxite mining and industrial activities in Gebeng.

Gebeng, Kuantan is the primary industrial land in Pahang, with geographical coordinates of 3° 55' 0'' N to 4°01' 0'' N and 103° 22' 0''E to 103° 27' 0''E. Metal, chemical, petrochemical, polypropylene, polymer, palm oil, food, mining, wooden, and gas and electricity sectors are all represented in the Gebeng industrial estate. The Tunggak River is the most important river in the area, carrying the most garbage. It joined another river, the Balok, near Angler Marine Center, and eventually flowed into the South China Sea. As a result of the pollution caused by these activities, it has given some adverse effects that are harmful to the environment as well as human health. Due to the problem of river pollution, the water treatment plant has been a few ways which is used materials such as activated carbon as one of the materials to treat or to removed pollution that happen to river.

Activated carbon is also known as activated carbon charcoal or activated coal. Activated carbon has various functions for water treatment that is firstly can absorb many components which is organic and inorganic matter. It's also can be used to remove contaminants like dyes, heavy metals, pesticides (Kumar, 2020). Besides that, activated carbon structure presents a large active surface that enables it to adsorb a wide range of compounds and pollutants from particular environments and waste water (Bursic,2016). However, there are a few disadvantages by using activated carbon which is process need producing high-efficiency activated carbon and expensive.

There are many types or characteristics of activated carbon can be produces from various of plant which is bamboo chips. The needs to identify the most effective and suitable characteristics of activated carbon is important because it can produce the best result and at the same time give the best effectiveness of wastewater treatment and eco-friendly environment.

1.3 Objective

There are 3 objectives for this study based on the problem statement. The objectives are as below:

1. To produce Activated Carbon from bamboo chips as industrial waste water treatment by using 400 ^{o}C and 500 ^{o}C preparation method.
2. To identify the level pollutant contained in wastewater of Gebeng Industrial estate.
3. To determine the effectiveness of activated carbon from bamboo chips in treating wastewater.

1.4 Scope of study

This research focuses on the characteristics of industrial wastewater and the effectiveness of bamboo chip activated carbon in removing heavy metals from it. Industrial waste water samples were collected from Gebeng industrial district (palm oil activities). Physical and chemical properties of the wastewater are used to identify its characteristics. The chemical characteristic, which is the parameter of pH, biological oxygen demand (BOD), chemical oxygen demand (COD), and metal ions, is determined through a series of experiments. In addition, physical characteristics such as colour, odour, turbidity and Total suspended solids (TSS) must be observed. The main goal of this research is to see how effective bamboo chips activated carbon is at removing heavy metal ions from industrial wastewater by using Physico-Chemical method of activation. The aim of these experiments is to determine the effectiveness of Bamboo chips as waste water treatment. As a result, the lower cost of wastewater treatment using bamboo chip activated carbon adsorption is suggested as a more cost-effective treatment than other traditional methods.

1.5 Significant of study

To produce activated carbon from cheap and renewable precursors by comparing two different temperature of activation method process in treating wastewater in Gebeng industrialization. In addition, it is to study the effectiveness of whether bamboo chips can reduce pollution in water through BOD, TSS, turbidity and Ph. It is able to save costs for water treatment if the bamboo chip is able to prove to be used as activated carbon. It is important to find an efficient and economic treatment alternative to be commercialized in providing safe water for user.

CHAPTER 2

LITERATURE REVIEW

2.1 River

Rivers are described as a large, natural freshwater stream which flows to the ocean of water or other broad size and usually is fed into it by smaller streams, known as the tributaries. Rivers, water bodies flow dynamically and adjust continuously according to the flow of water. Some of the changes are related to a river or place these are spatial changes. Some of the shift is related to time, in particular the season of the year. Some changes occur abruptly, others occur even more progressively. Any modifications are man-made.

Usually rivers begin at a source, with power derived from gravity force, rivers flow downhill from river source to river mouth. The direction can involve all directions of the compass and can be a complex meandering path (Rosenberg, 2006). A point that flows downhill to a bigger body of water like an ocean, sea or wide lake. In guiding the streams of rivers, gravity plays an important part. The origin point for rivers is located on the watercourse at the highest point. The region from which runoff drains is also known as the watershed.

Rivers are complex ecosystems which, due to overuse and increased population growth, have been seriously damaged or even destruct. Rivers and human populations are connected closely with socio-economic developments and have contributed to significant depletion and changes in river habitats. However, many specific plants and animals have been affected by human disruption in their provision of vital products and services, such as water purification, power generation, retention of organic matter, nutrient recovery, recreation and habitat.The rivers reciprocate the surrounding ecosystem with water, materials, energy and nutrients. The quality of the river, sediment and biological communities all represent upstream and also downstream characteristics. In contrast, thermal, sculptural, watered and nutritionally complemented ecosystems in rivers and rivers are existing. River research has a multidisciplinary nature and is based on several biological, chemical, physical and engineering branches. Given that the overwhelming majority of rivers and streams are regulated in a way by humans, impacts on these systems may be significant and their efficiency can be improved.

2.2 Wastewater

Wastewater is any water that has been affected by anthropogenic influences and includes liquid waste released by domestic households, industrial facilities, manufacturing, or agriculture, and can include a wide variety of possible pollutants and concentrations. Wastewater also is watering whose physical, chemical or biological properties have been changed as a result of the introduction of certain substances which render it unsafe for some purposes such as drinking. The day-to-day activities of man is mainly water dependent and therefore discharge waste into water. Some of the substances include body wastes faeces and urine, hair shampoo, hair, food scraps, fat, laundry powder, fabric conditioners, toilet paper, chemicals, detergent, household cleaners, dirt, micro-organisms (germs) which can make people ill and damage the environment. It is known that much of water supplied ends up as wastewater which makes its treatment very important. Wastewater treatment is the process and technology that is used to remove most of the contaminants that are found in wastewater to ensure a sound environment and good public health.

Wastewater is a liquid that contains nitrogen and phosphorus from human waste, food and certain soaps and detergents. Once the water is cleaned to standards set and monitored by state and federal officials, it is typically released into a local water body, where it can become a source of nitrogen and phosphorus pollution. The composition of wastewater is 99.9% water and the remaining 0.1% is what is removed. This 0.1% contains organic matter, microorganisms and inorganic compounds. Wastewater effluents are released to a variety of environments, such as lakes, ponds, streams, rivers, estuaries and oceans. Wastewater also includes storm runoff, as harmful substances wash off roads, parking lots and rooftops. The organic content of wastewater is made up of human feces, protein, fat, vegetable and sugar material from food preparation, as well as soaps. Some of this organic content is dissolved into the water and some exist as separate particles. The portion of organic material that does not dissolve but remains suspended in the water is known as suspended solids. Wastewater is treated to remove as much organic material as possible.

Wastewater needs to be treated into clean water in order to avoid affecting the health of consumers due to the content contained in the wastewater. Water is an important use for humans, plants, and many more. Water treatment is installations where waste or dirty water is converted into better quality water through various physical and chemical processes.

2.2.1 Types of waste water

There are three types of wastewater, or sewage: domestic sewage, industrial sewage, and storm sewage. Domestic sewage carries used water from houses and apartments; it is also called sanitary sewage. Industrial sewage is used water from manufacturing or chemical processes.

2.2.1.1 Domestic waste water

Domestic wastewater is a community water that includes all the products that have been applied to the water for the use. It is thus composed of waste of the human body, which is faeces and urine and the waste water that is the result of personal washing, washing, preparing food and cleansing cookware. The strength and composition of the domestic wastewater changes on hourly, daily and seasonal basis, with the average strength dependent on per capita water usage, habits, diet, living standard and life style. The main reason is variation in water usage in households. Fresh waste water is an earthy, but harmless, grey, turbid substance. It contains large floating and suspended solids such as fabrics, rags, containers of plastic, cobs of maize, smaller solids, such as partially broken faeces, paper, vegetable peel and very small solids in the colloidal suspension, which is non-setable and contaminants of real solution. In aspect and in content it is dangerous, primarily because of the number of 'pathogenic' species causing a disease. Waste water can soon lose its dissolved oxygen content in warm climates and become 'stale' or 'septic.' Septic wastewater typically has a hydrogen sulphide offensive odour.

2.2.1.2 Industrial effluent

Industrial effluents are a main source of direct and sometimes persistent contaminants into marine environments with lasting consequences for the workings of the environment, such as shifts in the supply of foodstuffs and extreme threats to biosphere self-regulation. Industrial releases or waste include heavy-metals, pesticides, phenolic compounds and microorganisms, polychlorinated biphenyls, dioxins, polyaromastic hydrocarbons (PAHs), petrochemicals. The waste is normally dumped into water sources and has gained much attention because of the cumulative harmful environmental effects. Industrial waste that contains large levels of microbial nutrients will certainly support the development of substantially high types of coliforms and other microbial shapes. Industrial wastewater such as food processing, electrical appliance processing, chemical substances processing may generate wastewater that are containing heavy metal contaminants. (Madhukar J. Phadtare, 2015)Any of the heavy metals found to be carcinogenic in these effluents whereas other substances similarly present are poisonous in accordance with dosage and length of exposure. Undoubtedly, the environmental equilibrium of such a setting could be disturbed if wastes water from factories and residential areas is released into another area without proper treatment. Removal of heavy metals from industrial wastewater is the primary importance because they are not only causing contamination of water bodies and are also toxic to many life forms. (Madhukar J. Phadtare, 2015). Heavy metal water pollution represents an important environmental problem due to the possible toxic effects of the metal to both human and environment. (Z.A. Husoon, 2013). Therefore, during the dry season the industrial discharge contributes to a greater part of the river's flow, resulting in a further deterioration of water quality. Uses for which the river is used in contacts with the body subject people to severe dangers because of bacterial conditions. (Z.A Husoon,2013).

2.3 Water pollution

Water pollution happens when one or more substances building up in the water body to an extent that pose problems to the animals and humans (Chris, 2015). Water pollution also can be defined as the contamination of streams, lakes, seas, underground water or oceans by substances, which are harmful for living beings. If the concentration of substances naturally present in water increases then also the water is said to be polluted. Water is considered polluted if some substances or condition is present to such a degree that the water cannot be used for a specific purpose. Water pollution also defined as to be the presence of excessive amounts of a hazard pollutant in water in such a way that it is no long suitable for drinking, bathing, cooking or other uses. Pollution is the introduction of a contamination into the environment (Webster, 2010). It is created by industrial and commercial waster, agricultural practices, everyday human activities and most notably, models of transportation. No matter where human go and what human do, there are remnants earths environmental and its inhabitants in many ways. The three main types of pollution which is land pollution, air pollution and water pollution.

2.3.1 Sources of water pollution

Water pollution can occur from two sources which is firstly from point source and secondly is non-point source. Point source is pollution that be identify directly of source. For example, is includes pipe attached to a factory, oil spill from a tanker, effluents coming out from industries waste. Meanwhile, non-point source is pollution include wastewater effluent both municipal and industrial and storm sewer discharge and affect mostly the area near it (Asha, 2016).

2.3.1.1 Industrial Wastewater

There are several sources of water contamination. The city sewage and industrial waste released into rivers are the most polluting. The wastewater from industries varies so greatly in both flow and pollution strength. Waste in general is produced by human activity, for instance, extraction and processing of raw materials. Industrial waste management is intentionally done to reduce the adverse effects of waste on the environment and human health. Industrial waste management examines the broader context of waste treatment for wastes directly or indirectly originating from industries, and may include corporate sustainability, environmental impact, consideration of government policy and regulations, recycling, containment, handling and transport, centralized compared to on-site treatment, technologies, economics, avoidance and reduction (Agoro,2020). Industrial waste with a high carbon content that is handled under anaerobic conditions, whether intended or unintended, will produce CH_4. The potential for CH_4 production from industrial wastewater streams is determined by the quantity of degradable organic matter in the wastewater, the volume of wastewater, and the industrial sector's proclivity to treat their wastewater in anaerobic sludge. Industrial wastewater plants, chemical sludge may be generated as a result of neutralization, precipitation of toxic compounds, or coagulation (Omer,2019).

2.3.1.2 River Dumping

Freshwater pollution originates from many sources, including municipal, industrial and agricultural waste, wastewater and nutrient run-off, power generation, heavy industry, automobiles, and others the main form of contamination in these freshwater bodies is nutrient pollution, which involves nitrates and phosphates. Plants and animals need these nutrients to grow, but because of farm waste and fertiliser ruin, they have become a major pollutant.

2.3.2 Types of water pollution

There is some of types of water pollution which is firstly surface water. Surface water resources from huge oceans, lakes, and rivers. Contaminants such as chemicals, nutrients, and heavy metals are carried from farms, factories, and cities into streams and rivers and then to seas and oceans. Our seas are also sometimes spoiled by oil spills. And second types of water pollution are ground water. Ground water is Water stored underground in aquifers is known as groundwater. Groundwater gets polluted when contaminants pesticides, fertilizers or waste leached from landfills and septic systems make their way into an aquifer, rendering it unsafe for human use. It is virtually impossible to remove contaminants from groundwater. Groundwater can also spread contamination into streams, lakes, and oceans.

2.3.3 Effect of water pollution

To put it bluntly, water pollution kills. In fact, it caused 1.8 million deaths in 2015, according to a study published in the “lancet” website. Contaminated water can also make you ill. Every year, unsafe water sickens about 1 billion people. And low-income communities are disproportionately at risk because their homes are often closest to the most polluting industries. Pollution and wellbeing are more closely associated. Pathogens are known as diseases which cause microorganisms, and these pathogens spread disease directly to human beings. Some pathogens are found in a well-defined region around the world. Many diseases with water spread human beings to human beings. High precipitation and flooding are connected with severe weather and lead to various diseases for developing and developed countries. The food and vegetables grown in polluted water are the basis for 10% of the population. Many infectious diseases transmitted by water are associated with faecal water contamination and result in infection on faecal oral pathways (Omer, 2019). Polluted water health risks include various diseases including respiratory conditions, cancer, diarrheal disorders, neurological and cardiovascular diseases. Cancers and blue baby syndrome are responsible for nitrogen chemicals. In rural areas, the rate of mortality from cancer is higher than in urban areas because urban residents drink filtered water while rural residents have no treatment facilities and do not use unprocessed water. The risk of disease in poor people is higher because of insufficient sanitation, hygiene and water supply. In women who are exposed to contaminants during pregnancy, contaminated water has significant negative consequences it results in increased low birth weight as a result of the foetal health. To be specific, chemical pollutants from heavy metals such as arsenic and mercury to pesticides and nitrate fertilizers are getting into our water supplies. Once they are ingested, these toxins can cause a host of health issues, from cancer to hormone disruption to altered brain function. Children and pregnant women are particularly at risk.

2.4 Activated carbon

Activated carbon is an adsorbent produced from a wide range of organic based materials such as coal, coconut shell, wood chips, palm-kernel shell, corn cobs, saw dust and many others. Activated carbon is an adsorbent obtained from carbonaceous materials with a disorganized crystallographic structure, constituted by randomly distributed microcrystals. This microcrystalline structure is built from elementary structures such as graphene sheets and fullerene or quasi-graphitic fragments. However, this microcrystalline arrangement does not extend on a macroscopic scale resulting in a disordered and highly nano porous structure. Consequently, these materials present a high specific surface area (500–1500 m^2/g), a wide variety of functional groups (carboxylates, carbonyls, hydroxyls, amines) and a pore size distribution (< 1–100 nm). All these characteristics give them an extraordinary capacity to adsorb a great diversity of molecules. Activated carbon has many applications in the environment and industry for the removal, retrieval, separation and modification of various compounds in liquid and gas phases. Selection of the chemical activator agent is a major step controlling the performance and applicability of activated carbon (Kumar, 2020).

The advantages of activated carbon for zeolites or polymer-based adsorbents are high quality in wastewater treatment, simple process design, easy exploitation of the process, resistance to corrosive such as acid and alkali and toxic environments, high adsorption potential in gas and liquid purification and their use as supportive catalysts.

2.4.1 Function of activated carbon

Activated Carbons are the most powerful adsorbents known. It is basically a solid material consisting mainly of pure carbon. A characteristic feature is its porous structure and the resulting immense surface area which may be as large as 1500 m2/gm. Due to its exceptional adsorption qualities, activated carbon is widely used in process destined to purify, discolour, recuperate and remove odours at low cost and superior efficiency. Activated carbons work on the principle of adsorption. Adsorption is an interfacial process involving the collection of gaseous or solute components on the surface of adsorbent solids. This phenomenon is associated with physical attractive forces that bind gaseous and solute molecules commonly known as Van-der Waals forces. Adsorption is thus a physical process, for example the substances adsorbed on the solid do not undergo any chemical reaction with the latter. The adsorbing solid is referred to as adsorbent and the substance to be adsorbed from the liquid or the gas phase as the solute. The adsorption power and rate are determined by the kind of activated carbon, the particle size, the pore size and its distribution (Vairagade,2017).

2.5 Water Quality Parameters

Water quality is a study on water with suspended and dissolved substances will determine the physical, chemical, and biological properties of water and level of pollution are able to be determined before any further treatment is carried out. The physical and chemical characteristic of industrial wastewater presented is for most wastewater.

2.5.1 Physical Parameter

The physical characteristics of the industrial wastewater include the Odour, Turbidity and Total Suspended Solid (TSS).

2.5.1.1 Odour

Odour is another feature of industrial wastewater. Because the general public is more concerned about the effective operation of wastewater treatment facilities, determining odour has become highly significant in environmental issues. Hydrogen sulphide (H2S) is a natural by-product of anaerobic digestion that has a strong and unpleasant odour. It is discharged into the sky due to its limited solubility in wastewater, resulting in a disagreeable odour. At higher temperatures, odours are usually worse. The various disagreeable odours caused by various industrial wastewaters some sources of odour in the environment are shown in table 2.1 and figure 2.1

Table 2.1 Unpleasant Odours in Some Industries

Industries	Origin of Odours
Cement works, lime kilns	Acrolein, amines, mercaptans, dibutyl sulphide, H_2S, SO_2, etc.
Pharmaceutical industries	Fermentation produces
Food industries	Fermentation produces
Food industries (fish)	Amines, sulphides, mercaptans
Rubber industries	Sulphides, mercaptans
Textile industries	Phenolic compounds
Paper pulp industries	H_2S, SO_2
Organics compost	Ammonia, sulphur compounds

2.5.1.2 Turbidity

Turbidity is a measurement of how cloudy water is. Turbidity is made up of microscopic particles suspended in water. NTUs are the most common unit of measurement. It is a measurement of light's ability to travel through water. It is caused by the presence of solid and suspended solids such as silt, clay, organic materials, and microorganisms that obstruct light transmission through the water. When the water becomes cloudy, it means there is a lot of turbidity in the water. Turbidity also includes a parameter that determines whether the typical value is greater or lower. Turbidity is not a serious health hazard, but it can interfere with disinfection and offer a breeding ground for bacteria if it is greater than normal. High concentration of turbidity can damage the habitats for fish and other aquatic organisms. Besides that, it causes concern towards the aesthetic point of view. Turbidity of industrial effluent may be measured using basic equipment such as turbidity measurement or water quality equipment. Below is the example of turbidity ratings.

Turbidity Ratings

Good (<1 NTU) - It is recommended that new-borns and people with compromised immune systems drink boiled water or a safe alternative.

Fair (1-5 NTU) - It is recommended that children, the elderly, people with compromised immune systems and anyone seeking additional protection drink boiled water or a safe alternative.

Poor (>5 NTU) - It is recommended that all users drink boiled water or a safe alternative. Tap water intended for drinking should be brought to a rolling boil for at least one minute.

2.5.1.3 Total Suspended Solid (TSS)

TSS could be anything that floats or "suspends" in water, including sand, sediment, and plankton. TSS refers to anything floating or drifting in a body of water, including sediment, silt, and sand, as well as plankton and algae. All particles suspended in water that cannot pass through a filter are referred to as TSS. TSS refers to particles larger than 2 microns in size in water, whereas dissolved solids refer to particles less than 2 microns in size, which is the typical filter size. Although inorganic materials make up the majority of suspended solids, organic particles from decaying materials also contribute to the TSS concentration. TSS is an important aspect to consider while analysing water clarity since the higher the concentration of solids in water, the cloudier the water becomes. The ability of water to support varied aquatic life declines as TSS levels rise. TSS absorbs heat from the sun, raising water temperature while lowering DO because warmer water holds less oxygen than cooler water. Because less light reaches the water, the photosynthesis process slows down, resulting in a reduction in the amount of oxygen generated by aquatic plants, lowering the DO level even further.

2.5.2 Water Quality Chemical Parameter

The chemical characteristics of the industrial wastewater include the Ph, BOD and COD and zinc & cooper.

2.5.2.1 pH

The measurement of hydrogen ion activity in a solution is referred to as "pH." In the wastewater treatment process, pH determination is very significant. Extreme levels, particles, harmful chemical build up, and growing alkalinity levels are all prevalent concerns in wastewater. The acidity, neutrality, or alkalinity of a substance is determined by its pH value. The microorganism's activity will be determined by the alkalinity or acidity of the industrial effluent. The microorganism's activity increase as the alkalinity of the industrial effluent increases. However, if the alkalinity is too high, the bacterium cannot survive. To safeguard live organisms, the pH of wastewater should be kept between 6 and 9. The pH acidity is less than 6, while the alkalinity is more than 7. The pH of water should be between 6.5 and 8.5. When acidity is present in industrial and commercial wastewater, it can prevent the treatment process from working**.**

2.5.2.2 Biological Oxygen Demand (BOD)

The BOD test is used to determine the quantity of dissolved oxygen that aerobic biological organisms are expected to need to decompose waste in wastewater that is present in a water sample at a certain temperature over a certain length of time. BOD is typically measured in milligrams of oxygen consumed per litre (mg/l) of water sample over a 5-day incubation period at 20°C and is used to determine the degree of organic pollution in water (Clair, et al. 2003). It is critical to assess the amount of treatment necessary as well as the potential influence on the living beings who will be exposed to the water. Because measuring BOD takes too long (20 days at 20°C), it is preferable to determine BOD after 5 days of incubation, with BOD5 values accounting for almost 65 percent of total BOD.

The amount of dissolved oxygen in water is directly influenced by BOD. The quantity of oxygen accessible in water is measured as DO. It is necessary for the health of water bodies like as lakes and rivers. The presence of a high quantity of oxygen in water is a positive indicator, but the absence of oxygen indicates serious water pollution. A low BOD level suggests acceptable water quality, whereas a high BOD level suggests contaminated water. The greater the BOD level, the faster the oxygen in water is depleted. As a result, there is less oxygen available for aquatic life. Stressed aquatic creatures choke and die as a result of their suffocation. Several variables impact the rate of oxygen consumption by aquatic organisms, including temperature, pH, and the kinds of organic and inorganic components present in the water. In order to calculate BOD, two measurements are necessary. The first is the quantity of dissolved oxygen measured immediately, and the second is the quantity of dissolved oxygen measured after the sample has been incubated for 5 days. The quantity of oxygen required by microbes to break down organic matter in the sample during incubation is determined by the quantity of remaining or final dissolved oxygen.

Heterotrophic bacteria oxidise 1/3 of colloidal and dissolved organic matter into stable end products, which are carbon dioxide (CO2) and water, in aerobic processes in which oxygen (O2) is present (H2O). The remaining two-thirds of colloidal and dissolved organic matter is transformed into new microbial cells. By using a settling procedure, these new microbial cells may be removed from the water. Temperature is vital in most biological activities because as the temperature rises, the rate of biological processes accelerates, and as the temperature decreases, the pace of biological processes slows. When a biochemical reaction is allowed to complete, ultimate BOD (L0) is the maximum BOD level in water or the total quantity of oxygen absorbed by bacteria. The 5-day BOD is nearly usually used as a measure of relative pollution effect since the ultimate BOD takes too much time.

2.5.2.3 Chemical Oxygen Demand (COD)

Chemical oxygen demand is another method for determining oxygen demand (COD). The comparable quantity of oxygen required to chemically oxidise soluble and particulate organic matter in water is measured as COD. It is an important water quality metric since it gives an index for determining the environmental impact of discharged wastewater. It just takes two hours to determine the amount of oxygen necessary for the oxidation of all aqueous compounds, including those that cannot be decomposed biologically. A higher COD implies that there is a large amount of organic matter that may be oxidised in water, lowering the quantity of dissolved oxygen. Further dissolved oxygen depletion occurs under anaerobic conditions, which is detrimental to higher aquatic life forms. COD is frequently used as a substitute for BOD testing since it is both quicker and more accurate. COD levels, on the other hand, are always greater than BOD readings. As a result, weather conditions, distance from discharge sources, accessibility, runoff variables, and safety issues during sample time may all have a role in increasing and reducing COD concentration readings for each measurement.

2.5.2.4 Heavy Metals

Any metallic chemical element with a relatively high density that is dangerous or hazardous at low concentrations is referred to as a heavy metal. Copper (Cu) and zinc (Zn) are two examples of metals (Zn). Heavy metals can enter a water body from industrial and consumer waster, and even from acidic rain that breaking down soils before releasing heavy metals into streams, rivers, lakes and groundwater. Heavy metal cannot be damaged or degraded. They enter the human body in minute amounts by food, drinking water, and breathing. Some heavy metals, such as Cu and Zn, are necessary for human metabolism, but at high enough amounts, they can cause poisoning. Heavy metal has a proclivity for bioaccumulation as well. The accumulation of substances or chemicals in an organism, as well as the rise in its chemical concentration over time, is referred to as bioaccumulation. When an organism absorbs a potentially harmful material at a higher pace than the material is eliminated by catabolism and excretion, this is referred to as overabsorption.

Copper (Cu) is found in nature and is also discharged as a result of human activities such as coal-fired power plants, metal manufacturing, waste incinerators, sewage treatment operations, and the use of agricultural pesticides. It is widely utilised in a broad range of applications, including electronic and electrical applications, heat exchangers, motors, plumbing fittings, building construction and roofing, chemical and maritime equipment, culinary utensils, wood preservatives, anti-fouling agents in paints, and as a trace nutrient in livestock feeds. Humans are exposed to trace amounts of copper in their diet and drinking water. This is likely to be useful at low concentrations because Cu is one of the basic nutrients required by the human body. However, high concentration of Cu has adverse effects on health such as chest pains, vomiting and irritation of the eyes and nose.

Zinc (Zn) is used in the production of paints, plastics, rubber, dyes, wood preservatives, and cosmetics, as well as corrosion-resistant coatings, dry-cell batteries, and alloys (metal mixes) such as brass and bronze. Metal production processes, industrial coal combustion, garbage incineration, and worn rubber tyres on automobiles all contributed to the discharge of pollutants into the environment. Natural gas is also emitted in small volumes from the earth's crust. By accumulating in aquatic creatures and poisoning animals that ingest it, zinc pollution has a profound impact on the local aquatic ecology. Drinking polluted water from Zn water pipes or unintentional industrial leaks is the most common way to be exposed to potentially dangerous quantities of Zn. Although zinc is a necessary vitamin for humans, taking more than twice the daily recommended quantity can be detrimental. It might make you feel nauseous and give you stomach pains. Long-term exposure to high quantities can result in "metal fume fever," a condition that affects the lungs and the body's temperature regulating system.

2.6 Adsorption Method

Adsorption is defined as the accumulation of a material at the interface between two phases, such as liquid onto solid, with the adsorbate referring to the molecules that collect at the interface and the adsorbent referring to the solid on which the adsorption takes place, such as activated carbon, ion exchange, and metal hydroxides. The goal of carbon adsorption in water treatment is to remove dissolved odorous compounds or traces of organics, as well as refractory dissolved organics that cannot be removed by standard biological treatment and heavy metals from industrial effluent.

People have been pushed to create effective strategies for removing organic and inorganic chemicals such as metals and pesticides from water as a result of water pollution. In order to cleanse dirty water, a variety of techniques have been used, including coagulation, precipitation, ozone, ion exchange, and reverse osmosis. However, because these technologies frequently require substantial capital and operational expenditures, they have been shown to be restricted. Because it is simple in design and has a low investment cost, the adsorption process using solid absorbents has a lot of potential as one of the most efficient ways for eliminating organic and inorganic pollutants from wastewater. Natural materials, agricultural wastes, and industrial wastes are all readily available and can be used as low-cost absorbents in the local area. These materials can be used to make activated carbon, which may be utilised as an adsorbent for water and wastewater treatment (Crini, 2005).

Adsorption is a mass transfer process in which a material is transported from the liquid phase to the solid surface and is bonded by physical and/or chemical interactions. Adsorption capacity and surface reactivity are both enhanced by a large surface area (Kurniawan, et al. 2009). Adsorption is a prevalent process for the removal of organic and inorganic contaminants that occurs at the surface. When a solution containing absorbable solute comes into contact with a solid with a highly porous surface structure, liquid–solid intermolecular forces of attraction allow part of the solution's solute molecules to be concentrated or deposited on the solid surface. In adsorption operations, the solute that is held on the solid surface is referred to as an adsorbate, while the solid on which it is held is referred to as an adsorbent. Adsorption is the process of adsorbate accumulating on the surface of an adsorbent.

All of the component atoms in a bulk material's ionic, covalent, or metallic bonding needs are provided by other atoms in the substance. Adsorbates can be attracted to atoms on the surface of the adsorbent because they are not completely surrounded by other adsorbent atoms. The kind of bonding in the adsorption process is often classed as physisorption (characterised by mild Van Der Waals forces) or chemisorption (characterised by strong Van Der Waals forces) (characteristic of covalent bonding). It might also be caused by electrostatic attraction. In the adsorption process, equilibrium of solute adsorption between the solution and the adsorbent is achieved when the rate of solute adsorption from the bulk onto the adsorbent is at its lowest.

2.6.1 Factor Affecting Adsorption

The adsorption equilibrium is influenced by a variety of variables. Adsorbent properties and adsorbate qualities are the two components that determine adsorption equilibrium. Surface area, pore size distribution, and surface chemistry are the initial adsorbent features to consider. The second set of features is adsorbate properties, which include solubility, molecular structure, and degree of ionisation.

2.7 Bamboo chips

Bamboo (subfamily Bambusoideae) is a vast group of the family Poaceae that includes many different species. Herbaceous bamboos are found in more than 88 genera and 1,642 species around the world, with 28 genera and more than 120 species being herbaceous bamboos (Vorontsova et al., 2016). Bamboo is extensively spread throughout the tropical, subtropical, and temperate zones of all continents, with the exception of Europe and Antarctica, and may be found from lowlands to elevations of 4,000 m or higher. China is a bamboo distribution hotspot, with more than 34 genera and 534 species of bamboo found there. The economic and ecological importance of bamboo species may be seen in a number of nations. Bamboo is used to make a broad variety of items and has several applications for people and other animals, but it also has a significant influence on the environment.

Bamboos are abundant and widely distributed in Malaysia. Most of Malaysian bamboos grow gregariously, but in localized patches on river banks, in disturbed lowland forests, and on hillsides and ridge tops (Ng and Noor 1980; Wong 1989; Azmy 1991). The populations are pure stands as well as mixed with other species in the forest. In general, bamboos were regarded as weeds in the context of Malaysian Forestry (Watson and Wyatt-Smith 1961; Chin 1977). Nevertheless, at present, it is ranked second to rattan in economic importance in Peninsular Malaysia among the minor or non-timber forest products (Aminuddin and Abd. Latiff 1991).

The using of bamboo for its utilization has not been fully explored. The production of value-added products such as activated carbon will enlarge its application and help to deal with the emergent wastewater treatment challenge in Malaysia with a very low cost and environmentally friendly. Information on the chemical composition of the components that constitute bamboo is important. The feasibility of carbonization depends on the chemical composition of the bamboo. Determining the elemental composition of bamboo by elemental analysis is a key factor for the detailed design of the production of activated carbon from a bamboo carbonization plant and helps confirm the accuracy of material and energy balances of the bamboo carbonization process. The ultimate analysis of a bamboo component typically involves the determination of the percent of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulfur (S) and ash. Because of the concerns over the emission of chlorinated compounds for example dioxins, during combustion, the determination of halogens is often included in an ultimate analysis. The results of the elemental analysis are used to characterize the chemical composition of the organic matter in bamboo. The major average elements are carbon (47.6%) and oxygen (43.9%) accounting for around 91% of bamboo. Other elements include hydrogen (6.5%), nitrogen (0.3%), sulfur (0.3%) and ash (1.4%). (Keith, John and Gordon, Chemical Engineering Journal,2005).

Figure 2.2 Bamboo Chips

CHAPTER 3

METHODLOGY

3.1 Introduction

Methodology is the part where all the methods or procedures of the experiment were explaining such as to identify, pick, and analyse data in order to comprehend the detailed research issue. For this section, the assessment of wastewater quality parameters of Gebeng industrial area wastewater is carried out to determine the initial level of pollution before treatment process by using activated carbon from bamboo chips is conducted. The bamboo chips of activated carbon that has been crush into smaller parts will be heated at 500°C and will be compared with the 400°C of activated carbon in order to determine their comparison of effectiveness of bamboo chips activated carbon in treating wastewater sample. A basic of wastewater testing will be conducted in determining them. As a result, the methodology in this study clarified the procedures relating to the chosen agricultural activated carbon, bamboo chips, and the industrial wastewater sample obtained from the Industrial Gebeng area, Kuantan, Pahang. In this research, the equipment used and the approach to experimentation were discovered.

3.2 Material and Method

3.2.1 Introduction

The characteristic of the experiment needs to be identified first such as the study area and the bamboo chips locations for the activated carbon. Other than that, the volume of the activated carbon, the ability to perform the experiment, the test of the experiment and the position of the actual sampling also need to be considered.

3.2.2 Study Area

The research was conducted in the oil palm mill at Industrial Gebeng Area, which is located in Pahang's Gebeng District. The town is close to the port of Kuantan. The East Coast Expressway connects Pahang's main petrochemical cluster, Gebeng Industrial Estate, to Peninsular Malaysia's West Coast. Five kilometres from Kuantan, the Gebeng Industrial Estate offers a large tract of land for investment. By its strategic position, it is home to many multinational companies in the industry. The East West Expressway, which links Kuala Lumpur and Kuantan, is directly connected to the bypass.

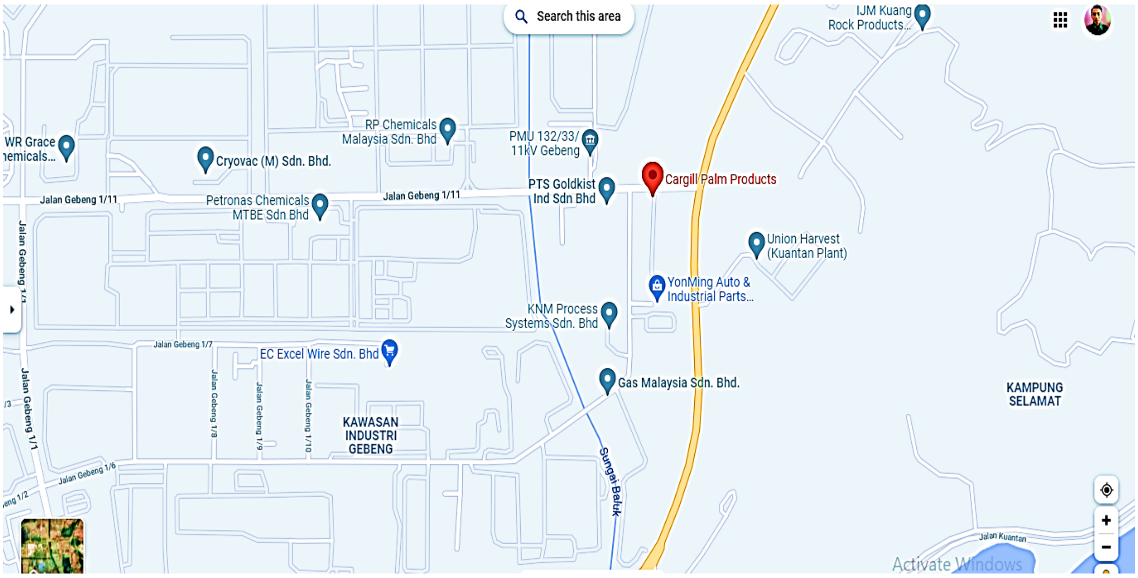


Figure 3.1 The view of the oil palm mill, Gebeng, Kuantan

Sources: Google Earth 2021

3.2.3 Material

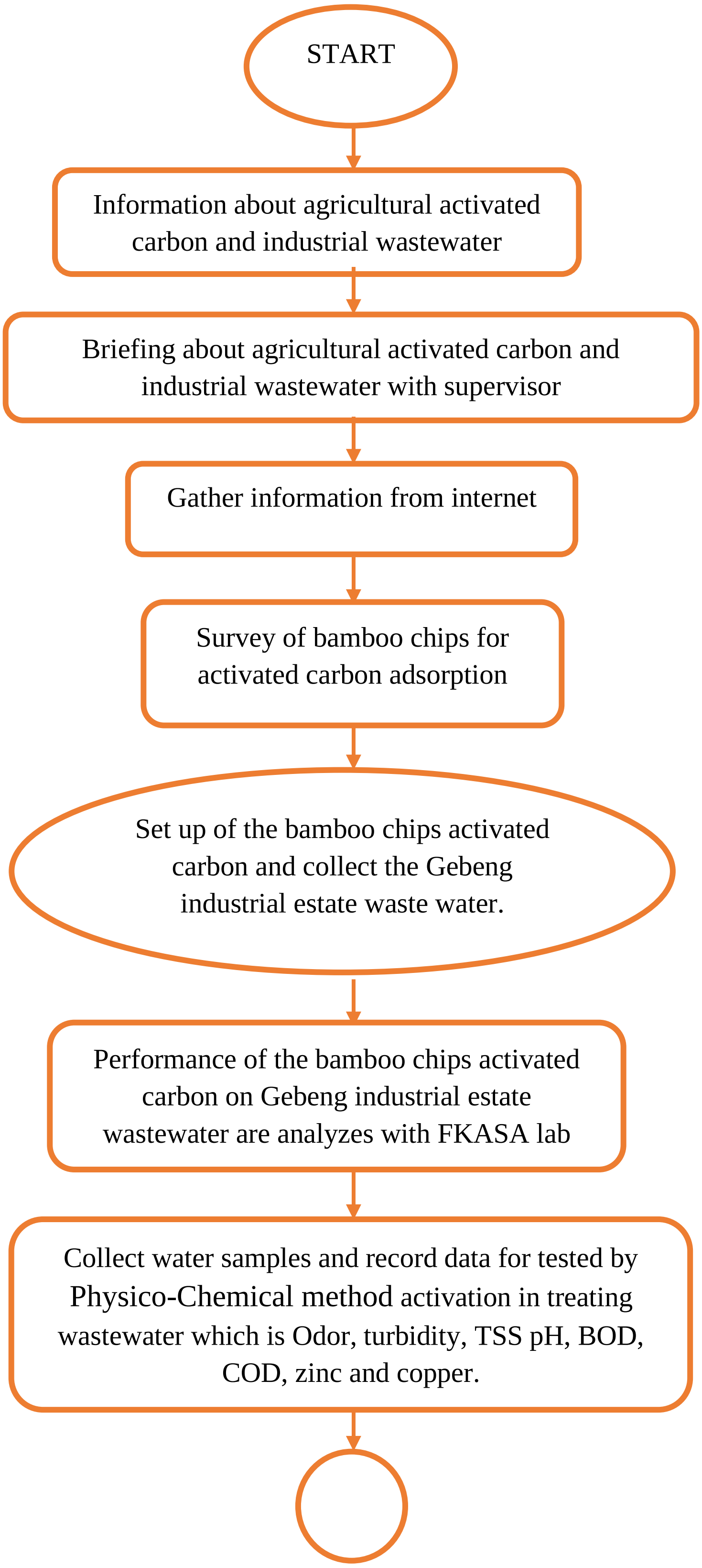
The study's content will consist of oil palm mill samples wastewater collected in the industrial Gebeng area, containing 4 litres. Each storage wastewater will be separated into different groups and treated with different ratio of activated carbon made from bamboo chips. The bamboo chips will be obtained in the agricultural area nearby.

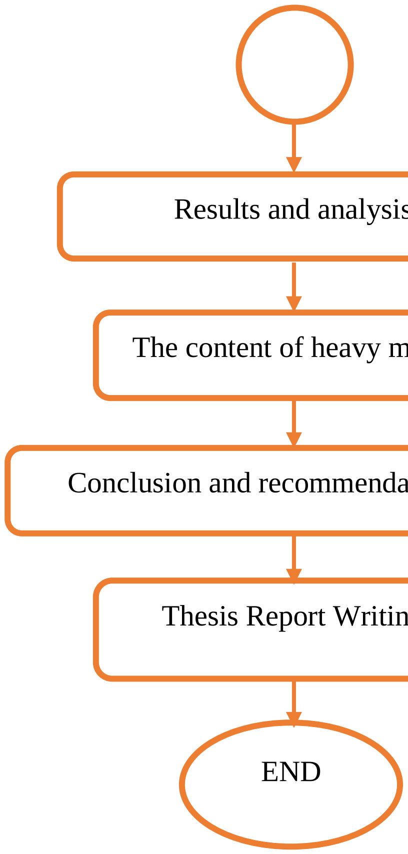
3.2.4 Sample Collection

The bamboo chips must be dried and converted into powdered activated carbon before any experiment can be conducted. The industrial wastewater sample must then be collected from the oil palm mill at the Industrial Gebeng Area using four bottles of 1000ml container. Then, the raw industrial wastewater sample were taken to the laboratory for Physico-Chemical method of activation in treating wastewater. For chemical research which is Ph, Biological oxygen demand (BOD), Chemical oxygen demand (COD) and heavy metals. For Physical research method that have been used for this experiment is Colour, Odour, Turbidity and Total Suspended Solid (TSS).

Based on environmental risk and criteria for sediment analysis, cooper and zinc were chosen. This sample was taken before the raw industrial wastewater sample being at the plant and they were treated with bamboo chips activated carbon which means at the termination of the study is to identify the initial and final heavy metals composition of the industrial wastewater.

3.3 Flow Chart of Methodology Study




Results and analysis
The content of heavy metal
Conclusion and recommendation
Thesis Report Writing
END

3.4 Experiment Set-up

3.4.1 Physico-Chemical Method of activation

The bamboo chip and their waste are obtained from the market and kite marker. It then been washed with distilled water in order to remove unwanted substance from it and dried under the hot sun until the water on it dried. The bamboo is then been cut into small pieces to make it easy for carbonization method in a muffle furnace with a temperature of 500 ^{o}C for 3hours. The bamboo samples were impregnated with Zinc Chloride ($ZnCl_2$) at different weight ratios of 1:2, 1:3 and 1:4 ($ZnCl_2$/bamboo). The resultant mixtures were heated on a hot plate until a paste was formed. The carbon samples were allowed to cool and then washed with distilled water to a pH of 6 and then dried in an oven between temperature ranges of 100^{o}C to 110^{o}C for 6 hours. The samples were named Physico-chemical Activated Bamboo Carbon (PABC). The industrial wastewater sample was taken to the laboratory for physical and chemical testing.

3.5 Analysis of Sample

The leachate liquid will be analyzed for heavy metals. The environmental laboratory at the Faculty of Civil Engineering and Earth Resources will conduct all of the laboratory analysis. pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), and heavy metal analysis are among the eight parameters used for the leachate liquid study**.**

3.5.1 Biological Oxygen Demand (BOD)

The quantity of oxygen required by a microbe, such as bacteria, during the breakdown of organic materials is known as the biochemical oxygen demand, or BOD. BOD is the oxygen necessary for the oxidation of several compounds found in wastewater, including sulphides, ferrous, iron, and ammonia. The amount of oxygen required will be determined by the BOD test. The difference between the two oxygen levels in the sample will be measured in BOD (milligrammes per litre). Dilution of the sample is done in the first step by mixing 100ml sample with 400ml dilution water in a clean beaker. Following the filling of the BOD bottle with the diluted sample, the initial DO is calculated. After that, the BOD bottle holding the wastewater sample and dilution water is incubated for 5 days at 20°C. After the sample has been withdrawn from the incubator and has reached room temperature, a final DO measurement is acquired with a DO metre. The formula for calculating BOD level is shown below.

$$BOD5 = DOi - DOt \div p$$

Where:

BODt = biochemical oxygen demand, mg/L

DOi = initial DO of the diluted waste water sample about 15 minutes after preparation, mg/L

DOt = final DO of the diluted wastewater sample after incubation for t days, mg/L

P = Dilution factor

3.5.2 Chemical Oxygen Demand (COD)

The COD test is used to determine the organic strength of wastewaters. The COD test uses a chemical (potassium dichromate in a 50% sulfuric acid solution) that “oxidizes” both organic (predominate) and inorganic substances in a wastewater sample, which results in a higher COD concentration than BOD concentration for the same wastewater sample since only organic compounds are consumed. The most popular current testing method for COD involves using sealed and heated (i.e., closed reflux) low-range (3-150 ppm) or high-range (20-1500 ppm) pre-prepared vials that change colour from orange to green based on the amount of oxidation and that are read using a laboratory colorimeter.

3.5.3 pH

The pH value is the negative logarithm (base 10) of the concentration of H+ ions in the solution. In the laboratory, pH is measured by electrometric pH measurement which is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode. The pH probe is placed in the sample (while stirring) and the number is recorded once the readings have stabilized. Because it is on a logarithmic scale, it will take ten times as much acid or base (caustic) to raise or lower the pH two units as it did to raise or lower it one unit.

3.5.4 Total Suspended Solid (TSS)

Measuring suspended solids in water is used for control of various treatment processes and for examination of wastewater quality. The level of suspended solids (or total suspended solids) in water and wastewater affects the quality of the water. Total suspended solids (TSS) is measured in laboratories by filtering a known volume of a sample, drying the filter and captured solids, then weighing the filter to determine the weight of the captured suspended solids in the sample. TSS is calculated as follows:

$$\text{Total Suspended Solid, mg/L} = (A - B \times 100)/C$$

Where:

A = weight of filter and dish + residue in mg

B = weight of filter in mg

C = volume of sample filtered in mL

3.5.5 Heavy Metals

The technique of Atomic Absorption Spectroscopy is used for heavy metal analysis (AAS). Zinc and Copper are the heavy metals considered in this study. A standard set of solutions has been established. To prevent the burner capillary from being clogged, the sample is filtered via a 0.45-micron micro-pore membrane filter. Standards are directly proportional to the concentration of the element of interest.

3.6 Data Analysis

The goal was to figure out what the characteristics of the solid waste leachate in the research region were. All of the data collected during the in situ and ex situ tests was analysed using Microsoft Excel in order to meet the study's goals. Data is analysed in terms of comparisons between homogenous segments within the group and against some external criterion. The comparison of the effects of various treatments on distinct groups, as well as the process of making decisions about how to attain the study goals, are all part of the data analysis process. Data related to each hypothesis must be compiled in quantitative form and examined to see if there is a significant difference between the controlled and uncontrolled groups' results. For each type of activated carbon employed, the results of therapy are kept for over four weeks. To save time and avoid errors, the data is then calculated and structured in Microsoft Excel. The majority of researchers prefer to utilise Microsoft Excel as a database or statistical analysis application since it meets the study's data organisation criteria. Tables and graphs are used to make it easier to see the results and compare them.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Sample of wastewater from Gebeng industrial area is collected and level of pollution is determined by carrying the Physico-chemical parameter (Turbidity, TSS, BOD, COD, pH, Color and heavy metal). Wastewater sample is then treated with activated carbon from bamboo Chips at 500°C with Carbonized activated Carbon of three different ratios (1:2, 1:3, 1:4) (Bamboo chips/Zinc Chloride). Water characteristics and pollutant level in wastewater is measured with three different ratios of Activated Carbon and it is being compared among them which ratios are the best in treating the wastewater sample.

4.2 Characteristic of Industrial Wastewater

The wastewater sample was collected from the Oil palm Mill at the Gebeng Industrial plant. Since the waste sample will be discharged at the nearest river, the sample discharged need to meet the standard required by the Environmental Quality (Sewage and Industrial Effluents Regulations 1979, Environment Quality Act 1974). This has been strictly enforced by Department of Environemntal in order to avoid river and water contamination. The Environment Quality is a set of guidelines that a corporation or industry should follow in order to avoid water and river contamination. All of the Physico-Chemical parameter data is presented in the table below.

Table 4.1 Initial level of pollutant wastewater sample and allowable standard values discharges.

Parameters	Sample Values (Ratio)	Standard Values
pH	5.73	5.5 – 9.0
BOD (mg/L)	34.3	< 50
COD (mg/L)	428.7	< 200
TSS (mg/L)	1539	< 100
Turbidity (NTU)	900	-
ZINC (mg/L)	502	< 2.0
COOPER (mg/L)	3.68	< 1.0

4.3: Laboratory Analysis

4.3.1 pH Value

pH is necessary in measuring the acidity or alkalinity of water. The initial pH of wastewater sample recorded is 5.73 which are acidic. Based on the figure 4.1 which is graph of pH against ratio, for all wastewater sample treated with activated carbon, the pH is decreasing and indicates that the wastewater sample turned acidic over 3 different ratios of Activated carbon. For the 400°C of Activated Carbon, in the first ratio of 20 gram of AC it recorded the pH of 5.2 and goes decreasing until the ratio of 40 gram of Ac. This result remains decreasing with the sample of 500°C of Activated Carbon where the first ratio it gets is 5.15 and goes down until 4.84. Both of this treated wastewater sample are acidic and Bamboo Activated Carbon shown they are not successfully turn the wastewater sample into natural or alkali. This is because of the inorganic and organic particles in wastewater sample where the activity of bacteria is aggressive on it. Moreover, acidic of wastewater can lead to corrosive nature. The Activated Carbon from bamboo chips need some improvement so that it can adsorb the inorganic and organic particle in the wastewater sample efficiently so that the pH can remain in the range (5.5 – 9.0) of standard B Environment Quality Act 1974 as stated in the table 4.1.

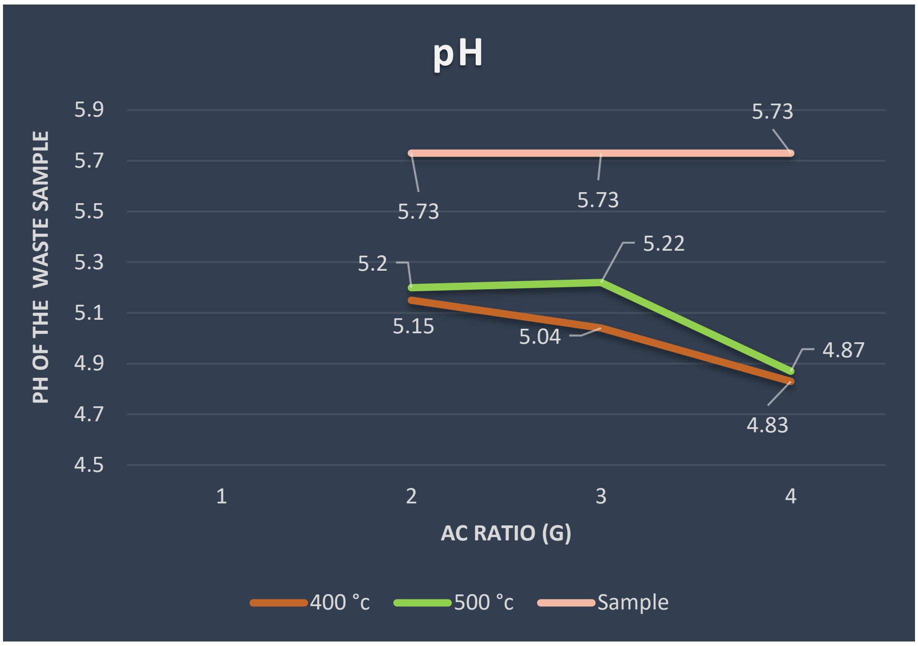


Figure 4.1 pH value for treated water for different ratio of temperature

4.3.2 Total Suspended Solids (TSS)

TSS is all particles that suspended in water that is not able to pass through a filter. The initial TSS of the wastewater sample is 1539 mg/l. From the figure 4.2 which is graph of TSS against ratios of treatment, for all wastewater treated with Activate Carbon Bamboo Chips, the amount of TSS is decreasing. The result shows both of this Activated carbon successfully treated the wastewaters sample from 1539 mg/l for the initial of sample until the final of ratio 40gram which is 168 mg/l for 500 °C and 122 mg/l for 400°C of activated carbon. Decreasing in TSS indicates the decreasing of organic and inorganic particles in wastewater which is the main lead of TSS. From the 3 different ratios for both of this Activate Carbon, the ratio of 40 gram was proven to be the effective in treating the wastewater sample thus the aim of this experiment has achieved.

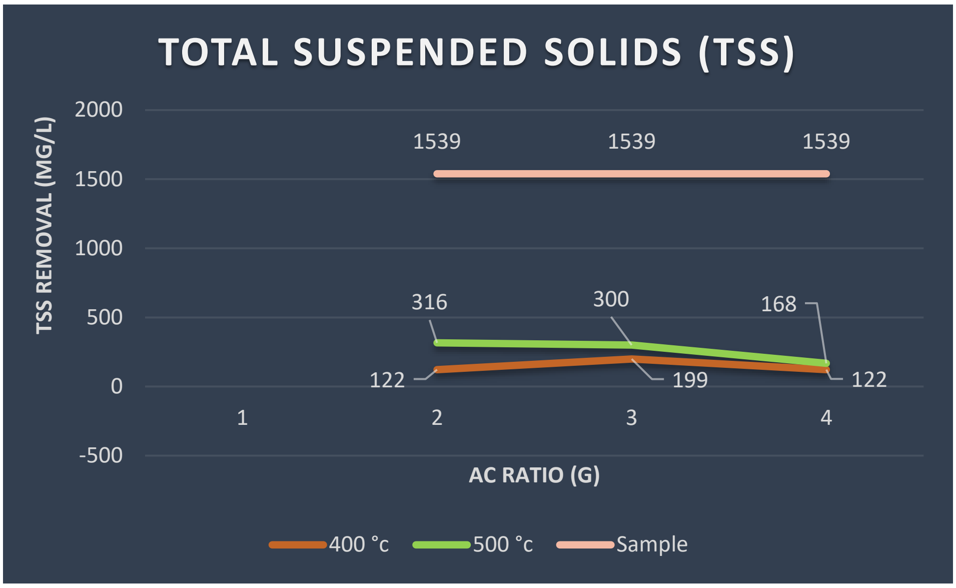


Figure 4.2 Amount of TSS for treated water for different ratio of temperature

4.3.3 Turbidity

Turbidity is the quality of being cloudy, opaque or thick with suspended matter. The measurement of turbidity is the key test of water quality. The initial reading of turbidity for the wastewater sample recorded in the table 4.1 is 900 NTU. From the figure 4.3 which is graph of Turbidity against ratios of treatment, for all wastewater sample treated with Activated Carbon Bamboo Chips, the turbidity for both ratios of AC is decreasing. On the first ratio of 20 gram, both of this Activated Carbon managed to adsorb the particles in the wastewater sample until the result show decreasing in the turbidity from 900 NTU until 399.3 NTU for 500 °C of Activated Carbon and 148.7 NTU for 400°C of Activated Carbon, then the result goes down again where it shows the AC managed to purify the wastewater sample until 36.5 NTU for 500 °C of Activate Carbon and 27.4 °C of Activated Carbon. For both of this Activated Carbon, the 400 °C show the best temperature in preparing the Activated carbon and managed to adsorb the particles in the wastewater sample compared than 500 °C 0f temperature Activated Carbon. However, high turbidity indicates the high presence of suspended matters such as mineral and soil particles which scatter and absorb the incoming light into water. Decreasing in turbidity prove that activated carbon from bamboo chips is able to absorb suspended particles in wastewater thus treating the wastewater pollution.

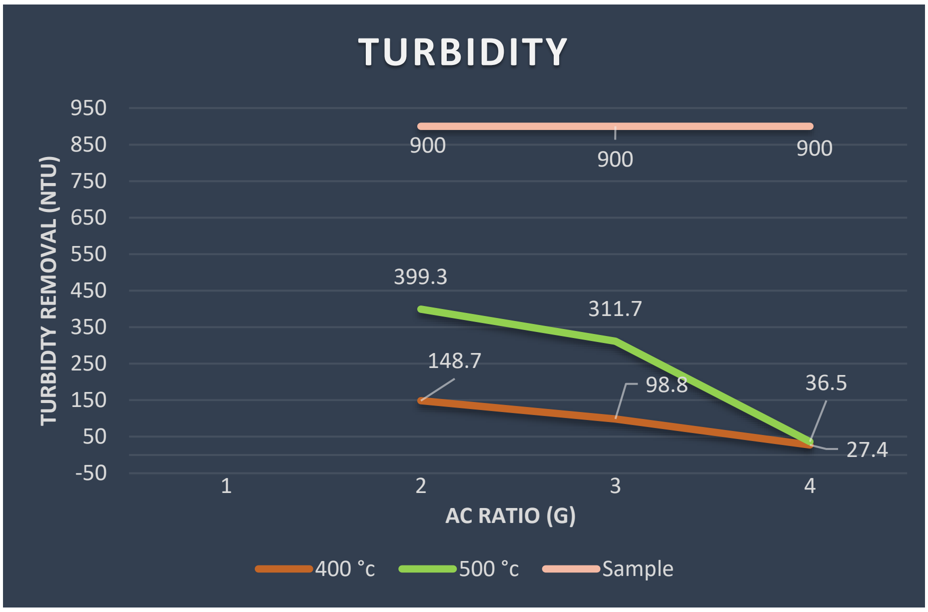


Figure 4.3 Turbidity for treated water for different ratio of temperature

4.3.4 Biological Oxygen demand (BOD)

Biological Oxygen Demand is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic atter present in a given water sample at certain temperature over a specific time period. The initial reading of BOD for the wastewater sample recorded in the table 4.1 is 34.3 mg/l. From the figure 4.4 which is graph of BOD against ratios of treatment, for all wastewater sample treated with Activated Carbon Bamboo Chips, the amount of BOD for both ratios of AC is decreasing. On the first ratio of 20 gram of AC, both of this Activated Carbon managed to adsorb the wastewater sample from 34.3 mg/l to 30.3mg/l for 500 °C of Activated Carbon and 19.6 mg/l for 400 °C of Activated Carbon. Both result shows decreasing in amount of BOD where the final result of both BOD is 5.55 mg/l for 500 °C of Activated Carbon and 1.35 mg/l for 400 °C of Activated Carbon.

Moreover, the 400 °C of Activated Carbon show the best result in reducing the amount of the BOD wastewater sample compared than the 500 °C of Activated Carbon. This shows that the Activated Carbon from Bamboo Chips are able to able to treat the wastewater polluted by adsorbing organic materials in wastewater sample. The lower of the BOD, the greater the quality of water as there is high concentration of dissolved oxygen available.

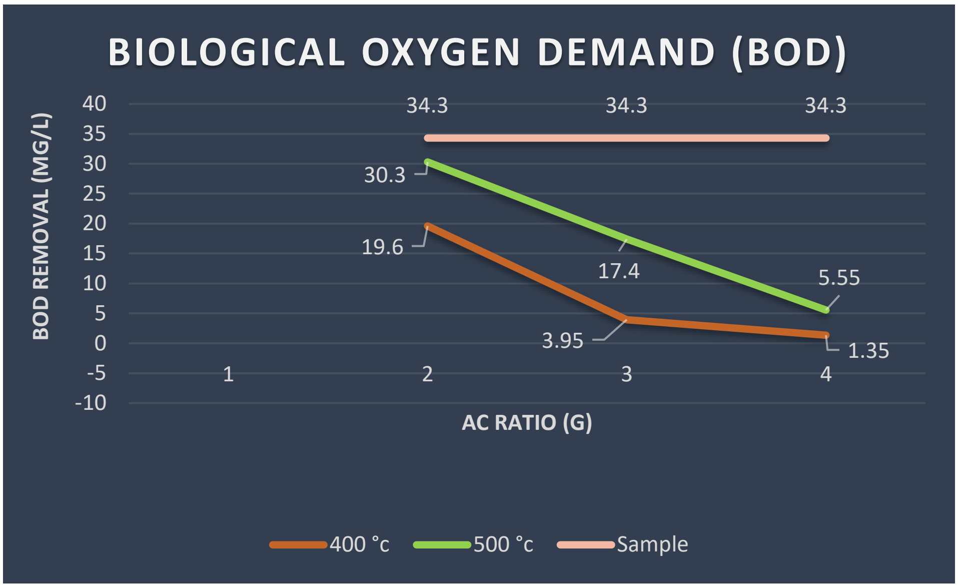


Figure 4.4 BOD for treated water for different ratio of temperature

4.3.5 Chemical Oxygen demand (COD)

Chemical Oxygen Demand is an indicative measure of the amount of oxygen that can be consumed by reaction in a measured solution. The initial reading of COD for the wastewater sample recorded in the table 4.1 is 428.7 mg/l. From the figure 4.5 which is graph of COD against ratios of treatment, for all wastewater sample treated with Activated Carbon Bamboo Chips, the amount of COD for both ratios of Ac is decreasing. On the first ratio of 20 gram of AC, both of this Activated Carbon managed to adsorb the wastewater sample from 428.7 mg/l to 273.7 mg/l for 500 °C of Activated Carbon and 216.3 mg/l for 400 °C of Activated Carbon. Moreover, both result of Activated Carbon shows decreasing in amount of COD where the final result of COD is 194 mg/l for 500 °C of Activated Carbon and 121.7 mg/l of Activated Carbon.

However, low level of COD indicates high level of dissolved oxygen as only small amount is needed to oxidize organic matter in wastewater. The low concentration of organic matter in water proves that Activated Carbon from Bamboo Chips are able to adsorb them plus reduce water pollution. As a result, the 400 °C of Activated Carbon was proven to adsorb the amount of COD in the wastewater sample compared than 500 °C of Activated Carbon.

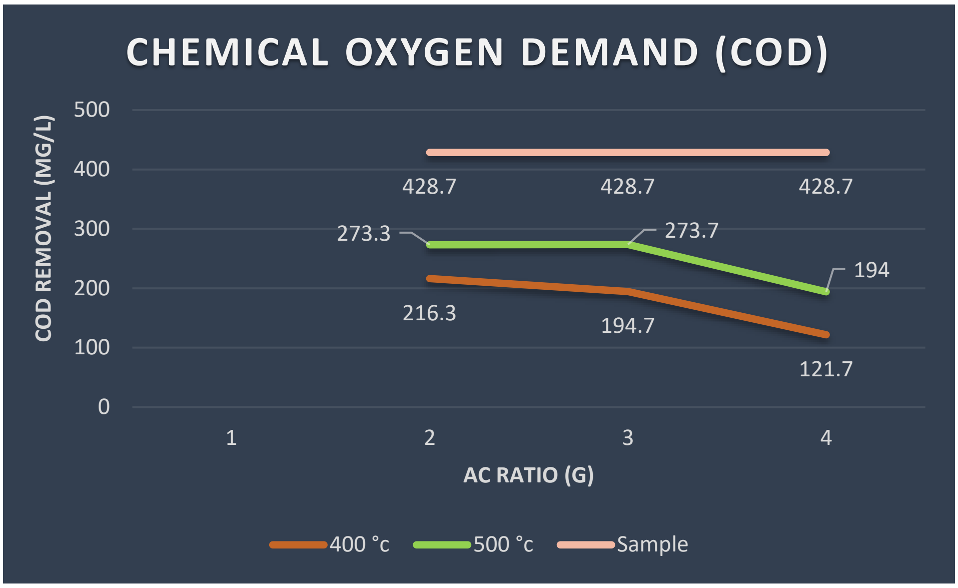


Figure 4.5 COD for treated water for different ratio of temperature

4.3.6 Zinc

Worldwide demand for zinc has increased significantly over the past several decades, which along with improper discharge of wastewater from mining, oil palm industries, mineral processing, landfill and dumpsite spills. Additionally, zinc, like other heavy metals can inhibit the function of a biological wastewater treatment systems. The initial reading of Zinc for the wastewater sample recorded in the table 4.1 is 502 mg/l which is exceed the allowable amount discharge by the regulations. From the figure 4.6 which is graph of Zinc against ratio of treatment, for all wastewater sample treated with Activated Carbon from Bamboo Chips, the amount of Zinc for both ratio of Ac is decreasing. On the first ratio of 20 gram of AC, both of this Activated Carbon able to adsorb the wastewater sample from 502 mg/l to 482 mg/l for 500 °C of Activated Carbon and 456 mg/l for 400 °C of Activated Carbon. From this result, the 400 °C of Activated Carbon show the best result in Zinc removal compared than 500 °C of Activated Carbon.

Even though both of this Activated Carbon shows decreasing amount of zinc from the wastewater sample, but they are still not in the standard allowable amount for industries wastewater discharge. Some improvement is needed in the preparation of Activated Carbon from Bamboo Chips in order to get the allowable amount for zin.

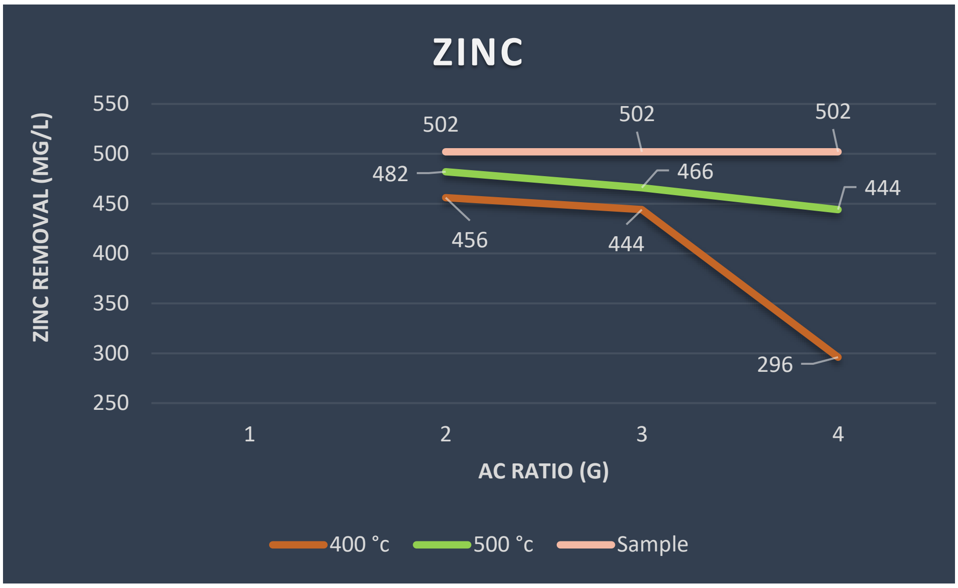


Figure 4.6 Amount of Zinc for treated water for different ratio of temperature

4.3.7 Cooper

Cooper is a type of heavy metals and too much of it is harmful. Breathing high levels of cooper can cause irritation of your nose and throat. Ingesting high levels of cooper can cause vomiting, nausea and diarrhea. In the table 4.1, the initial concentration of cooper for wastewater sample is 3.68 mg/l which is exceed the allowable amount for industries discharge.

From the figure 4.7 which is graph of Cooper against ratio of treatment, for all wastewater sample treated with Activated Carbon from Bamboo Chips, the amount of Cooper for both ratio of Ac is decreasing. On the first ratio of 20 gram of AC, both of this Activated Carbon able to adsorb the wastewater sample from 3.68 mg/l to 1.05 mg/l for 500 °C of Activated Carbon and 1.39 mg/l for 400 °C of Activated Carbon and they are still not in the allowable amount of discharge. Next, the result show decreasing again with the final result for both Activated Carbon are 0.7 mg/l for 500 °C of Activated Carbon and 0.53 mg/l for 400 °C of Activated Carbon and they are in allowable amount for industries discharge. From this result, the 400 °C of Activated Carbon show the best result in Cooper removal compared than 500 °C of Activated Carbon.

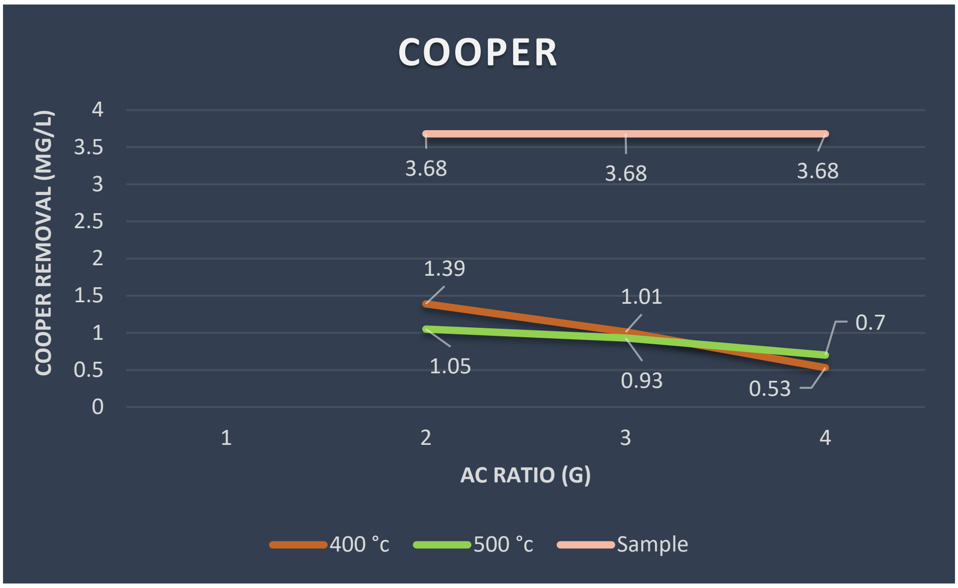


Figure 4.7 Concentration amount of Cooper for treated water for different ratio of temperature

Table 4.2 Final pollution level of wastewater sample based on ratio and two different temperature of Activated Carbon

Parameter	Initial Sample Reading	Final Reading					
		Ratio (20 gram)		Ratio (30 gram)		Ratio (40 gram)	
		400 °C	**500** °C	**400** °C	**500** °C	**400** °C	**500** °C
pH	**5.73**	5.15	5.2	5.04	5.22	4.83	4.87
BOD (mg/L)	**34.3**	19.6	30.3	3.95	17.4	1.35	5.55
COD (mg/L)	**428.7**	216.3	273.3	194.7	273.7	121.7	194
TSS (mg/L)	**1539**	122	316	199	300	122	168
TURBIDITY (NTU)	**900**	148.7	399.3	98.8	311.7	27.4	36.5
ZINC (mg/L)	**502**	456	482	444	466	296	444
COOPER (mg/L)	**3.68**	1.05	1.39	1.01	0.93	0.53	0.7

CHAPTER 5

CONCLUSION

5.1 Introduction and Conclusion

Rapid growth of development in Gebeng industrial area with multifarious industries and mining activities has overstressed the river system surrounding the area. Industrial activities based on petrochemical and bauxite mining also the oil palm mill have been identified as the contributor to chemicals and heavy metals pollution in water bodies based on the effluents discharged. The discharge from them was not been treated well. The heavy metals accumulated in sediment for a long period of time and pose toxic to aquatic ecosystem and human health. Water contamination with organic and inorganic compounds such as metals and pesticides have motivated people to develop methods of purification and extraction such as adsorption of pollutant by using activated carbon. The Activated Carbon was believed to adsorb the unwanted pollutants in the wastewater due to the high adsorbent and cheap preparation cost to produce. The Activated Carbon from Bamboo Chips was been develop for this experiment in order to solve the problems according the wastewater pollutant.

From the result on the table 4.1, the concentration of pH and BOD for wastewater sample was recorded follow the standard allowable discharge but the COD, TSS, Turbidity, Zinc and Cooper was exceeding the standard required by the Environmental Quality 1974. This show that the sample contains too much of heavy metal and polluted water that need to be treated. From this result also, it shows that the wastewater contains organic and inorganic particles, thus treatment process by using activated carbon from Bamboo Chips is proceed.

Based on the table 4.2 (Final pollution level of wastewater sample based on ratios and two different temperature of Activated Carbon), the ability of Activated Carbon from Bamboo Chips was proven in treating the wastewater sample. From the three different ratios for all the wastewater sample treated, the suitable ratio for preparation the Activated Carbon is the ratio of 40 gram, this was proven that mostly of the sample has reduce the pollutant until the lowest concentration. The first sample is COD where the concentration of them is lower than the standards discharge, the BOD also has the same result and Activated Carbon managed to remove the unwanted pollutants on them. For the Turbidity, the result also shows decreasing on the wastewater sample until the acceptable standard where the water become clear. For the heavy metal elements that has been tested, the zinc was found to be the highest and not reduce until the acceptable amount if discharge but the AC managed to reduce from the wastewater sample (502mg/l) until (296 mg/l) for ratio of 40 gram of the 400 °C as shown on the graph 4.6. For the cooper, both of the Activated carbon achieved the standard amount of the cooper concentration at the ratio of 40 gram of Activated carbon. This prove that the Activated Carbon from Bamboo Chips able to adsorb the heavy metals elements in the wastewater. The result for TSS and the pH, the last ratio of 40 gram of Activated Carbon show they managed to reduce the amount of the pollutant in the wastewater sample thus it shows the second objective of this experiment was achieved for all the test been conducted. Overall, all of the objectives for this experiment were achieved successfully.

5.2 Recommendation

As shown in the result and discussion above, Activated Carbon Bamboo chips can be used to treat the wastewater from industrial and the best ratio for preparation of them was the 40 grams. By the way, some of the tested conducted was not meet the required standard for industrial discharge, the test of pH, Zinc and TSS for the wastewater sample are not able to reduce the concentration of them and meet the required standard by the Environmental Quality Act 1974 for wastewater discharge. However, material with the lowest ash content produce the most active products or activated carbon should be low in ash but rich in carbon and volatiles. Due to that reason, some recommendation and further study are need in order to get more efficient result. The recommendations are:

I. Research on the other treatment method for heavy metal removal
II. Research on the environmental waste such as by combine two waste (bamboo chips and tea waste).
III. The reagent of Activated carbon could be change such as potassium hydroxide or sulphuric acid for future recommendation in treating wastewater.

REFERENCES

EBS – Wastewater Training and Consulting. (2021). Retrieved from pH Testing in Wastewater Treatment: https://www.ebsbiowizard.com/ph-testing-in-wastewater-treatment-964/#:~:text=The%20pH%20value%20is%20the,electrode%20and%20a%20reference%20electrode

Agoro, M. A. (2020). Heavy Metals in Wastewater and Sewage Sludge from Selected Municipal Treatment Plants in Eastern Cape Province, South Africa. Heavy Metals in Wastewater and Sewage Sludge from Selected Municipal Treatment Plants in Eastern Cape Province, South Africa.

Appanah, A. H. (1992). *bioversityinternational*. Retrieved from FRIM, Kepong, Kuala Lumpur, Malaysia.: https://www.bioversityinternational.org/fileadmin/bioversity/publications/Web_version/572/ch27.htm

Bahiru, D. B. (2020). Determination of Heavy Metals in Wastewater and Their Toxicological Implications around Eastern Industrial Zone, Central Ethiopia . *Journal of Environmental Chemistry and Ecotoxicology*, 72-79.

Bursic (2016). Energy efficiency strategies for sewage treatment plant: A Case Study in Malaysia. Energy efficiency strategies for sewage treatment plant: A Case Study in Malaysia.

Chin, T. (1977). ASEAN Seminar on Tropical Rainforest Management. *Effects of Cutting Regimes on Bamboo Infested Forest Areas*.

Engku Azman Tuan Mat, J. S. (n.d.). Wastewater Production, Treatment, and Use in Malaysia. Wastewater Production, Treatment, and Use in Malaysia.

Indranil Singha, P. K. (2020). Nano-membrane Filtration a Novel Application of Nanotechnology for Waste Water Treatment,. 327-332.

Keith, J. a. (2005). Clear Water Bay. *Production of High Surface Area Activated Carbons from Waste Bamboo Scaffolding*.

Kiepper, B. H. (2020). *University of Georgia Faculty of Engineering Outreach Service (EOS)*. Retrieved from Understanding Laboratory Wastewater Tests: I. ORGANICS (BOD, COD, TOC, O&G): https://extension.uga.edu/publications/detail.html?number=C992&title=Understanding%20Laboratory%20Wastewater%20Tests:%20I.%20ORGANICS%20(BOD,%20COD,%20TOC,%20O&G)#:~:text=The%20COD%20test%20uses%20a,only%20organic%20compounds%20are%20consumed

Kumar, A. (2020). With Corona Outbreak: Nature Started Hitting the Reset Button Globally. Retrieved from Frotier In Public Health

Mat1, E. A. (2011). *Wastewater Production, Treatment, and Use in Malaysia.* Malaysia: Water Resources Engineer, DID Malaysia.

MOHMOD, A. M. (1991). IV International Bamboo Workshop. *Bamboo in Malaysia: Past, Present and Future Research*.

Omer, N. H. (2019). Water Quality Parameters. Water Quality Parameters

Renou. (2008). Landfill Leacheate Treatment. *Review and Oppurtunity. Pub.Med.Gov,468-93*.

thermoscientific.com/water. (2016). Retrieved from Measuring Suspended Solids in water/ wastewater: https://tools.thermofisher.com/content/sfs/brochures/Measuring-Suspended-Solids-AppNote-AN-SSONLINE-EN.pdf

Udeh, N. (2018). International Journal of Engineering Inventions. *Production and Characterization of Activated Carbon from Nigerian Bamboo Using the Two Methods of Activation*.

Wyatt-Smith, W. &. (1961). Malayan Forester 24:225-229. *Eradication of the bamboo, Gigantochloa levis (Blanco).*

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APPENDICES

Appendix A:

ACCEPTABLE LIMITS FOR DISCHARGE OF INDUSTRIAL EFFLUENTS OR MIXED EFFLUENTS OR MIXED EFFLUENT OF STANDARDS A & B

Parameter	**Unit**	**Standard A**	**Standard B**
(1)	(2)	(3)	(4)
(i) Temperature	°C	40	40
(ii) pH Value	6.0 - 9.0		5.5 - 9.5
(iii) BOD5 at 20°C	mg/l	20	50
(iv) COD	mg/l	50	100
(v) Suspended Solids	mg/l	50	100
(vi) Mercury	mg/l	0.005	0.05
(vii) Cadmium	mg/l	0.01	0.02
(viii) Chromium, Hexavalent	mg/l	0.05	0.05
(ix) Arsenic	mg/l	0.05	0.10
(x) Cyanide	mg/l	0.05	0.10
(xi) Lead	mg/l	0.10	0.5
(xii) Chormium, Trivalent	mg/l	0.20	1.0
(xiii) Copper	mg/l	0.20	1.0
(xiv) Manganese	mg/l	0.20	1.0
(xv) Nickel	mg/l	0.20	1.0
(xvi) Tin	mg/l	0.20	1.0
(xvii) Zinc	mg/l	1.0	1.0
(xviii) Boron	mg/l	1.0	4.0
(xix) Iron (Fe)	mg/l	1.0	5.0
(xx) Phenol	mg/l	0.001	1.0
(xxi) Free Chlorine	mg/l	1.0	2.0
(xxii) Sulphide	mg/l	0.50	0.50
(xxiii) Oil and Grease	mg/l	Not detectable	10

PARAMETER UNIT STAND.

Appendix b:

STUDY AREA AND TEST PHOTO

Figure B1: Collected of Bamboo Chips

Figure B2: Bamboo Chips after in furnace

Figure B3: Blended of Bamboo Chips

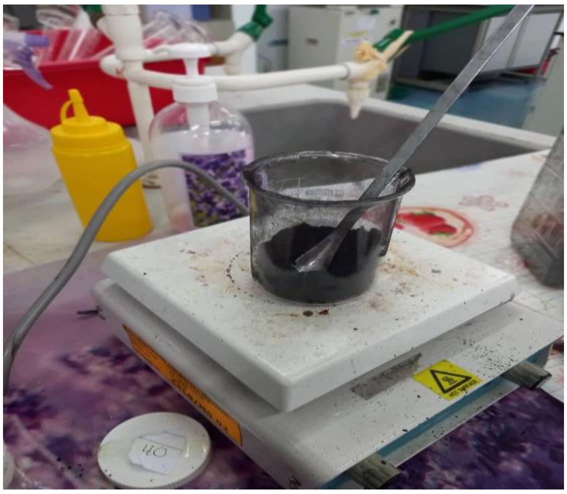

Figure B4: Stirred of Activated Carbon

Figure B5: Collected of Wastewater Sample

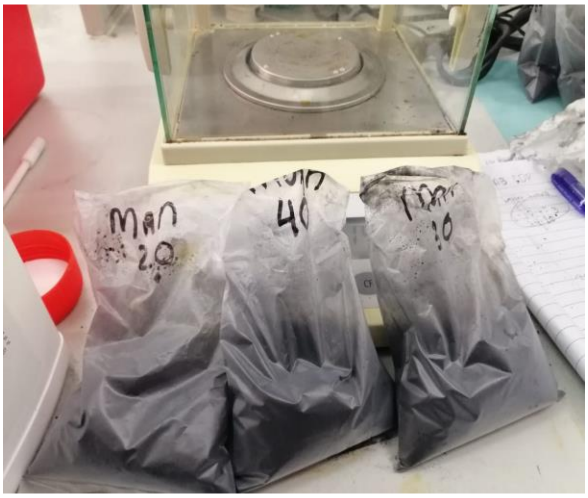

Figure B6: Three different ratios of Activated Carbon

Figure B7: wastewater sample mixed with Activated Carbon

Figure B8: Filtered of Wastewater sample

Figure B9: Total Suspended Solids test

Figure B10: BOD test

Figure B11: Cod test

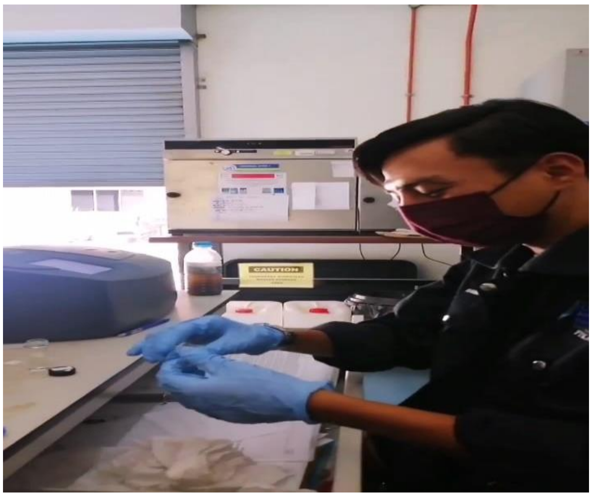

Figure B12: Zinc and Cooper test