REMOVAL OF IRON (II) USING VARIOUS ACTIVATED SLUDGE

SITI NORAZIZAH BINTI JAMIL

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ABSTRACT

The activated sludge is used as biological material to absorb the iron (II) in the contaminate wastewater. The objective of this research is to determine the best activated sludge at various sizes for removal of iron (II) in aqueous solution. Exposed to the iron greater than 0.3 mg/L may cause water staining that adversely affect plumbing fixtures, dishware, and produce a yellow to reddish appearance in water. The activated sludge were collected from different sources of industry include Palm Oil Mill Effluent, Food Industry and Polymer Industry. The activated sludge was dried up 12 hour at 105˚C. Solutions of 500mg/L of iron (II) sulphate are prepared as stock solution. The aqueous solution was mixed with the absorbent starting at 100 minutes until 200 minutes contact time. The solution and the activated sludge was separate using the centrifuged within 15 minutes at 3800 RPM. UV-Vis spectrometer at a 510nm wavelength was used to analyze the iron (II) concentration. The result show 77.5% of iron (II) removal efficiency was attained in the Polymer Industry dried activated sludge with 45µm size and 200 minutes of contact time. Meanwhile, Food Industry and Palm Oil Mill Effluent are 66% and 72% respectively.

ABSTRAK

Lumpur aktif digunakan sebagai bahan biologi untuk menyerap besi (II) dalam air sisa yang tercemar. Penyelidikan ini adalah untuk menentukan lumpur aktif terbaik dalam pelbagai saiz bagi menghilangkan besi (II) dalam larutan air. Terdedah kepada besi melebihi 0.3 mg / l boleh mempengaruhi peralatan paip, pinggan mangkuk, dan menghasilkan kekuningan di dalam air. Lumpur aktif dikumpulkan dari pelbagai sumber industri termasuk Sisa Kilang Minyak Kelapa Sawit, Sisa Kilang Makanan dan Sisa Polimer Industri. Lumpur aktif dikeringkan selama 12 jam pada keadaan 105 ˚ C. Kepekatan 500mg / L dari besi (II) sulfat di sediakan sebagai larutan simpanan. Larutan air dicampur dengan penyerap bermula pada 100 minit hingga 200 minit. Larutan air dan lumpur aktif di asingkan menggunakan *centrifuge* selama 15 minit pada 3800 RPM. *UV-Vis spectrometer* yang mengunakan panjang gelombang 510nm digunakan untuk menganalisis kepekatan besi (II). Sebanyak 77.5% besi (II) dapat dihilangkan menggunakan lumpur kering aktif dari Sisa Polimer pada saiz zarah 45µm dan pada masa 200 minit. Sementara itu, Sisa Kilang Makanan dan Sisa Kilang Minyak Kelapa Sawit masing- masing adalah 66% dan 72%.

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LIST OF SYMBOL

µm	Micrometer
%	Percentage
mg/l	Miligram per liter
˚C	Degree Celsius
ml	Mililiter
g	Gram

LIST OF ABBREVIATION

RE	Removal Efficiency
DAS	Dried Activated Sludge
Fe	Ferrum/Iron
Min	Minute

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Now a day, the increasing of industrial activities such as food industries, palm oil industry, mining industries, steel industry, dye industry etc has contribute pollution to our environment. Due to the activities cause the accumulation of heavy metal such as cuprum (II), lead, zinc, iron, mercury, cadmium, and uranium contains in effluent discharge from the wastewater. Iron (II) or also known as ferrum is one of the metal potential hazards toward human body. According to the Engineering Services Division, Ministry of Health Malaysia, drinking water quality standard 2009, maximum concentration of iron is 0.3 mg/L. Based on Environment Quality (Sewage and Industrial Effluent) Regulation 1979, maximum discharge of iron in standard A and B is 1.0 mg/L and 5.0 mg/L respectively. The water quality control of industrial wastewater is classified into two set of standards, A and B, according to the river area into which wastewater is discharge. Standard A applies to wastewater discharge upstream from a drinking water intake point, while Standard B applies to discharge downstream from an intake point (Anonymous, 2009). Exceeding iron concentration greater than 0.3 mg/L causes water staining that adversely affect plumbing fixtures, dishware and clothes and produce a yellow to reddish appearance in water (Shokoohi et al., 2009).

Table 1 Types of heavy metal and their effect on human health (Alluri et al., 2007)

Pollutants	**Major sources**	**Effect on human health**	**Permissible level (ppm)**
Arsenic	Pesticides, fungicides, metal smelters	Bronchitis, dermatitis	0.02
Cadmium	Welding, electroplating, pesticide fertilizer, nuclear fission plant	Kidney damage, bronchitis, bone narrow, cancer	0.06
Lead	Paint, pesticide, smoking, automobile emission, mining	Liver, kidney, gastrointestinal damage, mental retardation in children	0.1
Manganese	Welding, fuel addition, ferromanganese production	Inhalation or contact causes damage to central nervous system	0.26
Iron	Pesticide fertilizer, metal smelters	Itchiness, lung cancer, anemia, diabetes	0.3
Mercury	Pesticides, batteries, paper industry	Damage to nervous system, protoplasm poisoning	0.01
zinc	Refinery, brass manufacture, metal plating, plumbing	Zinc fumes have corrosive effect on skin, cause damage to nervous membrane	15

As the technologies keep growth, the typical techniques were used to investigate the remove the heavy metal in aqueous solution. Since the adsorption is a well- establishes technique for heavy metals removal, the use of activated sludge biomass as adsorbent also offers a potential alternative to existing methods for heavy metal removal (Xuejiang et al., 2005). The adsorption of metal onto various type of biomass has been introduced as a cost-effective method in multiple studies due to direct use of microbial biomass.

To develop the investigation, dried activated sludge were used as a biosorbent to decrease the iron contamination in the effluent of wastewater discharge. Activated sludge is an active biological material produced by activated sludge plants, especially in aerobic, anaerobic and aeration system, which affects all the purification processes (Anonymous, 2009). Solids in the aeration tank are referred to as sludge. Because the sludge is aerated, and the bacteria become very active during aeration, the term ‘‘activated sludge’’ is used to describe the process where bacterial solids are active in the purification of the wastes within the aeration tank. (Gerardi., 2002). Capability of microorganism to bind heavy metal in aqueous solution has been of scientific interest (Aksus et al., 2002). Ronda et al., (2007) showed that *Saccharomyces Cerevisiae* can remove toxic metals, recover precious metals and clean radio-nuclides from aqueous solutions to various extents. *Saccharomyces Cerevisiae* is a product of many single cell and alcohol fermentations.

In industrial wastewater treatment plant, the activated sludge process also used for the several purposes, for example, oxidizing carbonaceous matter, removing phosphate, generating a biological floc that is easy to settle and generating a liquor low in dissolved or suspended material.

The term biosorption is referring to the ability of biological materials to accumulate heavy metal from wastewater through physical- chemical pathway. It also can be defined as “a non-directed physic-chemical interaction that may occur between metal/radionuclide species and microbial cells”. It is biological method of environmental control and can be an alternative to conventional contaminated water and wastewater treatment facilities. There are many advantages through the biosorption process such as possibility to metal recovery, cost effectiveness, minimization of chemical and biological sludge, regeneration of biosorbent and no additional nutrient requirement (Ahalya et al., 2003). The biosorption process involves a solid phase (a biological material) and a liquid phase containing a dissolved species to be sorbed (a metal ion). Due to higher affinity of the sorbent for the sorbate species the latter is attracted and bound with different mechanism. The process continues till equilibrium is establishing between the amounts of solid-bound sorbate species its portion remaining in the solution (Alluri et al., 2007).

The study of the optimal size for various dried activated sludge is required to identify the removal of iron (II) through the effect of reaction time, concentration, temperature and dosage activated sludge. Therefore, the purpose for this research is to study the effect of various dried activated sludge in a variety of size for removal of iron (II) in aqueous solution.

1.1 Problem Statement

Heavy metal such as lead, uranium, copper, arsenic, iron, etc is potential hazard to the environment and cause damage to ecosystems and human health. Sometime, the present of all the heavy metal from the discharge industrial wastewater is unconscious by the human since they have no sign till people saw and feel the effect of impact by the heavy metal contamination. Some metals usually form compounds that can be toxic, carcinogenic or mutagenic, even in very low concentration.

Iron is commonly found in rock and soil. Under proper conditions, iron will leach into the water resources from rock and soil formations (Shokoohi et al. 2009). It is very expensive to treat the wastewater effluent that contains iron (II) such as from metal, and titanium dioxide industries. During this time, alternative way for low cost adsorbent has been searching. Reused the microbe from the activated sludge provides economical cost in large plant.

1.2 Research Goal

i. To determine the best activated sludge at variable size for removal Iron (II) in aqueous solution
ii. To observe the potential of activated sludge as lower cost adsorbent
iii. To observe the effect of contact time, dosage and initial concentration for iron(II) adsorption

1.3 Scope of Research

This research is to study the removal of iron (II) by using various dried activated sludge. This investigation were run on several process parameters include effect of contact time, activated sludge dosage and influence of activated sludge towards the ion (II) initial concentration. The dried activated sludge also was being at variable size particle, so that, the efficiency of removal of iron (II) can be observe directly. In order to analyze the initial and final concentration of iron (II) removal, UV-Vis spectrophotometer was used with the setup wavelength.

1.4 Research Advantageous

i. Provide less contaminant of iron (II) in effluent discharge of wastewater treatment
ii. To obey the standard quality of iron (II) based on Industrial and Sewage 1979 Regulation.
iii. To remove the heavy metal in industrial effluent wastewater Discharge
iv. Cost benefit regarding to the used of the activated sludge
v. To reduce the disease from the heavy metal contamination

CHAPTER 2

LITERATURE REVIEW

2.1 Activated Sludge

Activated sludge is a biological process performed by a variable and mixed community of microorganisms in wastewater treatment in which air or oxygen is forced into wastewater to develop a biological floc which reduces the organic content in an aerobic aquatic environment. Activated sludge also can be defined as biomass produced in raw or settled wastewater by the growth of organisms in aeration or aerobic tank in the presence of dissolved oxygen. The aeration tank is the place where the activated sludge is agitated. Aeration serves two important purpose include supplying the required oxygen to the organism to grow and providing optimum contact between the dissolved and suspended organic matter and the microorganism. The time that the mixed liquor is aerated varies from as little as thirty minutes to as much as thirty six hours depending upon the treatment process used (Anonymous, 2003).

Figure 2.1 Activated sludge are aerating properly (Durbin M., 2008)

Figure 2.1 show the oxidation ditch contains variable of microorganism and waste product is mixing well. The mechanical aerators are installing in the treatment tank so it will supply good condition to the microorganism.

The invention of the activated sludge process is connected with the efforts of British and American engineers at the end of the last century to intensify biological purification in fixed-film systems. The experiments with wastewater aeration did not provide the expected results until May, 1914 when Ardern and Lockett introduced a recycle of suspension formed during the aeration period. The suspension, known as activated sludge was in fact an active biomass responsible for the improvement of treatment efficiency and process intensity.

The term "activated" comes from the fact that the particles are teeming with bacteria, and protozoa. Oxygen is required by these bacteria and other types of microorganisms present in the system to live, grow, and multiply in order to consume the dissolved organic "food", or pollutants in the waste. These microorganisms derive energy from carbonaceous organic matter in aerated wastewater for the production of new cells .the conversion of this organic matter into compounds contain lower energy, such as carbon dioxide and water.

In all activated sludge plants, once the wastewater plant has received sufficient treatment, excess mixed liquor is discharged into settling tanks and the supernatant is run off to undergo further treatment before discharge. Part of the settled material, the sludge, is returned to the head of the aeration system to re-seed the new sewage entering the tank. The remaining sludge is further treated prior to disposal.

The uses of activated sludge in wastewater treatment are to obtain the maximum possible removal of organics substances with the shortest possible time and to produce flocculant biological flocs so that they will have a good settling. Biological flocs very efficient in removing organics substances at rapid rate flocs those normally settle poorly and vice versa. A typical activated sludge treatment process may yield the 30 mg/l suspended material, 10 mg/l of phosphate, 12 mg/l ammonia nitrogen and 20 mg/l biological oxygen demand (Wang et al., 2009)

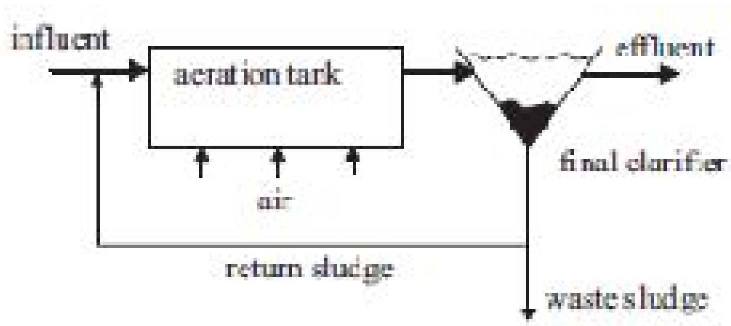

Figure 2.2 Typical flow scheme of conventional activated sludge plant (Weijers., 2000)

Figure 2.2 show the flow scheme of an activated sludge. The air is mechanically diffuse to the aeration tank and contains different types of microorganism also called activated sludge oxidize pollutants to less harmful compounds producing new biomass.

An activated sludge process basically consists of two operating units which are an aerobic or aeration basin and a secondary clarifier. The reaction taking place in the aeration basin involves both bulk liquid and microbial floc phase. Metabolic reactions occur simultaneously with mass transfer within the floc metric. A concentration gradients is established inside the flocs which affect reaction rates in the system (Mustafa et al., 2009)

2.1.1 Biological Component in Activated Sludge

The biological component of the activated sludge system is comprised of microorganisms. Regarding Water Environment Association 1987, the composition of these microorganisms is 70 to 90 percent organic matter and 10 to 30 percent inorganic matter. Activated sludge consists of microorganism approximately 95 % bacteria and 5 % higher organism (protozoa, rotifers, and higher forms of invertebrates. The microorganism present in the activated sludge are depends on environmental conditions, process design, the mode of plant operation, and the characteristics wastewater influent. Protozoa, for example are useful biological indicator for the condition of activated sludge. Strictly speaking, these microorganisms are proving to be excellent indicators to the aerobic environment. Protozoa are also function as toxic environment indicator since they exhibit a greater sensitivity to toxicity than bacteria. Rotifers are also able to indicate the toxic environments. They are able to consume both microbes and particulate matter. Rotifers are more sensitive to toxic conditions than bacteria but they only found in a very stable activated-sludge environment.

Particular ones are considered indicator microorganism that can be observed using microscopes. Significant numbers of a particular species can indicate the condition of the process (Anonymous, 2003). Cell makeup depends on both the chemical composition of the wastewater and the specific characteristics of the organisms in the biological community. Activated sludge is different from primary sludge because activated sludge contains many living organisms which can feed on the incoming wastewater. The activated sludge is subsequently separated from the treated settlement and may be re-used.

2.1.2 Activated Sludge as an Adsorbent

Shokoohi et al. (2009) investigate the removal of iron by dried biomass of activated sludge. Dried activated sludge, prepared as a powder, was tested as a sorbent for the removal of iron from aqueous solution. The effects of various experimental parameters including initial iron concentration, mass of biomass and contact time were examined and optimal experimental conditions were obtained. The equilibrium time for iron adsorption onto biomass was determined as 150 min. the rate of iron removal was directly correlated to biomass amount and contact time. Increasing contact time resulted improvement in iron removal efficiency. When the weight of the biomass increased the iron removal efficiency also increased.

Xuejiang et al. (2005) investigated the biosorption of Cu (II) and Pb (II) ions from aqueous solutions by dried activated sludge as a functional of initial pH, initial metal ion concentration and temperature. The result showed that both the heavy metal uptake process followed the pseudo-second-order equation. The equilibrium data fitted very well to both Langmuir and Frendlich adsorption models.

Ju et al. (2008) was investigated the low cost, locally available biomaterial are the ability to remove dyes from aqueous solution. Granular prepared from dried activated sludge (DAS) were utilized as a sorbent for the uptake of Rhodamine-B (Rh-B) dye. The effect of various experimental parameters (dye concentration, sludge concentration, swelling, pretreatment and other factors) were investigated and optimal experimental conditions were ascertained.

Choi et al. (2006) was investigated alternative method s of metal removal and recovery based on biological materials. The study was testing with various types of sludge. In this study, sewage sludge, anaerobically digested sludge, drinking water treatment plant sludge and leachate sludge were tested. Dried sludge and three other types of dried sludge have been examined for potential utilization as low cost material for the uptake of heavy metals from wastewaters.

The adsorption of heavy metal on the sludge surface is usually attributed to the formation of complexes between metals and as carboxyl, hydroxyl, and phenolic surface functional groups of the extracellular polymeric substances. This biopolymer can be produced by many different species of bacteria isolated from activated sludge in the adsorption of metal ion form solution (Yuncu B. et al., 2006)

The capability of some living microorganisms to accumulate metallic elements have been observed. However, further researches have revealed that active or dead microbial biomass can passively bind metal ions via various physic-chemical mechanisms. Biosorbent behavior for metallic ions is a function of the chemical make-up of the microbial cells of which it consists (Wang J. et al., 2009)

2.1.3 Advantages of Activated Sludge

As many industries and plant keep establish, the more wastewater treatment will be develop. The following are diverse advantage of using activated sludge in the wastewater treatment.

i. Activated sludge can be used for one household up a huge plant
ii. Can functioning in removal of organics
iii. Oxidation and Nitrification achieved well
iv. Biological nitrification without adding chemicals
v. Biological Phosphorus removal
vi. Solids or Liquids separation easily
vii. Capable of removing until 97% of suspended solids
viii. The most widely used wastewater treatment process

2.2 Heavy Metal

Most the research has indicated the urban soils are contaminated by heavy metals. This phenomenon has been attributed to modern industry, traffics and mining activities in urban area (Zhang et al., 2005). Mining activities affect relatively small area, but can have large local impact on the environment. Release of metals from mining sites occurs primarily through acid mine drainage and erosion of waste dumps and tailing deposits (Tamas et al., 2005). Numerous processes exist for removing dissolved heavy metals, including ion exchange, precipitation, phytoextraction, ultra filtration, reverse osmosis and electro dialysis (Mier et al., 2000)

Some of heavy metal contains are required as micronutrients, it can be toxic when present higher than the minimum requirements (Ahmad et al., 2009).
Many contaminations discharge into surface water rapidly become associated with the particulate matter and incorporate in sediments. Metal in aquatics system become part of the water sediment system and their distribution is controlled by a dynamics set of physical chemical interactions and equilibrium, largely governed by pH, concentration and type ligands and chelating agents, oxidation state of the mineral components and the redox conditions of the system (Singh K.P et al., 2005)

Khan et al.(2004) investigated the adsorption process is being widely used by various researches for the removal of heavy metal from waste streams and activated carbon has been frequently used as an adsorbent. Despite its extensive use in the water and wastewater treatment industries, activated carbon remains an expensive material. In recent years, the need for safe and economical methods for the elimination of heavy metals from contaminated waters has necessitated research interest towards the production of low cost alternatives to commercially available activated carbon. Therefore there is an urgent need for the removal of heavy metals should be studied in detail.

Alluri et al. (2007) investigated biosorption as an eco-friendly alternative for heavy metal removal. The biosorption process (biological material) containing a