

REMOVAL OF NICKEL FROM AQUEOUS SOLUTION BY USING
DRIED WATER HYACINTH (*EICHHORNIA CRASSIPES*)

NORHASLIN BINTI HASHIM

A thesis submitted in fulfillment of the
requirements for the award of the degree of
Bachelor of Chemical Engineering

Faculty of Chemical Engineering and Natural Resources
Universiti Malaysia Pahang

MAY 2008

I declare that this thesis entitled “Removal Of Nickel From Aqueous Solution By Using Dried Water Hyacinth (*Eichornia Crassipes*) “is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : NORHASLIN BINTI HASHIM

Date : 14th MAY 2008

Special dedication to:

For My Mother, Saniah Binti Parni

For My Father, Hashim Bin Bakar

Beloved Siblings: Nasrik, Nazri, Syafina Alia

For My Uncle and Aunty: Pak long, Mak long, Pak Usu, Mak Usu

and

For My lovely Friends

ACKNOWLEDGEMENT

Alhamdulillah. Praise be to God for His help and guidance that I finally able to complete this thesis. First and foremost I offer my sincerest gratitude to my supervisor Mrs Jun Haslinda Binti Hj Shariffuddin , who has adviced and guidanced me throughout my thesis with her patience and knowledge.

I also thank the members of my graduate committee for their guidance and suggestions, especially for all his advice, encouragement. I also thank the FKKSA lab staff, without whose knowledge and assistance this study would not have been successful. The Chemical Engineering and Natural Resources Faculty has provided the support and equipment.

To my best friends for their encouragement and support especially at times when things were going tough. I cannot end without thanking my family, on whose constant encouragement and love especially my mother, Saniah Binti Parni and my father, Hashim Bin Bakar. In hope, this study will benefits to all of us.

ABSTRACT

Biosorption has emerged as a new technology compared to classical method like chemical precipitation for removal metal from aqueous solution. In this present study, a dried Water Hyacinth (*Eichornia Crassipes*) was used as a biosorbent for Ni (II) removal from aqueous solution. The removal characteristics of nickel by dried Water Hyacinth were evaluated as a function of biosorbent dosage, contact time , pH and temperature . The percent Ni(II) uptake was analyzed by using Atomic Absorption Spectrophotometer . At optimal conditions, nickel uptake increased when biosorbent dosage increased. In this study, the optimum dosage was obtained at 0.3g. Removal of Ni (II) was more than 90% in 50 min of contact time. Removal of Ni (II) using dried Water Hyacinth is highly pH dependent. Within the tested pH range (pH 2-8), the maximum removal of Ni(II) was observed between pH 6 . The maximum removal of Nickel is at T= 35 °C. Result indicates that dried Water Hyacinth is suitable for the removal of nickel from aqueous solution.

ABSTRAK

Proses penyerapan secara biologi muncul sebagai suatu kaedah baru menggantikan kaedah lama seperti pemendakan kimia untuk menyingkirkan logam dari larutan akues. Dalam kajian ini, keladi bunting yang di jadikan serbuk digunakan sebagai agen penyerapan bertujuan untuk menyingkirkan ion Nikel dari larutan akues. Ciri-ciri keberkesanan keladi bunting sebagai agen penyerapan di uji dengan beberapa parameter iaitu dos agen penyerapan, masa, pH dan suhu. Peratusan penyingkiran Nikel dari larutan akues di analisa menggunakan Atomic Absorption Spectrophotometer. Dalam keadaan optimum, kadar penyerapan nikel berkadar langsung dengan dos agen penyerapan. Dose maksimum yang dicapai adalah 3g/ L. Penyerapan Nikel melebihi 90 % dalam masa 50 minit ujikaji. Penyerapan Nikel bergantung kepada pH. Julat pH yang dikaji adalah antara 2 hingga 8. pH maksimum untuk penyerapan Nikel adalah 6 . Suhu maksimum penyingkiran Nikel dari larutan akues adalah 35 °C. Hasil keputusan dari parameter yang dikaji menunjukkan keladi bunting amat sesuai dijadikan sebagai agen penyerapan Nikel.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	TITLE	i
	DECLARATION PAGE	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF SYMBOLS	x
	LIST OF FIGURES	xi
	LIST OF TABLES	xii
	LIST OF APPENDICES	xiii
1	INTRODUCTION	
1.0	Background of study	1
1.1	Objectives	3
1.2	Scope of study	3
1.3	Problem statement	3

2	LITERATURE REVIEW	
2.1	Biosorption	5
2.1.1	Biosorbent	6
2.1.2	Factors that affecting biosorption	9
2.1.3	Biosorption mechanism	10
2.2	Nickel	
2.2.1	Characteristics	15
2.2.2	Applications	15
2.2.3	Effects Nickel to environment	16
2.2.4	Effects Nickel to health	16
2.3	Water Hyacinth	
2.3.1	Physical description	18
2.3.2	Growth habit	18
2.3.3	Roles of Water Hyacinth in the effluent from waste	19
3	METHODOLOGY	
3.1	Introduction	20
3.2	Overall methodology	21
3.3	Chemical requirements	22
3.4	Chemical equipments	22
3.5	Experimental Methodology	22

3.5.1	Biosorbents preparation	23
3.5.2	Preparation of NiSO ₄ solution	23
3.5.3	Effect of biosorbents dosage	23
3.5.4	Effect of pH	24
3.5.5	Effect of contact time	24
3.5.6	Effect on temperature	24
3.6	Analysis	25
4	RESULT & DISCUSSION	
4.1	Introduction	26
4.2	Effect on biosorbent dosage	26
4.3	Effect on pH value	28
4.4	Effect on contact time	30
4.5	Effect of temperature	31
5	CONCLUSION	
5.1	Conclusion	33
5.2	Recommendations	34
6	REFERENCES	36
	APPENDIX A	43
	APPENDIX B	53
	APPENDIX C	58

LIST OF SYMBOLS

S	-	amount of metal absorbed
C	-	equilibrium solution concentration
K	-	Freundlich constant
n	-	Freundlich constant
C _i	-	initial concentration
C _e	-	equilibrium concentration
q	-	adsorbtion capacities

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
2.1	Ring structure of carbonate (CO_3^{2-}) and oxalate ($\text{C}_2\text{O}_4^{2-}$) ions.	12
3.1	Overall methodology	21
4.1	Effect of biosorbent dosage on Nickel removal	28
4.2	Effect of pH on Nickel concentration	30
4.3	Effect of contact time on Nickel removal	31
4.4	Effect of temperature on Nickel removal	34

LIST OF TABLES

TABLE NO	TITLE	PAGE
2.1	A comparison of heavy metal uptake capacities (mg/g) of various macrophytes.	7
2.2	Unmodified/ modified agricultural waste utilized for remove of heavy metal absorption.	8
3.1	Characteristics of parameter on Nickel removal	25
4.1	Effect of biosorbent dosage on Nickel removal	27
4.2	Effect of pH on Nickel removal	29
4.3	Table of contact time on Nickel removal	31
4.4	Table of temperature on Nickel removal	32

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Results AAs	44
B	Analysis of results for experiment	53
C	Figures in laboratory experiments	58

CHAPTER 1

INTRODUCTION

1.1 Background of study

According to the World Health Organization (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans IARC Monographs Vol 49, 1990), the carcinogenic risk to humans posed by industrial exposure to nickel and its components which are metallic nickel and nickel alloys, nickel oxides and hydroxides, nickel sulfides and nickel salts . Nickel carbonyl is identified as the most acutely toxic nickel compound, causing severe damage to the respiratory system in experimental animals and in humans. On the basis of evidence from human and animal studies, welding fumes are classified as possibly carcinogenic to humans. Nickel are widely use in industrial include rechargeable (NiCad) batteries, pigments for paints or ceramics, electroplating, electroforming and sintered metal coatings. These various applications are introduced into aquatic ecosystems as by-products of industrial processes and acid-mine drainage residues . The presence of toxic heavy metals contaminated in aqueous streams, arising from the discharge of untreated metal containing effluent into water bodies, is one of the most important environmental issues (Hawari and Mulligan , 2006) . Their presence in aquatic ecosystem poses human health risks and causes harmful effect to living organisms (Xuejiang et al., 2006). The effluents from metal finishing processes may contain up to 10 mg/L of copper, chromium, nickel and zinc. Nickel is a major concern because the larger usages in developing countries and their no degradability nature. Therefore, it is important to develop new methods for metal removal and for the

reduction of heavy metal ions to very low concentrations. Biosorption, a biological method of environmental control can be an alternative to conventional physicochemical technologies waste-treatment facilities such as ion exchange, chemical precipitation, reverse osmosis and evaporative recovery. This conventional method for this purpose is often inefficient and/or very expensive (Chong et al .,Volesky,1995 ; Leusch et al ., 1995;Yu and Kaewsarn , 1999; Zhao et al., 1999) .

Biomaterials that are available in large quantities may have a potential to be used as low cost adsorbents, because they represent unused resources that are widely available and environmentally friendly (Deans and Dixon, 1992) . Past recent research was still searching of an effective biosorbent that can be use to remove nickel from aqueous solution. According to Hanif et al ., 2007 , the percentage sorption Ni(II) ability of *C. fistula* (Golden Shower) from seven industries are in the following order: TILHU (99.88 %) >GI (99.85%) ≈BMI (99.85%) > TIFU (99.80%) > TIHHU (99.78%) > TIDU (99.77%) Ni–Cr PI (90.59%).However , study on dried Water Hyacinth (*Eichornia Crassipes*) as an adsorbent is only few in this field . Hence there is a need to investigate dry Water Hyacinth ability to remove nickel from aqueous solution.

1.2 Objectives

The goal of this study are :

- To access the ability of Water Hyacinth (*Eichhornia crassipes*) to remove Ni(II) from aqueous solution.
- To study the effect of biosorbent dosage, contact time , pH and temperature in removal of Nickel using biosorption process.

1.3 Scope of study

The scopes of study of this project are:

- Biosorbent dosage towards the removal of Nickel from aqueous solution.
- pH values effect in removal Nickel from aqueous solution.
- Contact time towards the removal of Nickel from aqueous solution.
- Effect temperature in biosorption of Nickel from aqueous solution

1.4 Problem statement

Activated carbon usually use by chemical industry for wastewater treatment. The industries have to spend high cost to buy activated carbon. Due to this problem, some researcher found the other alternative adsorbent which have characteristic almost the same like activated carbon especially to remove metal from aqueous solution . Aquatic plants, such as Water Hyacinth (*Eichhornia crassipes*), pennywort (*Hydrocotyle umbellate*), and duckweeds (*Lemna spec.*) (US EPA, 1988) are known to be effective in single pond wastewater treatment.

The major characteristics of Water Hyacinth , that make them an attractive biological support media for bacteria, are their extensive root system and rapid growth rate. The root system could act as a cheap biosorbent for various materials which are soluble in water. Water Hyacinth is now being considered as an aquatic pest in most of the watersheds where it has been introduced. It can cause enormous ecological and economical damage when it is not controlled since it suppresses aquatic life (ZBC News ,2007) . Besides that, due to the high rate growth, water hyacinth formed as mats float on the water surface. It can block an irrigation system, interfere fishing, recreation, and power generation. These mats also prevent sunlight penetration and reduce the aeration of water, leading to oxygen deficiency, competitively exclude submerged plants, and reduce biological diversity. Therefore, this study chooses water hyacinth as biosorbent in

solving to environmental problem. The aim of this study is to evaluate the effectiveness of Water Hyacinth as biosorbent in the removal of Nickel from aqueous solution.

CHAPTER 2

LITERATURE REVIEW

2.1 Biosorption

Biosorption can be defined as the ability of biological materials to accumulate heavy metals from wastewater through metabolically mediated or physico-chemical pathways of uptake (Fourest and Roux , 1992) . In simple word it can be described as the binding and concentration of heavy metals from aqueous solutions by certain types of inactive, dead , microbial biomass . There are several applications of biosorption such as metal plating and metal finishing operations , mining and ore processing operations , metal processing (waste recovery) , battery and accumulator manufacturing operations , thermal power generation (coal-fired plants in particular) , and nuclear power generation. Biosorption is a new technology for removing metal ions from aqueous solutions for replacing conventional methods such as reduction or oxidation, ion exchange , filtration , electrochemical treatment , membrane technology , evaporation recovery , chemical precipitation , chemical lime coagulation and solvent extraction . These conventional ways has many disadvantages like extremely expensive, incomplete metal removal and generation of toxic compound. Thus, biosorption is a good method compare with others because it has major advantages include low cost, high efficiency, minimization of chemical and or biological sludge, no additional nutrient requirement, regeneration of biosorbent and possibility of metal recovery (Kratochvil and Volesky , 1998)

2.1.1 Biosorbent

Dead and metabolically inactive cells can serve as a basis for the progress to treat and removing heavy metals, nuclear fuel and radioactive elements. They can be highly selective, cheap and efficient compare to activated carbon that used in classical methods. Some types of biosorbents would be broad range, binding and collecting the majority of heavy metals with no specific activity, while others are specific from certain metals. Recent biosorption experiments have focused attention on waste materials, which are by-products or the waste materials from large-scale industrial operations. For example , the waste mycelia available from fermentation processes , olive mill solid residues (Pagnanelli et al ., 2002) , activated sludge from sewage treatment plants (Hammamni et al , 2003) , biosolids (Norton et al , 2003) , aquatic macrophytes (Keskinkan et al , 2003 ; Norton et al , 2003) used dewatered waste activated sludge from a sewage treatment plant for the biosorption of zinc from aqueous solutions . The adsorption capacity was determined to be 0.564 mM/g of biosolids. The use of biosolids for zinc adsorption was favorable compared to the bioadsorption rate of 0.299 mM/g by the seaweed *Durvillea potatorum* (Aderhold et al , 1996) . Keskinkan et al. (2003) studied the adsorption characteristics of copper , zinc and lead on submerged aquatic plant *Myriophyllum spicatum*. The adsorption capacities were 46.69 mg/g for lead, 15.59 mg/g for zinc and 10.37 mg/g for copper. Table 2.1 gives a comparison of heavy metal uptakes of various macrophytes.

Table 2.1 : A comparison of heavy metal uptake capacities (mg/g) of various macrophytes

Adsorbent	Metal uptake capacities (mg/g)		
	Lead	Zinc	Copper
<i>M.spicatum</i> (Keskinan et al., 2003)	46.69	15.59	10.37
<i>M.spicatum</i> (Wang et al., 1996)	55.6	13.5	12.9
<i>P.lucens</i> (Schneider and Rubio,1999)	14.1	32.4	40.8
<i>S.herzgoi</i> (Schneider and Rubio,1999)	-	18.1	19.7
<i>E.crassipes</i> (Schneider and Rubio,1999)	-	19.2	23.1

Another inexpensive source of biomass where it is available in copious quantities is in oceans as seaweeds, representing many different types of marine macro-algae. However most of the contributions studying the uptake of toxic metals by live marine and to a lesser extent freshwater algae focused on the toxicological aspects , metal accumulation , and pollution indicators by live , metabolically active biomass . Focus on the technological aspects of metal removal by algal biomass has been rare. Table 2.2 below shows some low cost materials for removal metal.

Table 2.2: Unmodified/ modified agricultural waste utilized for remove of heavy metal adsorption

Species	Type of absorbent	References
Cu(II)	Banana peel	Annadurai et al., (2002)
Zn, Cu, Ni	Streptomyces rimosus (bacteria), Saccharomyces cerevisiae (yeast), Penicillium chrysogenum (fungi), Fucus vesiculosus and Ascophyllum nodosum (marine algae	Bakkaloglu et al. (1998)
Ni(II)	Hazelnut shell	Demirbaş et al. (2002)
Cr(VI)	Hazelnut shell	Kobyta (2004)
Cr(VI)	Activated alumina	Bishnoi et al. (2003)
	Rice husk	
Cd(II)	Rice husk	Ajmal et al. (2003)
Cd(II)	Coirpith	Kadirvelu et al. (2001a)
Ni(II)	Coirpith	Kadirvelu et al. (2001b)
Ni(II)	Almond husk	Hasar (2003)
Cr(VI)	Almond shell	Dakiky et al. (2002)
Cr(VI)	Ethylenediamine-modified rice hull	Tang et al. (2003)

2.1.2 Factors that affecting biosorption

The investigation of the efficiency of the metal uptake by the microbial biomass is essential for the industrial application of biosorption, as it gives information about the equilibrium of the process which is necessary for the design of the equipment. The metal uptake is usually measured by the parameter 'q' which indicates the milligrams of metal accumulated per gram of biosorbent material and 'qH' is reported as a function of metal accumulated, sorbent material used and operating conditions. The following factors affect the biosorption process:

- 2.1.2.1 pH seems to be the most important parameter in the biosorptive process: it affects the solution chemistry of the metals, the activity of the functional groups in the biomass and the competition of metallic ions (Friis and Myers-Keith, 1986; Galun et al., 1987).
- 2.1.2.2 Biomass concentration in solution seems to influence the specific uptake: for lower values of biomass concentrations there is an increase in the specific uptake (Fourest and Roux, 1992; Gadd et al., 1988). Gadd et al. (1988) suggested that an increase in biomass concentration leads to interference between the binding sites. Fourest and Roux, (1992) invalidated this hypothesis attributing the responsibility of the specific uptake decrease to metal concentration shortage in solution. Hence this factor needs to be taken into consideration in any application of microbial biomass as biosorbent.
- 2.1.2.3 Biosorption is mainly used to treat wastewater where more than one type of metal ions would be present; the removal of one metal ion may be influenced by the presence of other metal ions. For example: Uranium uptake by biomass of bacteria, fungi and yeasts was not affected by the presence of manganese, cobalt, copper, cadmium, mercury and lead in solution (Sakaguchi and Nakajima, 1991). In contrast, the presence of Fe^{2+} and Zn^{2+}

was found to influence uranium uptake by *Rhizopus arrhizus* (Tsezos and Volesky, 1982) and cobalt uptake by different microorganisms seemed to be completely inhibited by the presence of uranium, lead, mercury and copper (Sakaguchi and Nakajima, 1991)

2.1.2.4 Temperature seems not to influence the biosorption performances in the range of 20-35 °C (Aksu et al., 1992)

2.1.3 Biosorption mechanisme

Adsorption and desorption studies invariably yield information on the mechanism of metal biosorption: how is the metal bound within the biosorbent. This knowledge is necessary for understanding of the biosorption process and it serves as a basis for quantitative stoichiometric considerations which constitute the foundation for mathematical modeling of the process.

Various metal-binding mechanisms have been postulated to be active in biosorption, such as :

- Chemisorption by ion exchange, complexation, coordination and/or chelation
- Physical Adsorption
- Precipitation
- Oxidation/Reduction.

For example, more studies show that fungal biomass and seaweed in particular have indicated a dominant role of ion exchange metal binding. Indeed, the biomass materials offer numerous molecular groups which are known to offer ion exchange sites: carboxyl, sulfate, phosphate, amine, could be the main ones.

2.1.3.1 Ion Exchange

Ion exchange is a reversible chemical reaction wherein an ion in a solution is exchanged for a similarly charged ion attached to an immobile solid particle. These solid ion-exchange particles are either naturally occurring inorganic zeolites or synthetically produced organic resins. Synthetic organic resins are the predominant type used today because their characteristics can be tailored to specific applications.

Ion exchange reactions are stoichiometric and reversible, and as such they are similar to other solution-phase reactions. For example, in the reaction



The nickel ions of the nickel sulfate (NiSO_4) are exchanged for the calcium ions of the calcium hydroxide Ca(OH)_2 molecule .

2.1.3.2 Complexation

The metal removal from solution may also take place by complex formation on the cell surface after the interaction between the metal and the active groups. Aksu et al., 1992 hypothesized that biosorption of copper by *C. vulgaris* and *Z. ramigera* takes place through both adsorption and formation of coordination bonds between metals and amino and carboxyl groups of cell wall polysaccharides . Complexation was found to be the only mechanism responsible for calcium, magnesium, cadmium, zinc, copper and mercury accumulation by *Pseudomonas syringae* . Microorganisms may also produce organic acids (e.g., citric, oxalic, gluonic, numeric , lactic and malic acids), which may chelate toxic metals resulting in the formation of metallo-organic molecules . These organic acids help in the solubilisation of metal compounds and their leaching from their

surfaces. Metals may be biosorbed or complexed by carboxyl groups found in microbial polysaccharides and other polymers.

2.1.3.3 Chelation

The word *chelation* is derived from the Greek word *chele*, which means *claw*, and is defined as the firm binding of a metal ion with an organic molecule (ligand) to form a ring structure. The resulting ring structure protects the mineral from entering into unwanted chemical reactions. Figure 2.1 shows examples the carbonate (CO_3^{2-}) and oxalate ($\text{C}_2\text{O}_4^{2-}$) ions

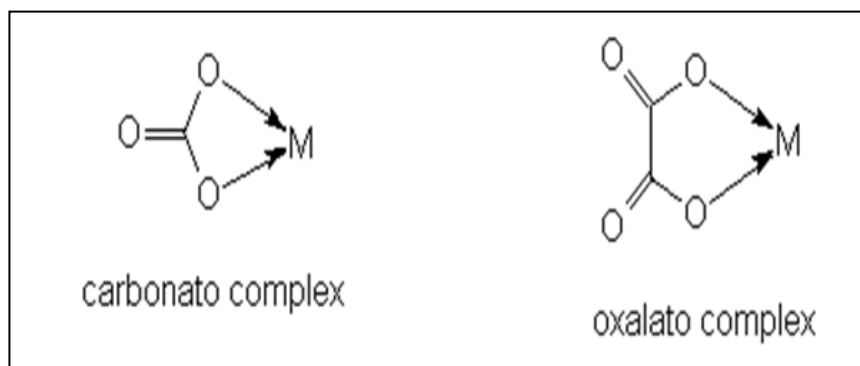


Figure 2.1 : Ring structure of carbonate (CO_3^{2-}) and oxalate ($\text{C}_2\text{O}_4^{2-}$) ions

2.1.3.4 Precipitation

Precipitation may be either dependent on the cellular metabolism or independent of it. In the former case, the metal removal from solution is often associated with active defense system of the microorganisms. They react in the presence of toxic metal

producing compounds, which favor the precipitation process. In the case of precipitation not dependent on the cellular metabolism, it may be a consequence of the chemical interaction between the metal and the cell surface. The various biosorption mechanisms mentioned above can take place simultaneously.

2.1.3.5 Coordination (Complex Formation)

A coordination complex is any combination of cations with molecules or anions containing free pairs of electrons . Bonding may be electrostatic , covalent or a combination of both ; the metal ion is coordinately bonded to organic molecules . Example of the formation of a coordination compound is:



Where coordinate covalent bonds are formed by donation of a pair of electrons from H_2O and Cl^- (Lewis bases) to Cu^{2+} (Lewis acid).

In general, biosorption of toxic metals and radionuclide's is based on non-enzymatic processes such as adsorption . Adsorption is due to the non-specific binding of ionic species to polysaccharides and proteins on the cell surface (Figure 2) or outside the cell^{4,19}. Bacterial cell walls and envelopes, and the walls of fungi, yeasts and algae , are efficient metal biosorbents that bind charged groups . The cell walls of gram-positive bacteria bind larger quantities of toxic metals and radionuclide's than the envelopes of gram-negative bacteria .

Bacterial sorption of some metals can be described by the linearized Freundlich adsorption equation:

$$\log S = \log K + n \log C \quad (2.4)$$

where:

S is the amount of metal absorbed in $\mu\text{mol/g}$

C is the equilibrium solution concentration in $\mu\text{mol/L}$

K and n are the Freundlich constants.

Biomass deriving from several industrial fermentations may provide an economical source of biosorptive materials. Many species have cell walls with high concentrations of chitin, a polymer of *N*-acetyl-glucosamine that is an effective biosorbent .

Biosorption uses biomass raw materials that are either abundant (*e.g.*, seaweeds) or wastes from other industrial operations (*e.g.*, fermentation wastes) . The metal-sorbing performance of certain types of biomass can be more or less selective for heavy metals, depending on the type of biomass, the mixture in the solution, the type of biomass preparation , and the chemical-physical environment .

It is important to note that the concentration of a specific metal in solution can be reduced either during the sorption uptake by manipulating the properties of the biosorbent or upon desorption during the regeneration cycle of the biosorbent. Due to the complexity of the biomaterials used, it is possible that at least some of these mechanisms are acting simultaneously to varying degrees, depending on the biosorbent and the solution environment.

2.2 Nickel

2.2.1 Characteristics

Nickel is silvery-white , hard , malleable , and ductile metal . It is produced by mining and refining sulphide and oxide ores . It is of the iron group and it takes on a high polish. It is a fairly good conductor of heat and electricity . Most nickel compounds are blue or green . Nickel dissolves slowly in dilute acids but , like iron , becomes passive when treated with nitric acid . Finely divided nickel adsorbs hydrogen .

2.2.2 Applications

Nickel is used in many industrial and consumer products. Common uses of nickel include production of stainless steel and other corrosion-resistant metals containing nickel. Other products which contain nickel include rechargeable (NiCad) batteries, coins , welding rods and wires , electronic or computer equipment , and pigments for paints or ceramics . Nickel is also used in electroplating, electroforming and sintered metal coatings. The major use of nickel is in the preparation of alloys. Nickel alloys are characterized by strength, ductility, and resistance to corrosion and heat. In the laboratory, nickel is frequently used as a catalyst for hydrogenation , most often using Raney nickel , a finely divided form of the metal.

2.2.3 Effects of Nickel to environment

Nickel is released into the environment a large number of processes such as electroplating and steel manufacturing. It will then settle to the ground or fall down after reactions with raindrops. It usually takes a long time for nickel to be removed from air. Nickel can also end up in surface water when it is a part of wastewater streams . The

larger part of all nickel compounds that are released to the environment will adsorb to sediment or soil particles and become immobile as a result. In acidic ground however, nickel is bound to become more mobile and it will often rinse out to the groundwater. High nickel concentrations on sandy soils can clearly damage plants and high nickel concentrations in surface waters can diminish the growth rates of algae and microorganisms.

2.2.4 Effect of Nickel to health

Nickel is naturally present in the environment. Human may also be exposed to nickel in food and water. Some consumer products that may contain nickel include jewellery, kitchen tools and coins.

Foodstuffs naturally contain small amounts of nickel. Chocolate and fats are known to contain severely high quantities. Nickel uptake will boost when people eat large quantities of vegetables from polluted soils. Plants are known to accumulate nickel and as a result the nickel uptake from vegetables will be eminent. Smokers have a higher nickel uptake through their lungs. Finally, nickel can be found in detergents.

Humans may be exposed to nickel by breathing air , drinking water , eating food or smoking cigarettes . Skin contact with nickel-contaminated soil or water may also result in nickel exposure. In small quantities nickel is essential, but when the uptake is too high it can be a danger to human health such as:

- 2.2.4.1 Risk to get lung , nose and prostate cancer
- 2.2.4.2 Sickness and dizziness after exposure to nickel gas
- 2.2.4.3 Lung embolisme
- 2.2.4.4 Respiratory failure
- 2.2.4.5 Birth defects
- 2.2.4.6 Asthma and chronic bronchitis
- 2.2.4.7 Skin rashes – allergic to jewellery
- 2.2.4.8 Heart disorders

Carcinogenicity- Nickel and certain nickel compounds have been listed by the National Toxicology Program (NTP) as being reasonably anticipated to be carcinogen. The International Agency for Research on Cancer (IARC) has listed nickel compounds within group 1 (there is sufficient evidence for carcinogenicity in humans) and nickel within group 2B (agents which are possibly carcinogenic to humans) . OSHA does not regulate nickel as a carcinogen. Nickel is on the ACGIH Notice of Intended Changes as a Category A1, confirmed human carcinogen.

2.3 Water Hyacinth

Water Hyacinth (*Eichornia Crassipes*) is an aquatic plant which floats on lakes and slow-moving streams of rivers. It is really beautiful but it can be an environmental nightmare . Water-hyacinth is a wild fern belonging to the Family Pontederiaceae . A native to South America, it has been naturalized in many tropical and subtropical regions of the world. It first appeared in Egypt in the 1890s, then it has invaded many water ways including African rivers and Lake Victoria.

2.3.1 Physical descriptions

It grows up to three feet in height. It has thick, waxy, rounded, glossy leaves, which rise well above the water surface on stalks. The leaves are broadly ovate to circular, 4 to 8 inches in diameter, with gently incurved sides, often undulate. Leaf veins are dense, numerous, fine and longitudinal. Water hyacinth leaf stalks are bulbous and spongy. Water hyacinth grows an erect thick stalk (to 20 inches long) at the top of which is a single spike of several (8 to 15) showy flowers. The flowers have 6 petals, purplish blue or lavender to pinkish, the upper petals with yellow, blue-bordered central splotches. Water hyacinth reproduces vegetative by short runner stems (stolons) that radiate from the base of the plant to form daughter plants, and also reproduces by seed. Its roots are purplish black and feathery.

It grows and spreads rapidly since it has a high growth rate and is able to reproduce vegetative by the outgrowth of buds on the leaf axils and rootstocks giving ramets. The ramets eventually break off from the parent plant to become new individuals. Water hyacinth also has a very high capacity uptake nutrients especially Nitrogen and Phosphorus from water, and stored it in its tissue.

2.3.2 Growth habit

Water hyacinth can form impenetrable mats of floating vegetation. It reproduces by seeds and by daughter plants which form on rhizomes and produce dense plant beds. In one study, two plants produced 1,200 daughter plants in four months. Individual plants break off the mat and can be dispersed by wind and water currents. As many as 5,000 seeds can be produced by a single plant and these seeds are eaten and transported by waterfowl. Seedlings are common on mud banks exposed by low water levels.

2.3.3 Roles of Water Hyacinth in the effluent from waste

Singhal and Rai (2003) reported, water hyacinth has potential to clean up various wastewaters due to its fast growth and large biogas production. It means, water hyacinth can remove heavy metal that contaminates water that usually comes from industrial. Several studies have shown, inorganic contaminants such as nitrate, ammonium and soluble phosphorus, heavy metals can be removed efficiently by water hyacinth through uptake and accumulation (Reddy et al., 1982; Reddy, 1983; Muramoto and Oki, 1983; Zhu et al., 1999). Organic pollutants such as phenols (Nora and Jesus, 1997) also can be absorbed, but whether those kinds of organic contaminants removed through uptake or an enhancement of mineralization due to the microbial consortia associated with the root surface is rarely studied and reported.

Previous studies have documented the phytoremediation ability of the obnoxious free-floating freshwater weed water hyacinth (*Eichhornia crassipes* (Mart.) Solms) for nutrient-rich wastewaters (Gamage and Yapa, 2001; Jayaweera and Kasturiarachchi, 2004; Sooknah and Wilkie, 2004; Tripathi and Upadhyay, 2003). The ability of water hyacinth to remove heavy metals is also well documented (Chua, 1998; Cooley and Martin, 1979; Cordes et al. 2000; Hardy and O'Keeffe, 1985; Kelley et al. 2000; Klumpp et al. 2002; Lytle et al. 1998; Vesik and Allaway, 1997; Vesik et al. 1999; Wang et al. 2002) though other studies have clearly manifested that hyacinths are more efficient in the phytoremediation of low concentrations of heavy metals (Hardy and Raber, 1985; Ingole and Bhole, 2003; Kay et al., 1984; Rulangaranga and Mugasha, 2003; Soltan and Rashed, 2003; Zhu et al., 1999).

Previous study did not show dried water hyacinth as biosorbent to remove metal such as Nickel in biosorption process. Thus, the ability of water hyacinth as biosorbent needs more research.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The purpose of this experimental work is to understand and analyzed result according to access the ability of Water Hyacinth (*Eichhornia crassipe s*) to remove Ni(II) from aqueous solution and to study the effect of biosorbent dosage , contact time , pH and temperature in removal of Nickel using biosorption method .

3.2 Overall Methodology

The whole experimental flow will be simplified in Figure 3.1 below.

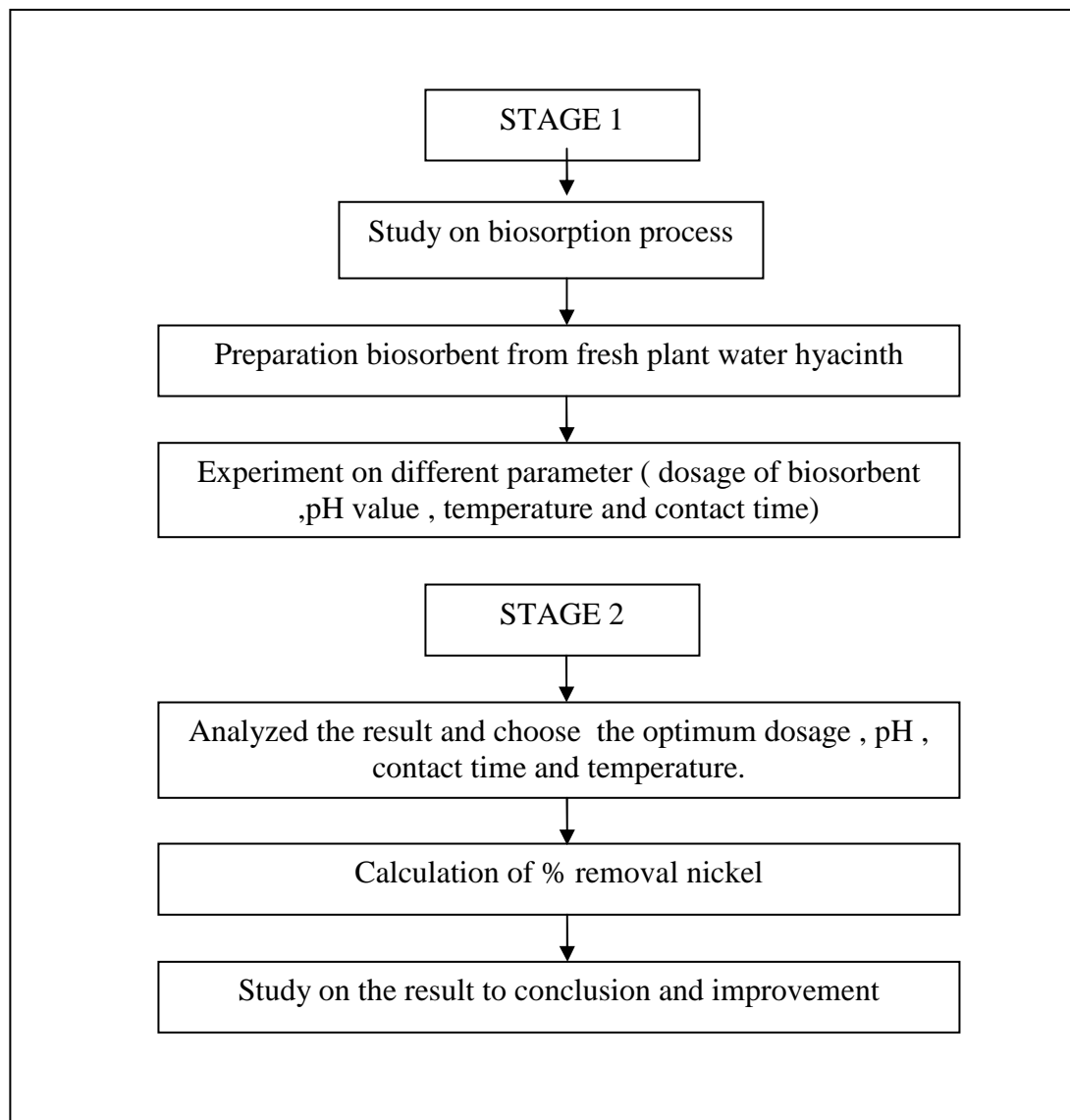


Figure 3.1: Overall methodology

3.3 Chemical Requirements

- 3.3.1 Nickel Standard Solutions
- 3.3.2 0.1M Sodium Hydroxide (NaOH)
- 3.3.3 0.1 M Hydrochloric Acid (HCL)
- 3.3.4 Deionized Water
- 3.3.5 Biosorbent (*Enchornia Crassipes*)

3.4 Chemical Equipments

- 3.4.1 Z-5000 Polarized Zeeman Atomic Absorption Spectrophotometer
- 3.4.2 pH meter (HM 30P)
- 3.4.3 Orbital shaker (PA 250/25. H)
- 3.4.4 Octagon siever (OCT-DIGITAL 4527-01)
- 3.4.5 Electric balance Shimadzu (AW220)
- 3.4.6 Laboratory blender (WARING COMMERCIAL)
- 3.4.7 Oven (Memmert)
- 3.4.8 100 mL Erlenmeyer Flask
- 3.4.9 50 ml beaker
- 3.4.10 Conical flask
- 3.4.11 Filter paper
- 3.4.12 Pippete

3.5 Experimental Methodology

Four parameters that have been test in this experiment:

- i. Effect on biosorbent dosage
- ii. Effect on pH value
- iii. Effect on contact time
- iv. Effect on temperature

3.5.1 Biosorbents preparation

The Water Hyacinth (*Eichornia crassipes*) was collected from lake , Pekan in September 2007. It was used as the study of material in the experiments on biosorption process of nickel from aqueous solution. The fresh plant was thoroughly washed with running water and three times with distilled water to remove dirt .The washed water hyacinth was oven dried at 60 °C for 72 hour until constant weight , then cut into small pieces “with homogenous known particle size of <0.255 mm” (Hanif et al., 2007) and powdered using domestic mixer . No pretreatments were used prior to biosorption experiments.

3.5.2 Preparation of NiSO₄ . 6H₂O solution

The experiments were conducted using solutions of nickel in the form of 10 g/L of NiSO₄.6H₂O. The solutions were prepared by dissolving 10 g NiSO₄ 6H₂O per liter of distilled water.

3.5.3 Effect of biosorbents dosage

Different amount of biosorbent dose ranging from 0.5 g/L – 5.0 g/L of biosorbent was added to Ni(II) solution in 100 mL Erlenmeyer Flask , while keeping the pH 6.0, temperature 25 °C and concentration of the Ni(II) ions 20 mg L⁻¹ .The sample was shaken using orbital shaker with 175 rpm for 30 minutes.

3.5.4 Effect of pH

For effect of pH experiment, concentration 20 mg L^{-1} of Ni(II) ions, 2.5 g/L of biosorbent dose in 100 mL metal solution at room temperature (25°C) with varying pH from 1.0 to 10. The sample was shaken using orbital shaker with 175 rpm for 30 minutes.

3.5.5 Effect of contact time

Effect of contact time was studied at optimum pH 6.0; constant metal concentration 20 mg L^{-1} , biosorbent dose 2.5 g/L in 100 mL of the solution at 25°C . The sample was shaken using orbital shaker with 175 rpm for 30 minutes. Samples were taken after 10, 20, 30, 40, 50 and 60 minutes.

3.5.6 Effect of temperature

Effect of contact time was studied at optimum pH 6.0; metal concentration 20 mg L^{-1} of Nickel solution and biosorbent dose 2.5 g/L in 100 mL . The sample was shaken using orbital shaker with 175 rpm for 30 minutes. Samples were taken at 25°C , 35°C , 45°C , 55°C and 65°C .