

**Removal of Heavy Metals From Effluents Using Ion-Exchange Resin**

by

Siti Nurul Asikhin Bte Shaaran

Dissertation submitted in partial fulfilment of  
the requirements for the  
Bachelor of Engineering (Hons)  
(Chemical Engineering)

JANUARY 2009

Universiti Teknologi PETRONAS  
Bandar Seri Iskandar  
31750 Tronoh  
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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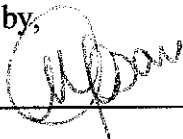
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A project dissertation submitted to the  
Chemical Engineering Programme  
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Approved by,



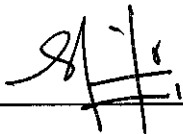
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(AP DR THANABALAN MURUGESAN)

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January 2009

## CERTIFICATION OF ORIGINALITY

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



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SITI NURUL ASIKHIN BTE SHAARAN

## ABSTRACT

The presence of heavy metals in the environment is major concern due to their toxicity. Contamination of heavy metals in water supplies has steadily increased over the last years as a result of expansion of industrial activities. Removal of trace amounts of heavy metals can be achieved by means of selective ion-exchange processes. In the present study, the removal of Ni(2+), Fe(3+), and Cr(3+) from industrial effluent was investigated. Experimental investigations were undertaken using the ion-exchange resin Amberlyst 15 wet resin (strongly acidic) and were compared with Activated Carbon. The influence of contact time, metal concentration and amount of resins on the removal process was investigated. For the determination of the adsorption behavior of the resin, the adsorption isotherms of metal ions have also been studied. The concentrations of metal ions have been measured by batch techniques. For investigations different amounts of resin were contacted with a fixed volume of Ni(2+), Fe(3+), and Cr(3+) ion containing effluent. The obtained adsorption affinity sequence in the presented work was Ni(2+) > Fe(3+) > Cr(3+). The metal ion concentrations were measured by AAS methods. The uptake of metal ions by the ion-exchange resins was reversible and thus has good potential for the removal of Ni(2+), Fe(3+), and Cr(3+) from the effluent. Selectivity increased in the series: Ni(2+) > Fe(3+) > Cr(3+). Ni(2+) and Fe(3+) shown 100% removal result using 20g of each resins and Cr(3+) shows promising percentage of removal. The results obtained showed that the Amberlyst 15 wet resin and Activated Carbon resin performed well for the removal of the heavy metals. As a low cost adsorbent, activated carbon is more preferable for the removal of heavy metals from the wastewater.

## ACKNOWLEDGMENT

First and foremost, thank to Allah s.w.t for this opportunity and seeing me through some truly difficult times especially through the journey of this Final Year Project (FYP) which ended on April 30, 2009

I am indebted to many individuals who helped and guided me during my final year where their presences are the essence to make my FYP a success. They are people of my respects who involved directly or indirectly throughout these years of my studies. I would like to express my warmest gratitude and appreciation to my FYP supervisor, Assoc. Prof. Dr Thanabalan Murugesan for his on-going encouragement and supports.

My biggest thanks to FYP coordinator, Mr Tazli and Assoc. Prof. Dr. Anita Ramli, all Chemical Engineering Department lecturers for the help and beneficial professional guidance to me. My appreciation also goes to staffs and technicians especially Mr Mohd Shahafizan, Mr Yusof, Mr Fadzli, Ms Nor Azimah to name a few for high commitment and cooperation during my completion of the Final Year Project.

Not to forget, a special thanks to BP Petronas Acetyls staff and engineer, Mr Govinda Ram for their utmost cooperation in guiding this project. Biggest thank to my beloved family my pillar of strength who never fail to give their best of guidance and support throughout the years .Last but certainly not the least, I wish everyone the very best and continue to provide excellent guidance and support to students in the future. Thank You.

***Regards,***

***Siti Nurul Asikhin Bte Shaaran***

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# CHAPTER 1

## INTRODUCTION

### 1.1 BACKGROUND OF STUDY

Ion exchange separation process is the most common method which is actively researched about in the field of various separation techniques. This separation technique is useful to remove ions from the aqueous phase by the exchange of cations or anions between the contaminants and the exchange medium. Ion exchange materials may consist of resins made from synthetic organic materials that contain ionic functional groups to which exchangeable ions are attached. They also may be inorganic and natural polymeric materials. After the resin capacity has been exhausted, resins can be regenerated for re-use.

High concentration of heavy metals which is usually heavy metal pollutant in the effluents can lead to environmental degradation. The purification of heavy metal solution has been investigated intriguingly since many heavy metals are very toxic and cause harm to the environment. Hence, successful separation may lead to recovery of pure chemicals in the effluent and thus reducing cost of sending the effluents to Kualiti Alam as scheduled waste. Therefore, less contamination to the environment<sup>[1]</sup>

The ion exchange process is an alternative technique for application in the treatment of industrial wastewater containing heavy metals and indeed it has been evidenced to be very promising in the removal and recovery of valuable species<sup>[1]</sup>

An ion exchanger, or ion exchange resin, can be a natural or synthetic substance which can exchange its own ions with the ions present in a solution which is passed

through it. The ion exchanger is porous and allows for a solution to permeate through the material. As the solution passes through the ion exchanger and leaves as effluent, it contains ions different from those with which it began.[11]

Metals ions in the effluents have different affinities to the ion exchange resin used. This research is to study the effectiveness of Amberlyst 15 (Wet) resin to separate these ions from the effluents. Hence, reduced or better removed the metals from the effluents.

The presence of heavy metals in the environment is major concern due to their toxicity. Contamination of heavy metals in water supplies has steadily increased over the last years as a result of over population and expansion of industrial activities.

Accordingly, ion exchange has been applied to waste streams from a number of industrial processes. For example, ion exchange is widely used for polishing operations to reduce residual heavy metal and other pollutants to very low levels in order to meet Department of Environment (DOE) requirements or to satisfy the stringent quality thresholds required for re-use of waste products. Solid phase methods based on ion-exchange resins have provided very convenient application and recovery of the extractant and are particularly appropriate for removal of heavy metal contaminants from non-nuclear power plant effluents, where ready regeneration of the saturated resin is desirable and where introduction of toxic organic solvents into the environment must be avoided.

There are two principal advantages of ion exchange processes. One is that quality effluent is attainable; a second is that specific species can be targeted for removal. However, a major disadvantage of current ion exchange technology, apart from that inherent in any batch process, is the relatively large volume of acidic wastes and flush waters that are needed. The attendant hazards of handling concentrated acids (and bases) have also been recognized.

Despite those disadvantages of current systems, ion exchange remains a technology of interest. Important characteristics of an ideal wastewater treatment resin would include: 1) high affinity for the target metal ions, which may be present in wastewater at relatively low concentrations (e.g., < 100 ppm); 2) relatively low affinity for other metal cations, to avoid premature inactivation of the resin that would lead to increased regeneration cycles; and 3) variable metal affinity in response to some easily changed system parameter, such as the pH. Commonly, simple cation exchange resins exhibit deficiencies in one or more of these areas.

The study of removal of heavy metals in the effluent is not only described the result for ion exchange resin. Powdered activated carbon is applied in this study for comparison purposes in terms of effectiveness and affinity.

Activated carbon is dominantly used for the purpose of adsorption by virtue of its high micropore volumes have shown greatest promise on wastewater treatment. The cost of highly activated carbon is the same order as those of the cheapest zeolites. Adsorption from solution, in comparison, is relatively simple to do it experimentally as no volume changes are involved and modern analytical techniques can be easily adapted to measure concentration changes in the solutions. However, competitive adsorption may occur between the solvent and the solute. Adsorption from solution may be further complicated because the solute may change chemically or its concentration may change in the solution (Harry Marsh, Fransisco Roqríguez-Reinoso, 2006).

Ion exchange technique works similarly as adsorption except that the species removed from solution is replaced with a species from the solid resin matrix so that the electroneutrality is maintained. As for adsorption which consist of the removal of a species from a fluid stream by means of a solid adsorbent with which the species has a higher affinity.

## 1.2 PROBLEM STATEMENT

Removing heavy metals from the effluents are very crucial in industry. Therefore, the removal of heavy metals from the industrial effluents has become mandatory. Method that is fairly effective to implement this task is by using ion exchange separation.

Since the metals that are being investigated in this research are Nickel(Ni), Chromium(Cr), Iron(Fe) contents in the effluents. This three (3) metals are of high toxicity and can cause adverse health effect to human as well as give impact to the environment. Proper and efficient experimental procedures to remove these toxic metals should be carried out in a very safe manner. This paper will be significant for alternative industrial effluent treatment which will help reduce cost of sending the effluent to Kualiti Alam for disposal.

The use of alternative low cost material as potential sorbents for removing heavy metals has been emphasized lately. Ion exchange resin is considered to be cost effective.

Hence the importance of understanding the behavior of metal ion mixtures and also the importance of exploring the effect of one metal concentration on the uptake of other metal ions. (M. Stoeppler, 1992)

Different ions can have different charges as well as affinities. A monovalent ion has a single charge, a divalent ion has two charges, and a trivalent ion has three charges. The charge on a resin bead must always remain neutral. This means that for every divalent ion of greater affinity which attaches to a bead, two of the ions must be released from the bead. For every trivalent ion which attaches to a bead, three of the ions must be released from the bead. In water treatment, the ion exchange resin which is used is usually more selective for divalent and trivalent ions, which is practical since the problematic ions are usually one of the two.

Certain conditions must be kept constant during the ion exchange process, especially if determining the ion exchange capacity of a resin, because the exchanging ability of a resin is a function of the affinity of the ions towards the exchanger. The contact time needs to be kept constant, for one. The contact time is the amount of water which passes through the exchanger with respect to the volume of the exchanger. The temperature needs to be kept constant, because temperature changes can affect the size of the pores in the ion exchange resin. The pH value of the water must be held constant as well, because the dissociation of the ions attached to the resin can be effected by changes in pH.

Thus, this project is significant in the aspects of economical, environmental health and sciences. In terms of economy, the cost to send the effluent for off-site treatment is minimized. Eventhough the ion exchange resin is consider costly but by using small amount of resin can be shown to remove a large amount of heavy metals is still cost efficient and the possibility to recover valuable product in the treat effluent can be profitable to the plant industry. Effective effluent treatment is able to control water pollution when it is already safe to discharge to any inland water which is applicable to any industry which has on-site wastewater treatment facility. Due to this, the life chain ecosystem which includes photosynthetic plant and marine life is protected. Heavy metals in the effluent can cause birth defect and some is carcinogenic which will effect the population expansion. Hence, it is crucial to treat the effluent effectively.

### 1.3 OBJECTIVE

The main objectives of this research are:

1. To compare the performance of ion exchange resin and activated carbon.
2. To determine the percentage removal of heavy metals using Amberlyst 15 wet resin and activated carbon.
3. To determine the affinities of the heavy metals ions towards Amberlyst 15 wet resin and activated carbon.
4. To abide to the Department of Environment parameters limit of heavy metals content in the effluent. Referring to the Department of Environment Legislation, as cited in the third schedule, *ENVIRONMENTAL QUALITY ACT 1974*, *ENVIRONMENTAL QUALITY (SEWAGE AND INDUSTRIAL EFFLUENTS) REGULATIONS 1978*<sup>[18]</sup>[Regulation 8 (1), 8 (2), 8 (3)]

Parameter (mg/L/day)	Maximum Permitted Value	
	Standard A	Standard B
Temperature (°C)	40	40
pH (units)	6.0 – 9.0	5.5 – 9.0
BOD <sub>5</sub> at 20 °C	20	50
COD	50	100
Suspended Solids	50	100
Mercury	0.005	0.05
Cadmium	0.01	0.02
Chromium, hexavalent	0.05	0.05
Arsenic	0.05	0.10
Cyanide	0.05	0.10
Lead	0.10	0.5
Chromium, trivalent	0.20	1.0
Copper	0.20	1.0
Manganese	0.20	1.0
Nickel	0.20	1.0
Tin	0.20	1.0
Zinc	1.0	1.0
Boron	1.0	4.0
Iron	1.0	5.0
Phenol	0.001	1.0
Free Chlorine	1.0	2.0
Sulphide	0.5	0.5
Oil and Grease	Not Detectable	10.0

\* Environmental Quality (Sewage And Industrial Effluents) Regulations 1979 - P.U. (A) 12/79

The parameter limits are to indicate the amount of heavy metals requirements in the effluents as according to Department of Environment (DOE), Malaysia legislation. The highlighted components are the main heavy metals in effluent that is emphasized in this study. Note that it is mandatory to abide to this requirement.

## **1.4 SCOPE OF STUDY**

This project is to investigate the selectivity of ion exchange resin is influenced by properties of the bead, the ions being exchanged, and the effluents in which the ions are present. This is known after the samples are tested with Atomic Absorption Spectroscopy (AAS) for the concentration of heavy metals. These tests shall present the performance of Amberlyst 15(wet) resin in reducing or removing of heavy metals contents in the effluents.

This study also includes the comparison of the effectiveness of the ion exchange resin (Amberlyst 15 wet resin) and Activated Carbon towards heavy metals removal in the effluent. In addition, this study will determine the amount of resin required to removed the heavy metals in the effluent

Effluents sample with constant volume and Amberlyst 15 resin with varying weight will be used throughout the experiments to identify the optimum separation of heavy metals from the effluents and to have a view of making the effluent less toxic.

## **1.5 RELEVANCY OF THE PROJECT**

This study is conducted using effluents taken from BP PETRONAS Acetyls Plant which the outcomes of this project may give new alternative for effluent treatment on-site not only for BPPA plant but to other industries as well. This is to ensure the quality of the environment is maintained and at the same time may help in reducing cost of having to treat the effluent off site.

## **1.6 FEASIBILITY**

This project can be done within the time frame since the chemicals and equipments needed are readily available in the laboratory. Therefore, the scope of study can be accomplished.



## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 INTRODUCTION

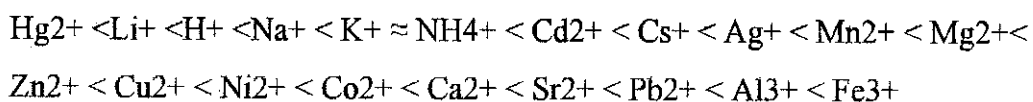
Ion exchange materials are insoluble substances containing loosely held ions which are able to be exchanged with other ions in solutions which come in contact with them. These exchanges take place without any physical alteration to the ion exchange material. Ion exchangers are insoluble acids or bases which have salts which are also insoluble, and this enables them to exchange either positively charged ions (cation exchangers) or negatively charged ones (anion exchangers). By ion exchange undesirable ions are replaced by others which don't contribute to contamination of the environment. The method is technologically simple and enables efficient removal of even traces of impurities from solutions. Examples of selective removal of heavy metal ions by ion-exchange are presented. They include removal of Pb(II), Hg(II), Cd(II), Ni(II), V(IV,V), Cr(III,VI), Cu(II) and Zn(II) from water and industrial wastewaters by means various modern types of ion exchangers(Dabrwocki A.,Hubicki Z.,Podkoscielny P, Robens E.,2004). Many natural substances such as proteins, cellulose, living cells and soil particles exhibit ion exchange properties which play an important role in the way the function in nature.

These solid ion exchange particles are either naturally occurring inorganic zeolites or synthetically produced organic resins. The synthetic organic resins are the predominant type used today because their characteristics can be tailored to specific applications.

An organic ion exchange resin is composed of high-molecular-weight polyelectrolytes that can exchange their mobile ions for ions of similar charge from the surrounding medium. Each resin has a distinct number of mobile ion sites that set the maximum quantity of exchanges per unit of resin.

Furthermore, the advantages of ion exchange processes are the very low running costs. Very little energy is required, the regenerant chemicals are cheap and if well maintained resin beds can last for many years before replacement is needed. There are, however, a number of limitations which must be taken into account very carefully during the design stages. When itemized these limitations appear to represent a formidable list and the impression can be given that ion exchange methods might have too many short comings to be useful in practice. However, this is not the case as the advantages mentioned above are very great and compensation can readily be made for most restrictions.

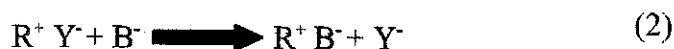
The order of affinity for some common cations is approximately:



Metal ions initially contained in an aqueous solution are exchanged with ions initially contained in a solid material (most of them in an organic ion exchange resin). Such a process is called cation exchange and can be illustrated by reaction



where R = ion exchanger; A<sup>+</sup> = positively charged metal ion; bars indicate phase of the ion exchanger. A similar process involving anions is called anion exchange:



where B- and Y- = anions or negatively charged metal ion complexes. Chemical selectivity of reactions (1) and (2) is desirable but is not a requirement. Contrary to many other chemical separations, reactions (1) and (2) can be successfully used even if they are shifted to the "wrong" direction. To achieve an efficient separation, column techniques are applied in industry.

For example, benzenesulfonate resins have relatively low heavy metal affinities and selectivities and require strong acids to release other bound metal ions when they are regenerated. Removal of trace amounts of heavy metals can be achieved by means of selective ion-exchange processes. The newly developed resins offered a high resin capacity and faster sorption kinetics for the metal ions such as Pb(2+), Cu(2+), Zn(2+), Cd(2+), and Ni(2+) ions. In the present study, the removal of Pb(2+), Cu(2+), Zn(2+), Cd(2+), and Ni(2+) ions from aqueous solutions was investigated. Experimental investigations were undertaken using the ion-exchange resin Lewatit CNP 80 (weakly acidic) and were compared with Lewatit TP 207 (weakly acidic and chelating). The optimum pH range for the ion-exchange of the above mentioned metal ions on Lewatit CNP 80 and Lewatit TP 207 were 7.0-9.0 and 4.5-5.5, respectively. The influence of pH, contact time, metal concentration and amount of ion-exchanger on the removal process was investigated. For investigations of the exchange equilibrium, different amounts of resin were contacted with a fixed volume of Pb(2+), Cu(2+), Zn(2+), Cd(2+), and Ni(2+) ion containing solution. The obtained sorption affinity sequence in the presented work was Ni(2+)>Cu(2+)>Cd(2+)>Zn(2+)>Pb(2+). The metal ion concentrations were measured by AAS methods. The distribution coefficient values for metal ions of  $10^{-3}$ M initial concentration at 0.1mol/L ionic strength show that the Lewatit CNP 80 was more selective for Ni(2+), Cu(2+) than it was for Cd(2+), Zn(2+) and Pb(2+). Langmuir isotherm was applicable to the ion-exchange process and its contents were calculated. The uptake of metal ions by the ion-exchange resins was reversible and thus has good potential for the removal of Pb(2+), Cu(2+), Zn(2+), Cd(2+), and Ni(2+) from aqueous solutions. The amount of sorbed metal ion per gram dry were calculated as 4.1, 4.6, 4.7, 4.8, and 4.7mequiv./g dry resin for Pb(2+), Cu(2+), Zn(2+), Cd(2+), and Ni(2+), respectively. Selectivity increased in the series:

$Cd(2+) > Pb(2+) > Cu(2+) > Ni(2+) > Zn(2+)$ . The results obtained showed that Lewatit CNP 80 weakly acidic resin had shown better performance than Lewatit TP 207 resin for the removal of metals. The change of the ionic strength of the solution exerts a slight influence on the removal of  $Pb(2+)$ ,  $Cu(2+)$ ,  $Zn(2+)$ ,  $Cd(2+)$ , and  $Ni(2+)$ . The presence of low ionic strength or low concentration of  $NaNO_3$  does not have a significant effect on the ion-exchange of these metals by the resins. (Pehlivan E., Altun T., 2006)

Other study relating to this research can be found in research (Santos Yabe M.J.1; de Oliveira E, Universidade Estadual de Londrina, Brazil) shown similar objectives to this report. Their report proposed on removal of heavy metals by adsorption process varies in pH range. After the adsorption process, the Pb concentration, as well as that of Cd, Ni, Cr and Cu, were below the detection limit. For other metals, removal was observed to be approximately 20-30% for Ca, Mg and Mn and above 80% for Cr, Pb, Ni, Cd and Cu, using alumina as an adsorbent.

Another approach for removing heavy metals in effluent using adsorption and coagulation by a group of researchers from Tongji University Shanghai (L. Koene and L.J.J. Janssen, 2000) shown similar results as this study.

A strong cation-exchange resin, Amberlite IR 120 and a natural zeolite, dolomite were used for the removal of lead(II) and cadmium(II). The optimum conditions were determined in a batch system as concentration range was between 5 and 100 mg/L, pH range between 1 and 8, contact time between 5 and 90 min, and the amount of adsorbent was from 0.1 to 1g. A constant stirring speed, 2000 rpm, was chosen during all of the experiments. The optimum conditions were found to be a concentration of 20 mg/L, pH of 5, contact time of 60 min and 0.5 g of adsorbent. Also, for investigation of exchange equilibria different amounts of ion exchange resin and dolomite were contacted with a fixed volume and concentration of a heavy metal bearing solutions. Sorption data have been interpreted in terms of Langmuir and Freundlich equations. The effect of adsorption temperature on the heavy metals adsorption onto dolomite was investigated at three different temperatures (20, 40 and 60

degrees C). Thermodynamic parameters were calculated. The results obtained show that the Amberlite IR 120 strong cation-exchange resin and dolomite performed well for the removal of these heavy metals. As a low cost adsorbent, dolomite can preferable for removal of heavy metals from wastewaters.(Kocaoba S.,2007)

Ion-exchange is an alternative process for uptake of heavy metals from aqueous solutions. In the present study, the sorption of nickel(II) ions from aqueous solution was investigated by using Lewatit MonoPlus SP 112 (strongly acidic, macroporous cation-exchange resin) in a batch adsorption system as a function of pH (2.0-8.0), initial nickel concentration (50-200mg/L), resin dosage (0.5-2.0g/L), contact time (0.5-3h), and temperatures (298-318K). The data were analyzed on the basis of Lagergren pseudo-first order, pseudo-second order (Types 1-5), Elovich and external, Weber-Morris intraparticle, pore-surface mass diffusion models. The experimental data showed that the maximum pH for efficient sorption of nickel(II) was 6.0. At the optimal conditions, nickel(II) ions sorption on the resin was decreased when the initial metal concentration increased. The results indicated that the resin dosage strongly affected the amount of nickel(II) ions removed from aqueous solution. The adsorption process was very fast due to 80% of nickel(II) sorption was occurred within 30min and equilibrium was reached at about 90min. Freundlich and Langmuir adsorption isotherm models were used for sorption equilibrium data and the maximum adsorption capacity (171mg/g) of Lewatit MonoPlus SP 112 was obtained from Langmuir isotherm. The thermodynamic parameters ( $\Delta G$  degrees , free energy change;  $\Delta S$  degrees , enthalpy change; and  $\Delta H$  degrees , entropy change) for sorption of nickel(II) ions were evaluated. The rise in temperature caused a partly increase in the value of the equilibrium constant ( $K(c)$ ) for the sorption of nickel(II) ions. Moreover, column flow adsorption study was also studied. Breakthrough curves were obtained from column flow studies by using both synthetic solution and rinsing bath water of filter industry. The column regeneration was carried out for two sorption-desorption cycles. The eluant used for regeneration of the cation-exchange resin was 7% (w/w) HCl. The experimental results demonstrated that Lewatit MonoPlus SP 112 cation-exchange resin could be used

effectively for the removal of nickel(II) ions from aqueous medium(Dizge N, Keskinler B, Barlas H.,2009)

Another study related to this project is using a gel resin containing sulfonate groups (Dowex 50W) investigated for its sorption properties towards copper, zinc, nickel, cadmium and lead metal ions. The use of selective ion exchange to recover metals from aqueous solution has been studied. The ion exchange behavior of five metals on Dowex 50W, depending on pH, temperature, and contact time and adsorbate amount was studied. Experimental measurements have been made on the batch sorption of toxic metals from aqueous solutions using cation exchanger Dowex 50W. The maximum recoveries (about 97%) Cu(2+), Zn(2+), Ni(2+), Cd(2+) and (about 80%) Pb(2+) were found at pH ranges 8-9. The amount of sorbed metal ion was calculated as 4.1, 4.6, 4.7, 4.8, and 4.7mequiv./gram dry resin for Pb(2+), Cu(2+), Zn(2+), Cd(2+), and Ni(2+), respectively. The precision of the method was examined at under optimum conditions. Selectivity increased in the series: Pb>Cd>Cu>Zn>Ni. It has been observed that, selectivity of the -SO(3)H group of the resin increases with atomic number, valance, degree of ionization of the exchanged metals. The equilibrium ion exchange capacity of resin for metal ions was measured and explored by using Freundlich and Langmuir isotherms. Langmuir type sorption isotherm was suitable for equilibrium studies(PehlivanE.,Altun T.,2006)

Alternatively, activated carbon can be used to remove the heavy metals in the effluent for comparison with Amberlyst 15 wet resin. Activated carbon was prepared from coirpith by a chemical activation method and characterized. The adsorption of toxic heavy metals, Hg(II), Pb(II), Cd(II), Ni(II), and Cu(II) was studied using synthetic solutions and was reported elsewhere. In the present work the adsorption of toxic heavy metals from industrial wastewaters onto coirpith carbon was studied. The percent adsorption increased with increase in pH from 2 to 6 and remained constant up to 10. As coirpith is discarded as waste from coir processing industries, the resulting carbon is expected to be an economical product for the removal of toxic heavy metals from industrial wastewaters(Kadirvelu K,Thamaraiselvi K, Nasivayam C.,2001)

A similar study on activated carbon (AC) prepared from coconut tree sawdust was used as an adsorbent for the removal of Cr(VI) from aqueous solution. Batch mode adsorption studies were carried out by varying agitation time, initial Cr(VI) concentration, carbon concentration and pH. Langmuir and Freundlich adsorption isotherms were applied to model the adsorption data. Adsorption capacity was calculated from the Langmuir isotherm and was 3.46 mg/g at an initial pH of 3.0 for the particle size 125-250 microm. The adsorption of Cr(VI) was pH dependent and maximum removal was observed in the acidic pH range. Desorption studies were carried out using 0.01-1 M NaOH solutions(Selvi K,Patthabi S, Kadirvelu K.,2001)

Another study related to this research Cr(VI) is the removal of Cr(VI) ions from aqueous solution under different conditions was investigated using activated alumina (AA) and activated charcoal (AC) as adsorbents. Batch mode experiments were conducted to study the effects of adsorbent dose, contact time, pH, temperature and initial concentration of Cr(VI). Results showed that the adsorption of Cr(VI) depended significantly on pH and temperature. Equilibrium studies showed that Cr(VI) had a high affinity for AA at pH 4 and AC at pH 2. For AA, maximum adsorption was found at 25 degrees C, indicating exothermic adsorption, while for AC, maximum adsorption was at 40 degrees C. Freundlich and Langmuir adsorption isotherms were also applied and they showed good fits to the experimental data. The results suggest that both AA and AC could be used as effective adsorbents for the removal of Cr(VI) ions(Mor S, Ravindra K, Bishnoi NR.,2007)

The equilibrium ion exchange capacity of resin for metal ions was measured and explored by using Freundlich and Langmuir isotherms(Pehlivan E., Altun T.,2006)

## **2.2 Amberlyst 15(Wet) Resin**

For this particular research i suggest the best yet method to implement this lab-based research is by using ion-exchange resin specifically Amberlyst 15(Wet) resin. This resin is well known for;

1. its high catalytic activity and selectivity resistance to polymer fouling,
2. long lifetime,
3. superior resistance to thermal, mechanical, and osmotic shock,
4. excellent stability,
5. low leaching,
6. suitable for aqueous and non-aqueous media applications.



## 2.3 Activated Carbon

Activated carbon is prepared from a variety of raw materials including wood, lignite, coal, bone, nut shells and petroleum residues. The new material is activated in an atmosphere of CO<sub>2</sub>, CO, O<sub>2</sub> water vapor air or other selected gases at a temperature between 573 K and 1273 K. This is often followed by quenching in air or water. Adsorption on activated carbon is associated with the presence of small and uniform pores. The surface area of activated carbon is approximately 1000 m<sup>2</sup>/g.(Harry Marsh, Francisco Rodriguez-Reinoso,2006)

1. cheapest hydrophobic adsorbent
2. workhorse of the pollution-control business
3. desorption and sorbent regeneration are since sorbate-sorbent interaction is lower
4. require less energy (heat of adsorption)

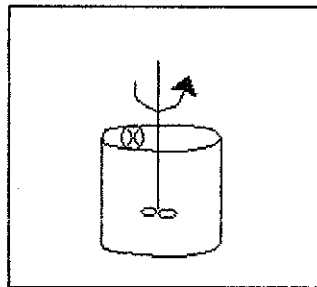
## CHAPTER 3

### METHODOLOGY

#### 3.1 RESEARCH METHODOLOGY

Procedure used in this laboratory research is by batch process. Since this is in liquid solid phase, done in small scale production gives higher conversion per unit volume. In batch process, the main steps operate discontinuously. This means that concentration varies with time. For laboratory scale; batch operation provides variability in production rate and reuse of equipment.

The experiment is conducted by mixing a fixed volume of effluents sample and resin at constant 250rpm.



Batch Reactor

General mole balance equation for batch process;

$$F_{A0} - F_A + \int_0^V r_A dV = \frac{dN_A}{dt}$$

(from Smith, Chemical Process Design and Integration)

### **3.2 OPERATIONAL ACTIVITIES**

Tasks required for the study of removal of heavy metals in the effluent using batch operation:

**1. Liquid mixing**

- mixing (liquid) operations may be necessary for a subsequent reaction. Two or more chemicals (resin and effluent) are mixed at constant agitation speed.

**2. Reaction**

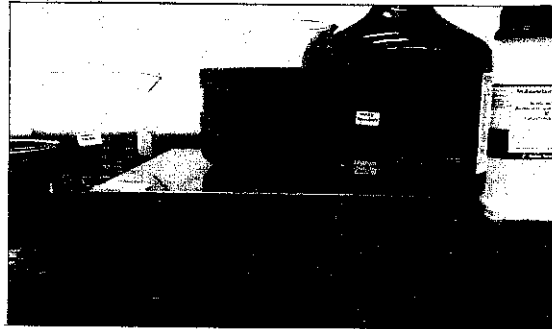
- Reaction taken place at few hours whereby every interval of 1 hour the samples of 6ml will be used for analysis of heavy metals.

**3. Separation**

- Separation is made by filtration (for powdered activated carbon) so that there is no resin particles in the samples.

**4. Analysis for heavy metals concentration**

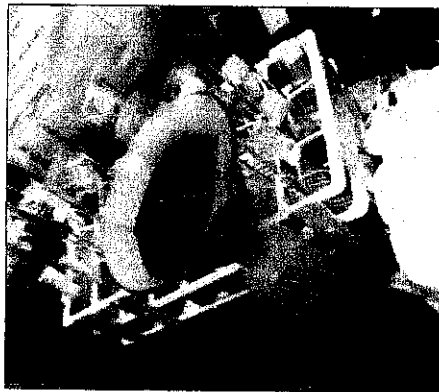
- All the samples are taken for heavy metal testing using AAS machine. Before AAS can be used, multistandard solution of the metals (Ni, Fe, Cr) are prepared accordingly



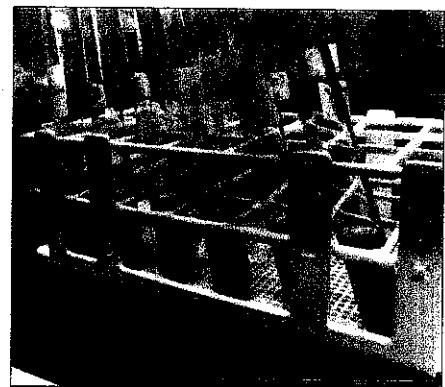
Batch Process using magnetic stirrer

Alternatives resin

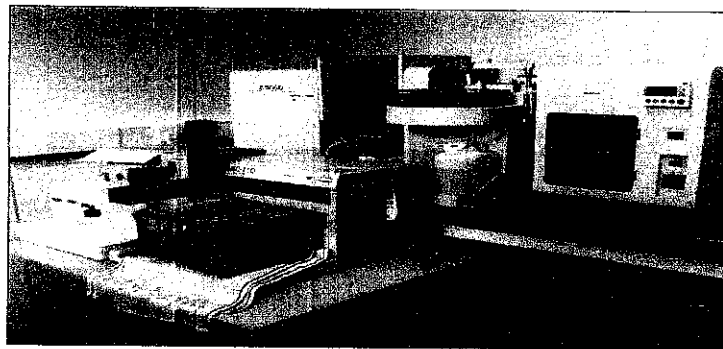
Amberlyst 15 wet resin



Filtering powdered activated carbon



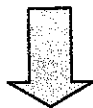
Samples after using Amberlyst 15  
wet resin



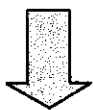
Heavy Metal test using Atomic Absorption Spectroscopy (AAS)

Experiment that are going to be conducted for this project:

Part 3.1.1: Preparing 1g, 10g, 20g, 30g, 40g resin- Put Ion exchange resin in a beaker. Then, weight the resin on a weight machine for 1g resin. Continue procedures (1) and (2) for 10g and 20g resin.



Part 3.1.2: Preparing Effluents at constant volume- For this experiment, 200ml sample of effluents will be evaluated.



Part 3.1.3: Batch Process-Put the 1 g prepared resin in a beaker. First pour 200ml sample into the beaker. Take sample at 0 hour. Then the samples were mixed at 500rpm for 1 hour interval.



Part 3.1.4: Metal Solution preparation 1ppm, 2ppm, 4ppm-Pipette 0.1 ml of 1000ppm metal(Fe, Cr, Ni) solution into a volumetric flask to get 1 ppm multistandard. Mark up the volumetric flask with deionized water. Continue dilution for 0.2 ml and 0.4 ml in 100 ml flask.



Part 3.1.5: Metal Testing using Atomic Absorption Spectroscopy(AAS) for Fe, Ni, Cr  
Prepare a standard solution of metals which is used to calibrate the equipment beforehand. Analyze each samples for Fe, Ni, Cr concentration by measuring light absorbency at a specific wavelength.

### 3.3 GANNTT CHART

No.	Detail / Week	Sem Break	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work	●	●	●	●												
2	Submission of Progress Report 1					√											
3	Project Work Continue					●	●	●	●								
4	Submission of Progress Work 2										√						
5	Seminar										●	●	●				
6	Project Work Continue										●	●	●				
7	Poster Exhibition												√				
8	Submission of Dissertation (Soft Bound)													√			
9	Oral Presentation															√	
10	Submission of Project Dissertation (Hard Bound)																√

Mid Semester Break

- √ Suggested milestone
- Process

### 3.4 CHEMICALS AND MATERIALS

Table 3.3.1: Chemicals and materials used.

No.	Chemicals	Quantity
1.	Effluents sample	1000m3
2.	Amberlyst 15(Wet) Resin	1000g
3.	Activated Carbon	1000g
4.	Multi standard metals solution (Cr,Ni,Fe)	500m3

### 3.5 EQUIPMENTS

Table 3.4.1: Equipments used.

No.	Tools/Equipment/Software
1.	Pipette
2.	Beakers
3.	Sampling bottles
4.	Weight machine
5.	Magnetic stirrer
6.	Atomic Absorption Spectroscopy(AAS)

### 3.6 ATOMIC ABSORPTION SPECTROSCOPY(AAS)



H																	He				
																	C	N	O	F	Ne
																	B	S	Cl	Ar	
																			Br	Kr	
																			I	Xe	
																	Pb	Bi	At	Rn	
Fr	Ra	Ac																			

**Figure 3.6:** Elements detectable by atomic absorption are highlighted in pink in this periodic table.(Ni, Cr, Fe for this particular study)

Atomic absorption methods measure the amount of energy (in the form of photons of light, and thus a change in the wavelength) absorbed by the sample. Specifically, a detector measures the wavelengths of light transmitted by the sample (the "after" wavelengths), and compares them to the wavelengths, which originally passed through the sample (the "before" wavelengths). A signal processor then integrates the changes in wavelength, which appear in the readout as peaks of energy absorption at discrete wavelengths. The sample, either a liquid or a solid, is atomized in either a flame or a graphite furnace. Upon the absorption of ultraviolet or visible light, the free atoms undergo electronic transitions from the ground state to excited electronic states.

It is therefore important to set the instrument parameters such that the light from the source (typically a hollow-cathode lamp) is directed through the region of the flame that contains the maximum number of neutral atoms. The light produced by the hollow-cathode lamp is emitted from excited atoms of the same element which is to be determined. Therefore the radiant energy corresponds directly to the wavelength which is absorbable by the atomized sample. This method provides both sensitivity and selectivity since other elements in the sample will not generally absorb the chosen



wavelength and thus, will not interfere with the measurement. To reduce background interference, the wavelength of interest is isolated by a monochromator placed between the sample and the detector.

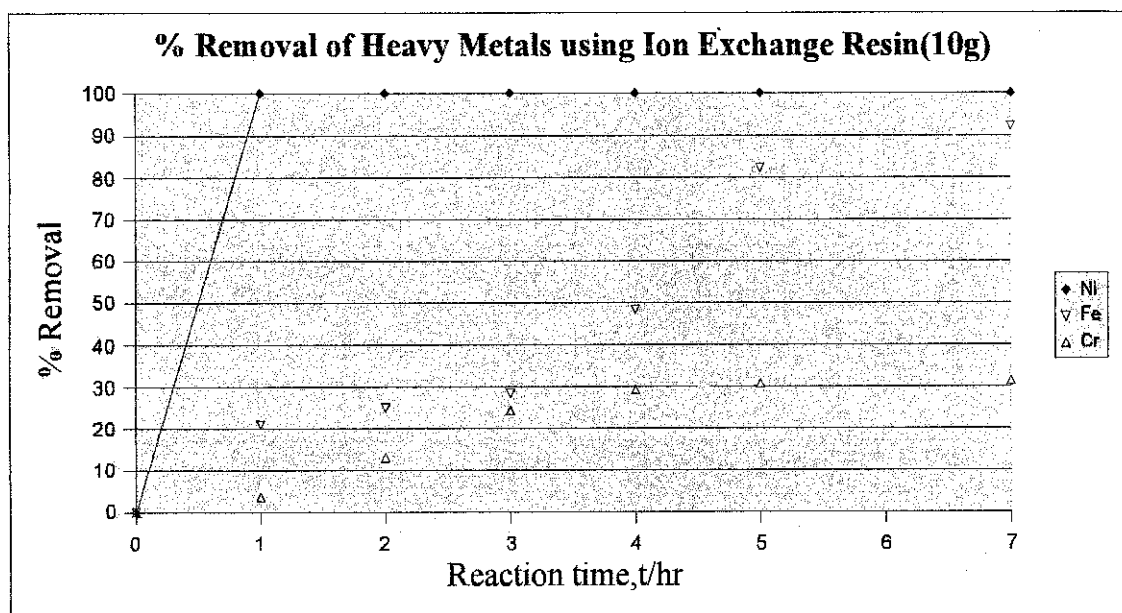
## CHAPTER 4

### RESULT AND DISCUSSION

#### 4.1 RESULTS

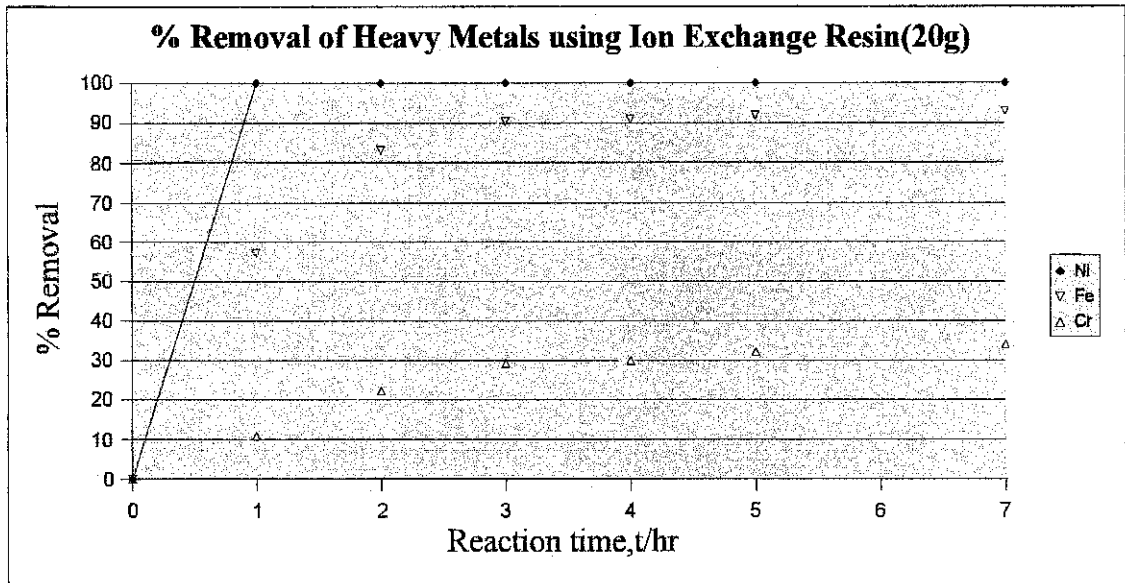
##### 4.1.1 Ion exchange resin

**Trial 1: 200 ml sample + 10g resin;**



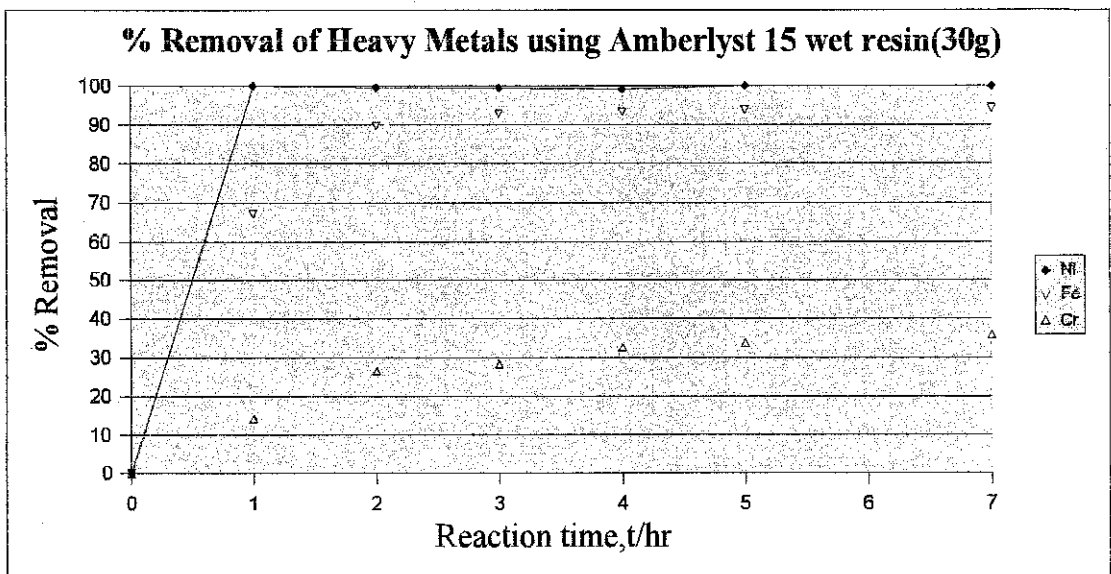
**Figures 4.1.1: % Removal of heavy metals using Amberlyst 15 wet resin(10g)**

**Trial 2: 200 ml sample + 20 g resin;**



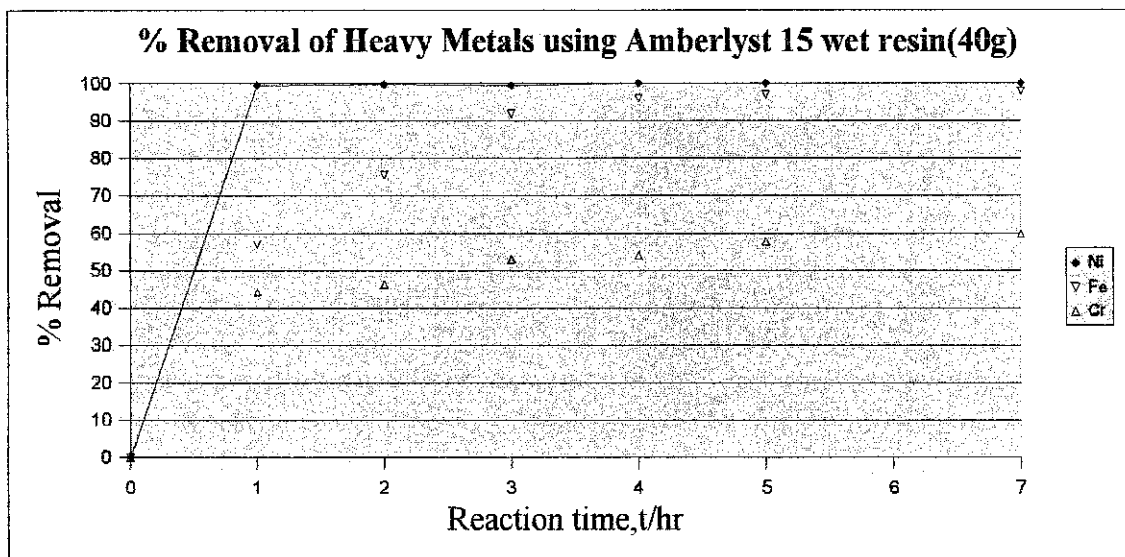
**Figures 4.1.2 :% Removal of heavy metals using Amberlyst 15 wet resin(20g)**

**Trial 3: 200 ml sample + 30 g resin;**



**Figure 4.1.3:% Removal of heavy metals using Amberlyst 15 wet resin(30g)**

**Trial 4: 200 ml sample + 40 g resin;**



**Figure 4.1.4:**% Removal of heavy metals using Amberlyst 15 wet resin(40g)

**4.1.1.1 Discussion**

Figures 4.1.1 to 4.1.4 above shows the percentage of heavy metals removed from the effluent using 10g, 20g, 30g and 40g of Amberlyst 15 wet resin. As the reaction time increased the percentage of removal for the 3 metals increased. For 10g of resin used, Ni(2+) is 100% removed, Fe(3+) is 92% removed and Cr(3+) shows only 31% removal. For 20g resin used, Ni(2+) is fully removed, 93% Fe(3+) and 34% Cr(3+) are removed. For 30g resin used, Ni(2+) is fully removed, 94% Fe(3+) is removed and 36% Cr(3+) removed. For 40g resin used, Ni(2+) is 100% removed, Fe(3+) 97% removed and Cr(3+) shows 60% removal from the effluent. The affinity of the heavy metals can be described as Ni(2+) > Fe(3+) > Cr(3+) based on each percentage removal. Further experiment should be conducted to analyze the heavy metals percentage removal.

### 4.1.2 Activated Carbon

#### Trial 6: 200 ml sample + 10 g resin;

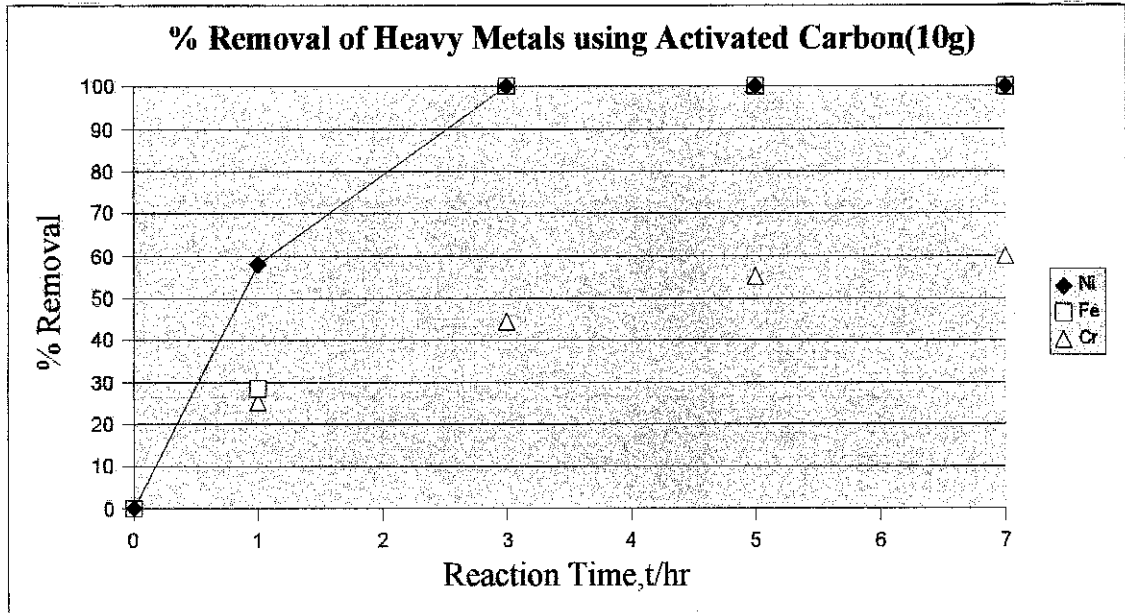


Figure 4.1.5: % Removal of heavy metals using Activated Carbon(10g)

#### Trial 7: 200 ml sample + 20 g resin;

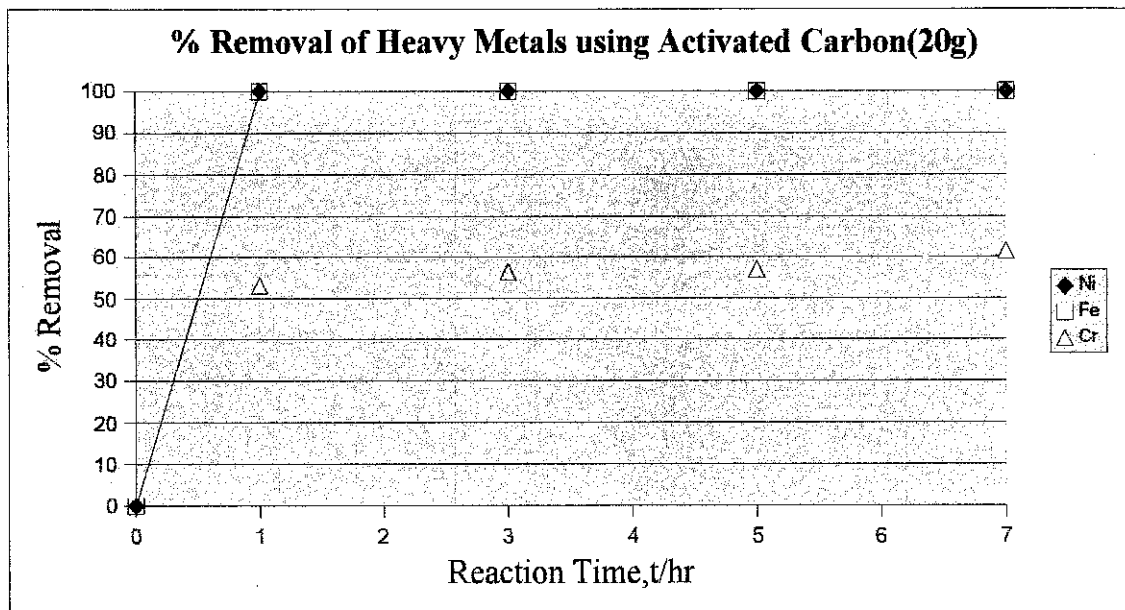
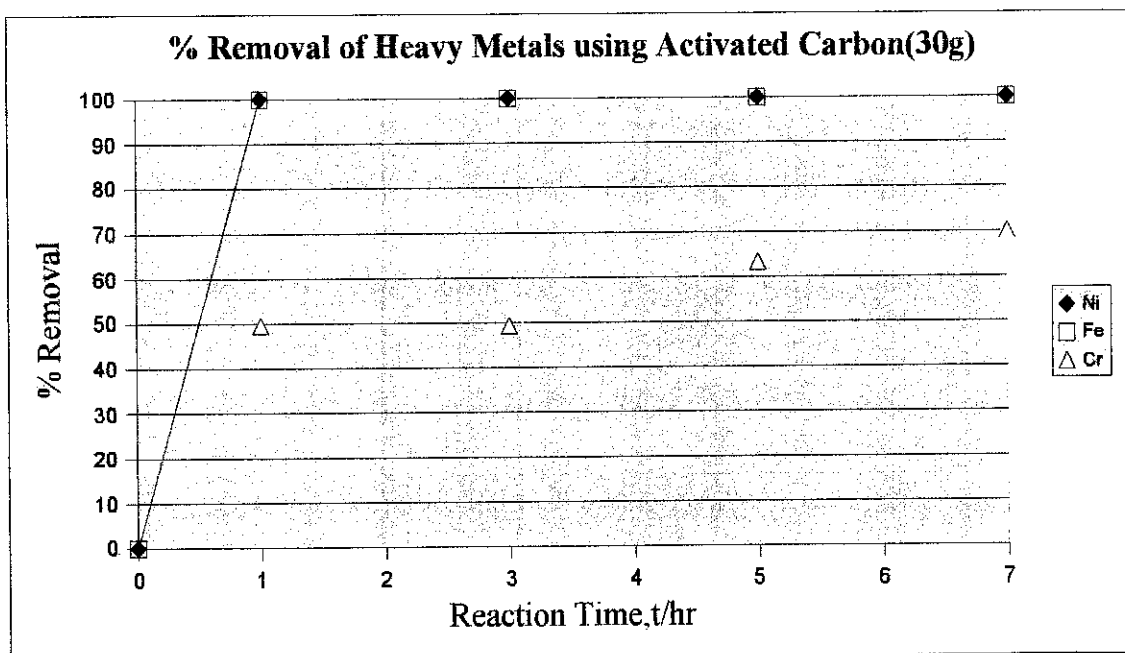


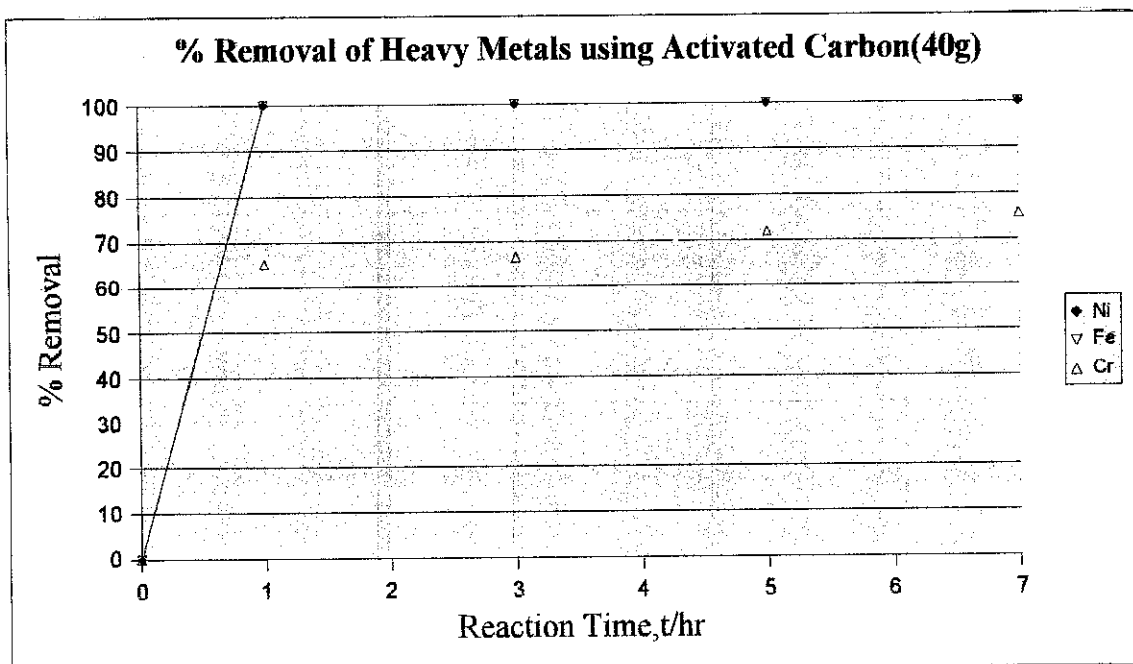
Figure 4.1.6: % Removal of Heavy Metals using Activated Carbon(20g)

**Trial 8: 200 ml sample + 30 g resin;**



**Figure 4.1.7: % Removal of Heavy Metals using Activated Carbon(30g)**

**Trial 9: 200 ml sample + 40 g resin;**

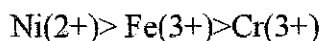


**Figure 4.1.8: % Removal of Heavy Metals using Activated Carbon(40g)**

#### 4.1.2.1 Discussion

Activated Carbon is an alternative adsorbent used for this study. **Figure 4.1.6 to Figure 4.1.9** show when further experiment being done using Activated Carbon of varying weight (10g,20g,30g 40g), the percentage removal of the heavy metals is being studied.

When using 10g,20g,30g and 40g of Activated Carbon resin, Ni(2+) and Fe(3+) resulted in 100% removal from the effluent. Cr(3+) shows significant percentage removal. When increased the weight of resin, the percentage removal of the heavy metals increased. For 10g resin used Cr(3+) is 60% removed, 20g resin;61% removed, 30g resin;70% removed and 40g resin;76% removal. The affinities of the 3 metals shows similar result as using Amberlyst 15 wet resin.



### 4.1.3 Comparison between Amberlyst 15 wet resin and Activated Carbon for Nickel, Ni(2+)

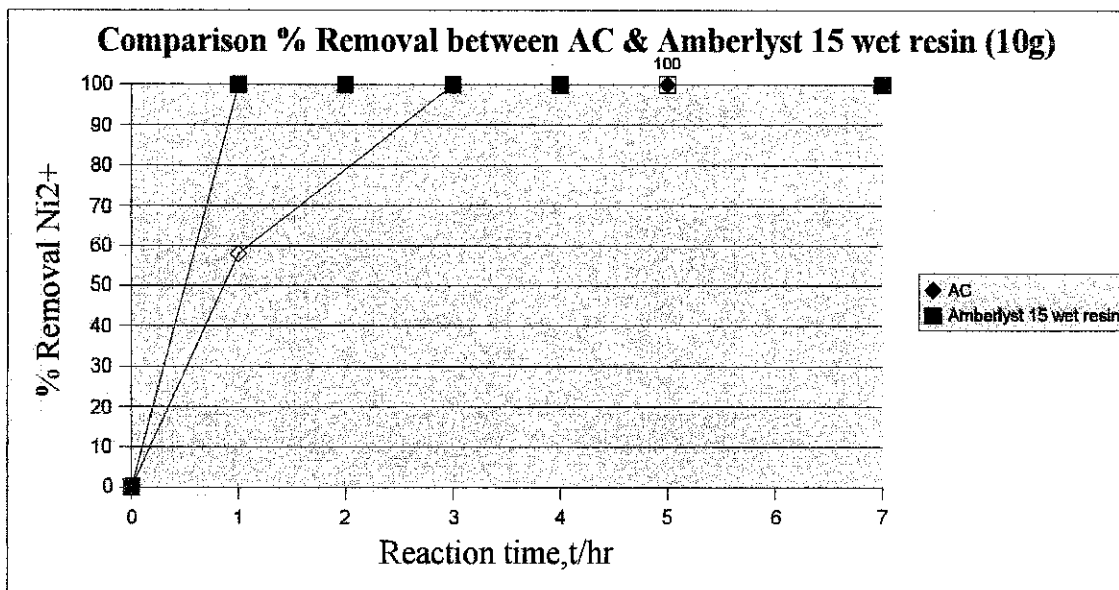


Figure 4.1.9 : Comparison between Activated Carbon & Amberlyst 15 wet resin, Ni<sup>2+</sup>(10g)

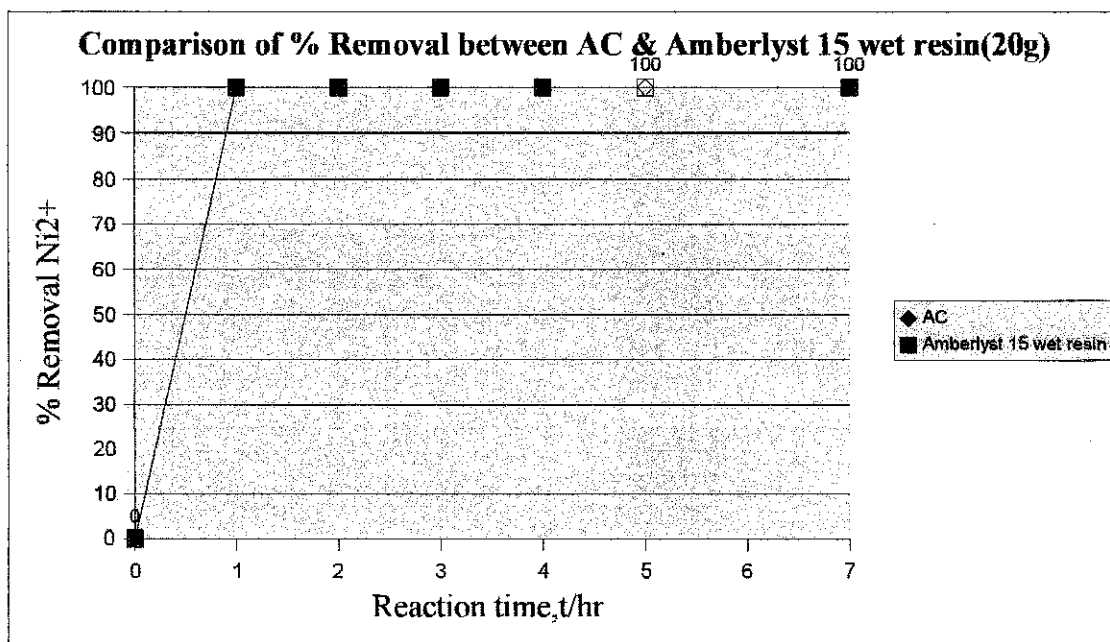
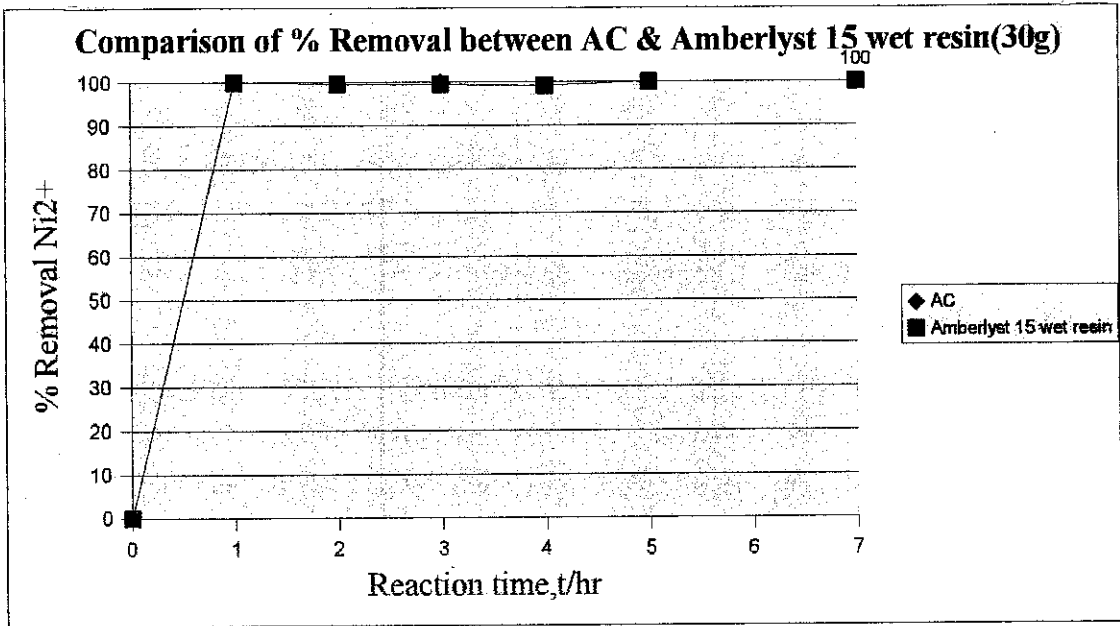
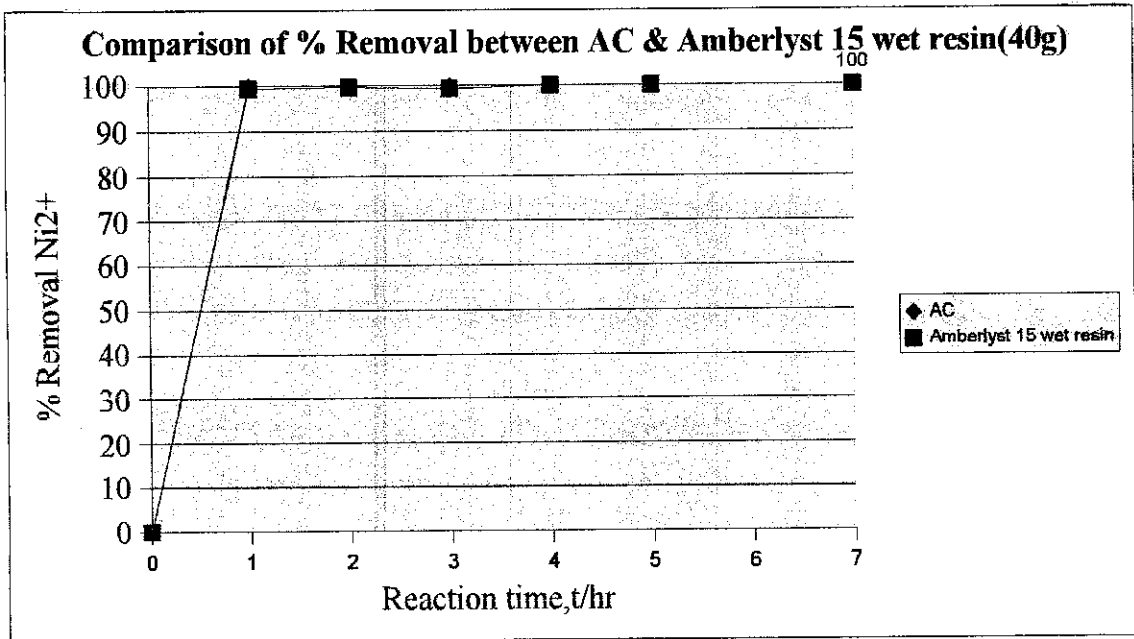


Figure 4.1.10: Comparison between Activated Carbon & Amberlyst 15 wet resin, Ni<sup>2+</sup>(20g)





**Figure 4.1.11:** Comparison between Activated Carbon & Amberlyst 15 wet resin, Ni<sup>2+</sup>(30g)



**Figure 4.1.12:** Comparison between Activated Carbon & Amberlyst 15 wet resin, Ni<sup>2+</sup>(40g)

#### 4.1.4 Comparison between Amberlyst 15 wet resin and Activated Carbon for Iron, Fe<sup>3+</sup>;

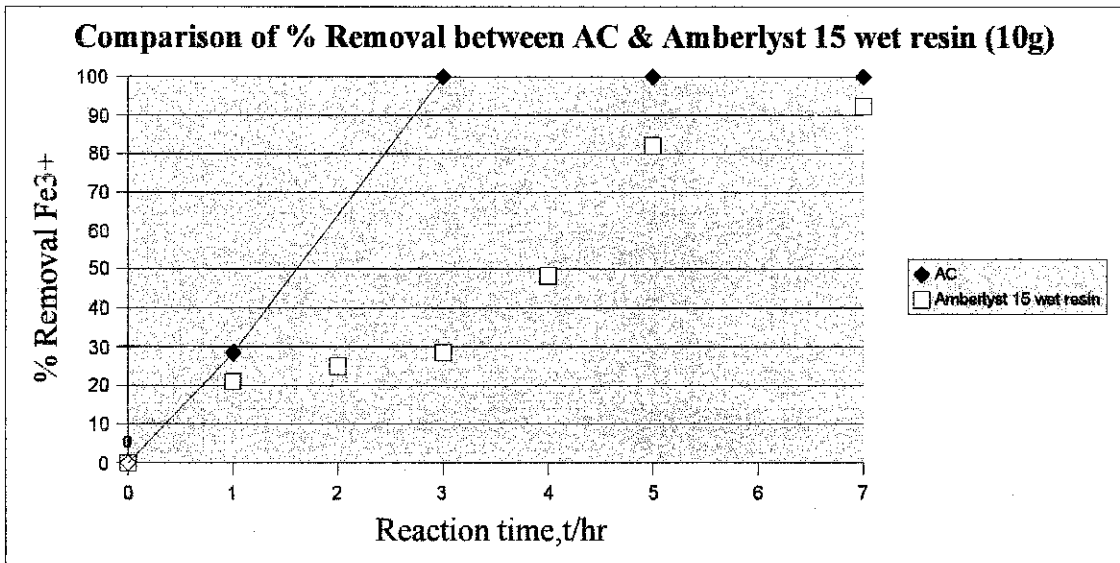


Figure 4.1.13 : Comparison between Activated Carbon & Amberlyst 15 wet resin, Fe<sup>3+</sup>(10g)

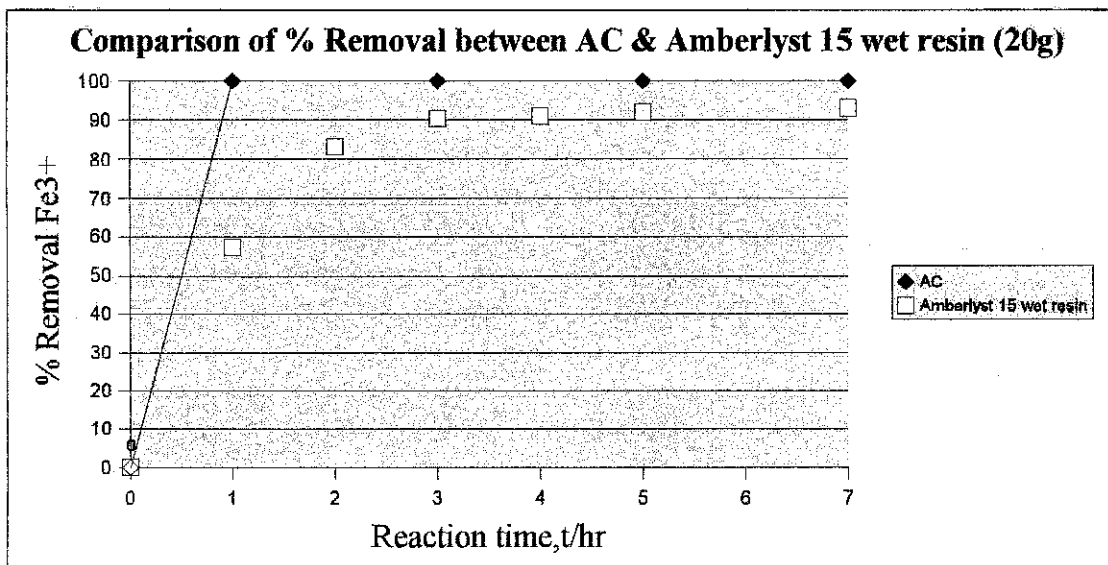
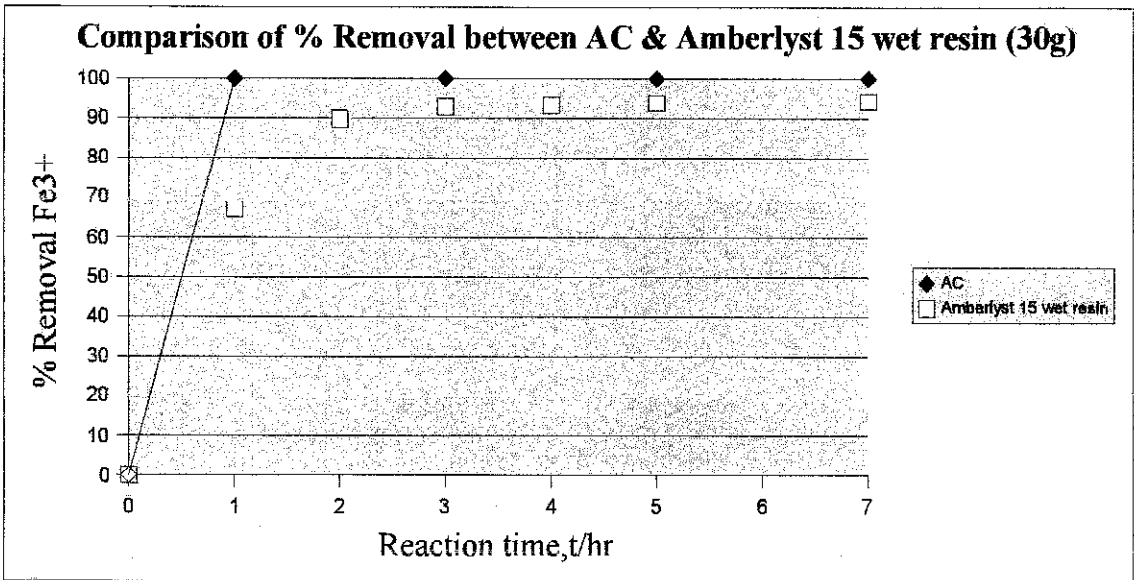
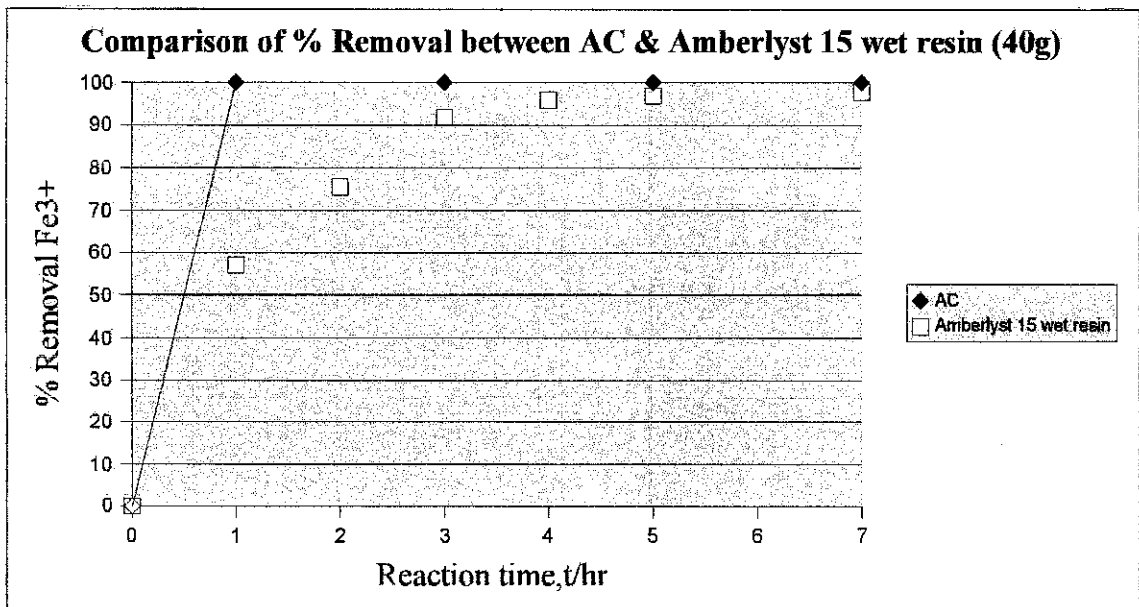


Figure 4.1.14: Comparison between Activated Carbon & Amberlyst 15 wet resin, Fe<sup>3+</sup>(20g)



**Figure 4.1.15 :** Comparison between Activated Carbon & Amberlyst 15 wet resin, Fe<sup>3+</sup>(30g)



**Figure 4.1.16:** Comparison between Activated Carbon & Amberlyst 15 wet resin, Fe<sup>3+</sup>(40g)

#### 4.1.5 Comparison between Amberlyst 15 wet resin and Activated Carbon for Chromium, Cr<sup>3+</sup>;

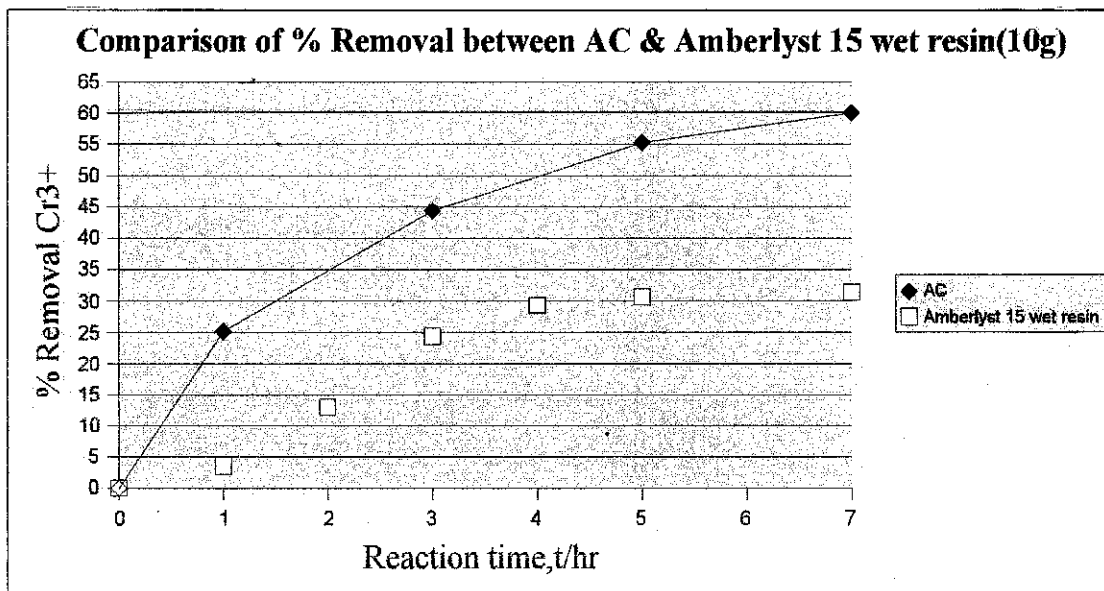


Figure 4.1.17: Comparison between Activated Carbon & Amberlyst 15 wet resin, Cr<sup>3+</sup>(10g)

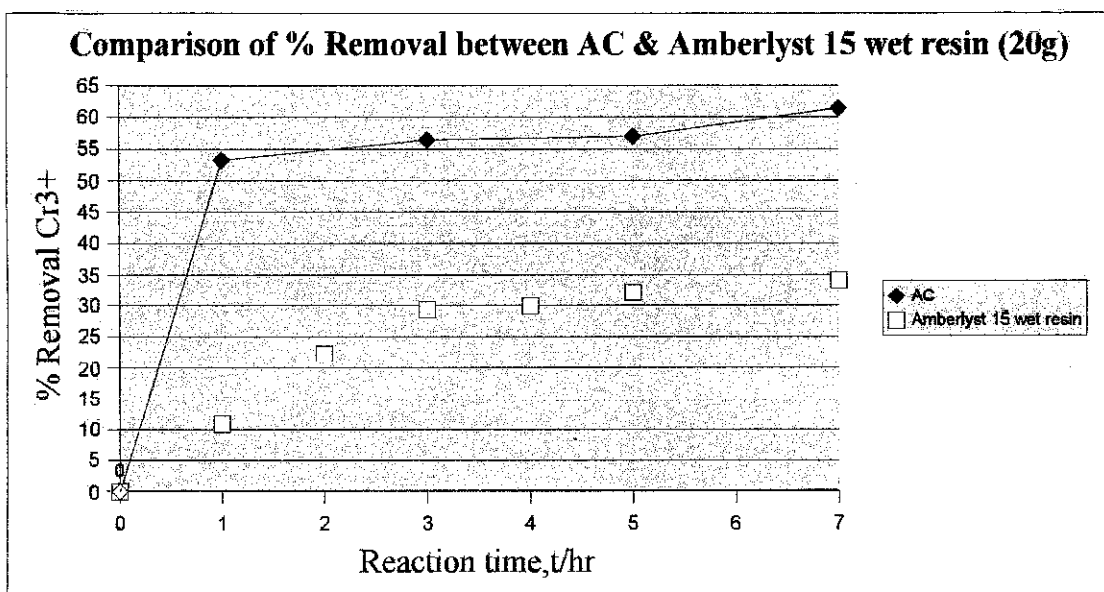
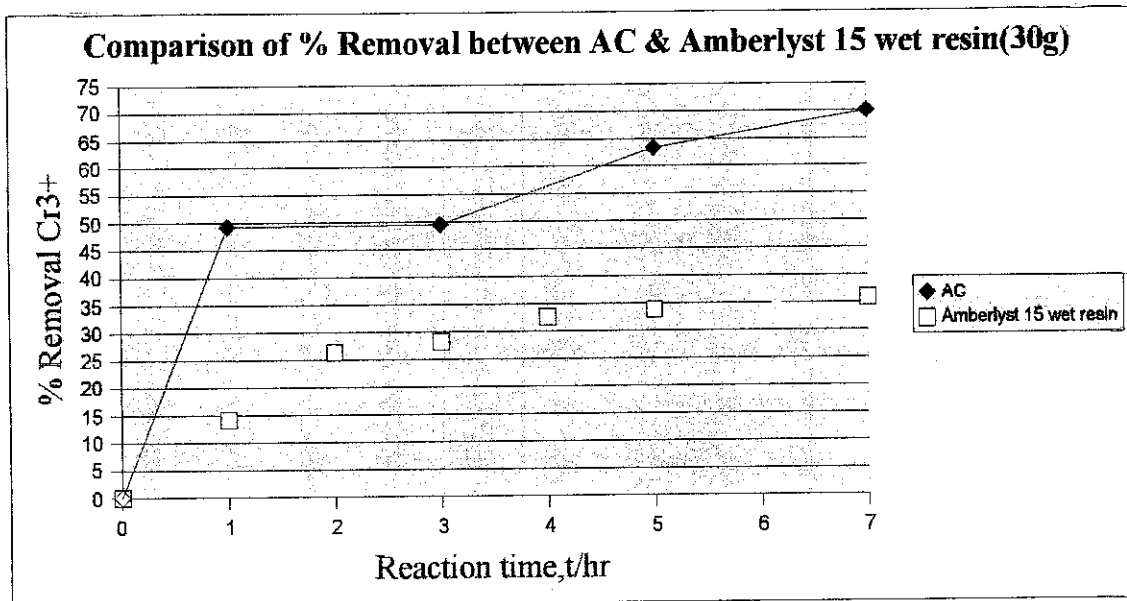
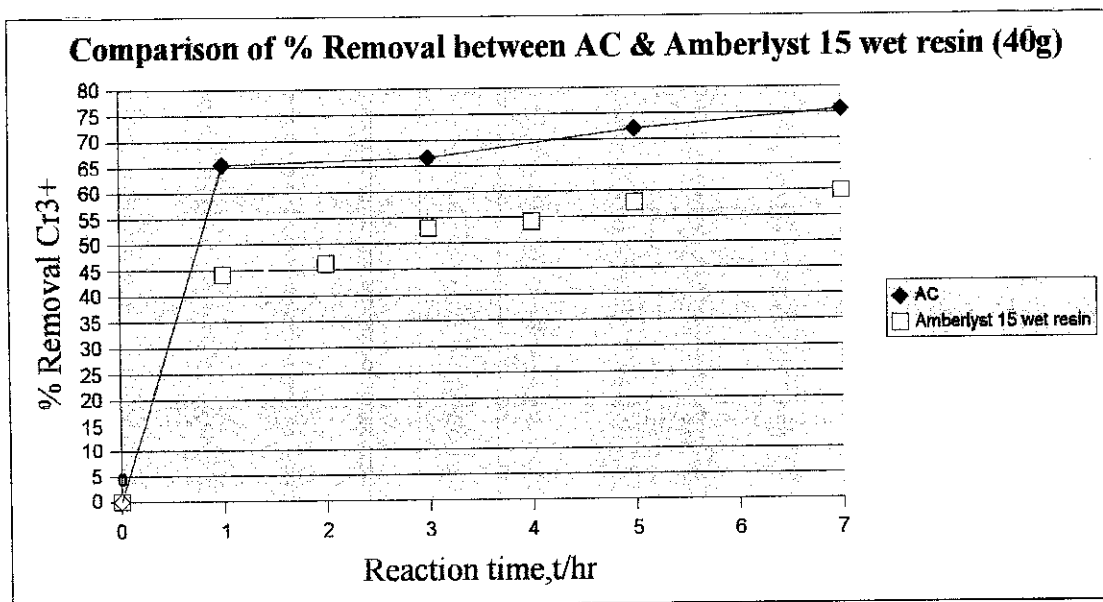


Figure 4.1.18: Comparison between Activated Carbon & Amberlyst 15 wet resin, Cr<sup>3+</sup>(20g)



**Figure 4.1.19:** Comparison between Activated Carbon & Amberlyst 15 wet resin, Cr<sup>3+</sup>(30g)



**Figure 4.1.20:** Comparison between Activated Carbon & Amberlyst 15 wet resin, Cr<sup>3+</sup>(40g)

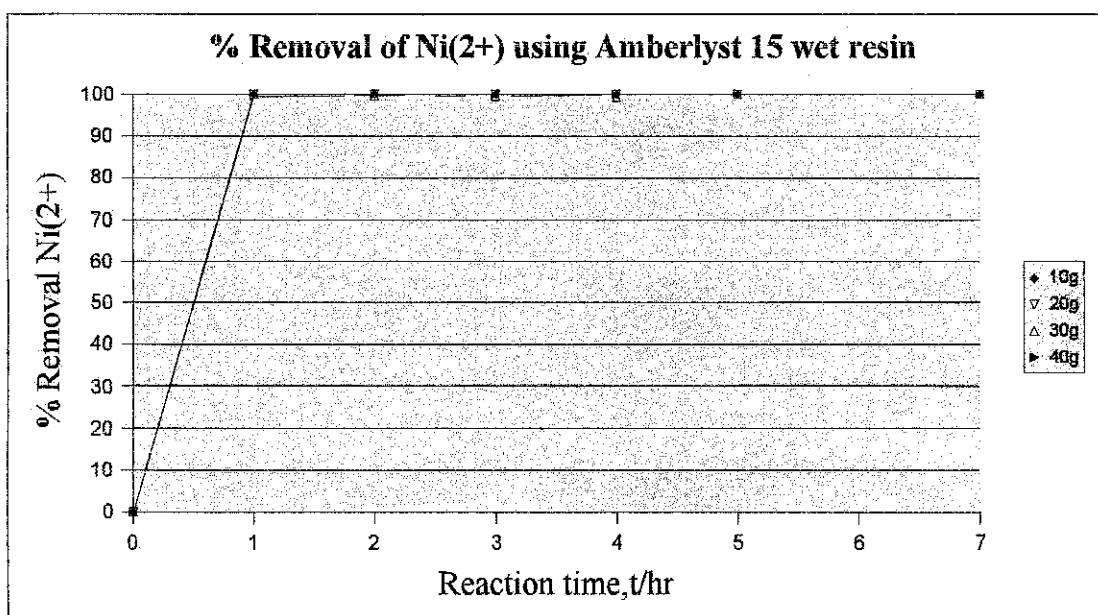
#### 4.1.2.2 Discussion

Figure 4.1.14 to 4.1.21 shown above presented the comparison of using activated carbon and Amberlyst 15 wet resin with varying weight (10g, 20g, 30g, and 40g) to treat the 200 ml effluent in 7 hours. All of the above graph shows that the heavy metals is being removed more effectively when using Activated Carbon. The percentage removal of all the three metals using Activated Carbon is higher than using Amberlyst 15 wet resin.

## 4.2 FINDINGS OF THE STUDY

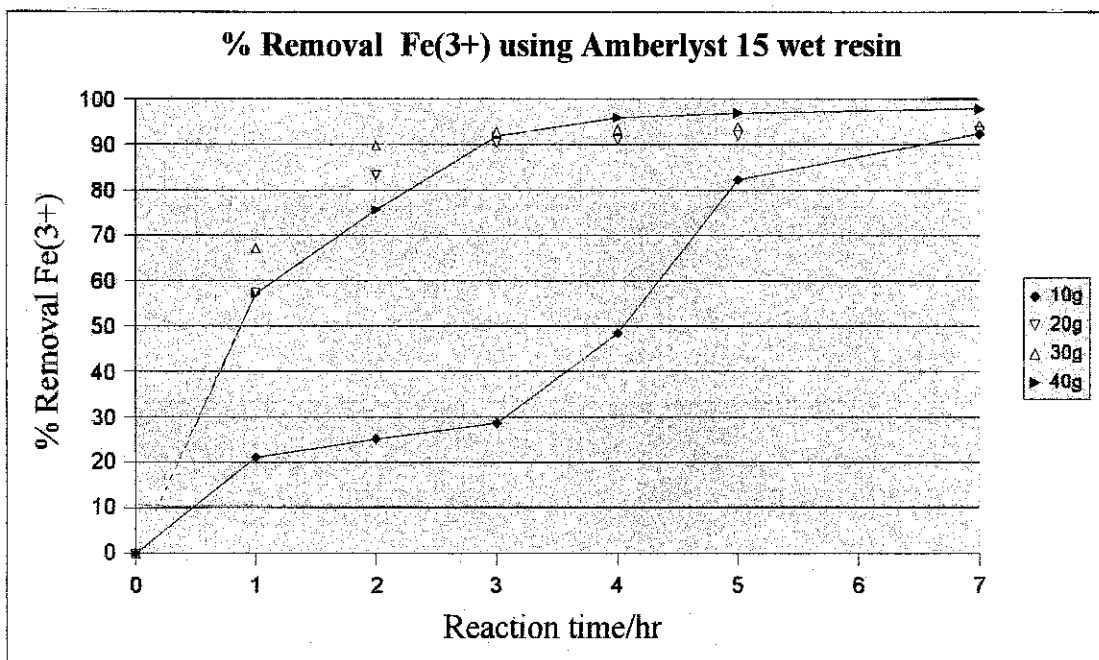
Findings indicate there are several type of resins commercially available that can be used to remove the heavy metals in the effluent which can cause adverse health effect to human and environment. Alternatives for low cost adsorbent has been the concern in treating the effluents efficaciously. Adsorption isotherm studies (T is constant) can be proved by having the graph below;

### 4.2.1 Adsorption isotherm study on Amberlyst 15 wet resin.



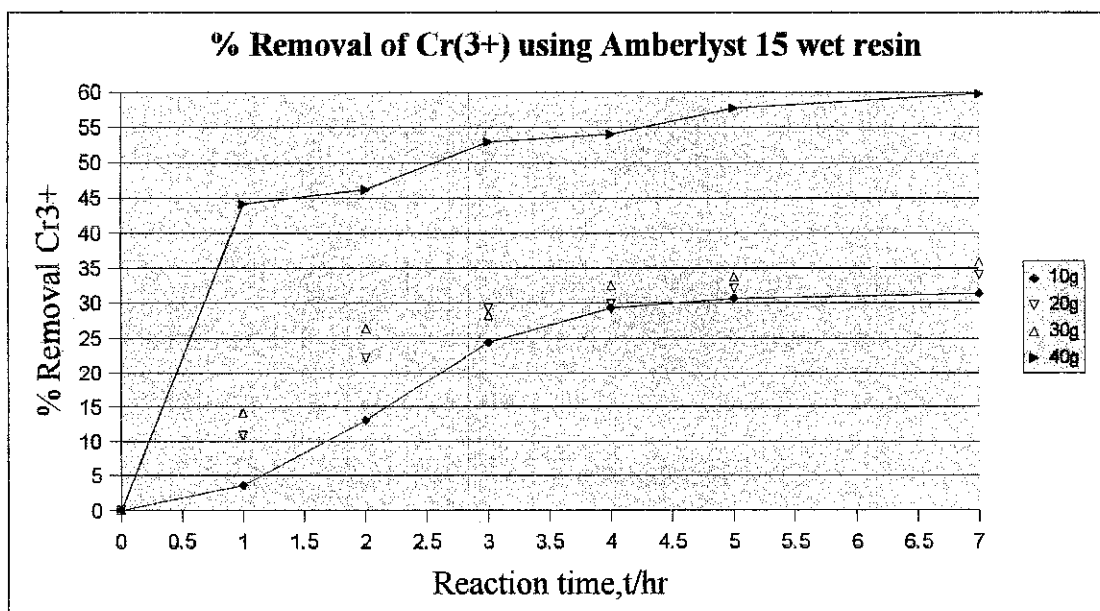
**Figure 4.2.1:** % Removal of Ni<sup>2+</sup> using Amberlyst 15 wet resin

**Figure 4.2.1** shows the 100% removal of Ni(2+) from the effluent using Amberlyst 15 wet resin.



**Figure 4.2.2:** % Removal of Fe<sup>3+</sup> using Amberlyst 15 wet resin

Figure 4.2.2 above shows using Amberlyst 15 wet resin capable of giving up to 99% removal of Fe(3+) from the effluent.



**Figure 4.2.3:** % Removal of Cr<sup>3+</sup> using Amberlyst 15 wet resin

Figure 4.2.3 shows that the highest percentage removal is 60% of Cr(3+) when using 40g of Amberlyst 15 wet resin.



#### 4.2.2 Adsorption isotherm study on Activated Carbon.

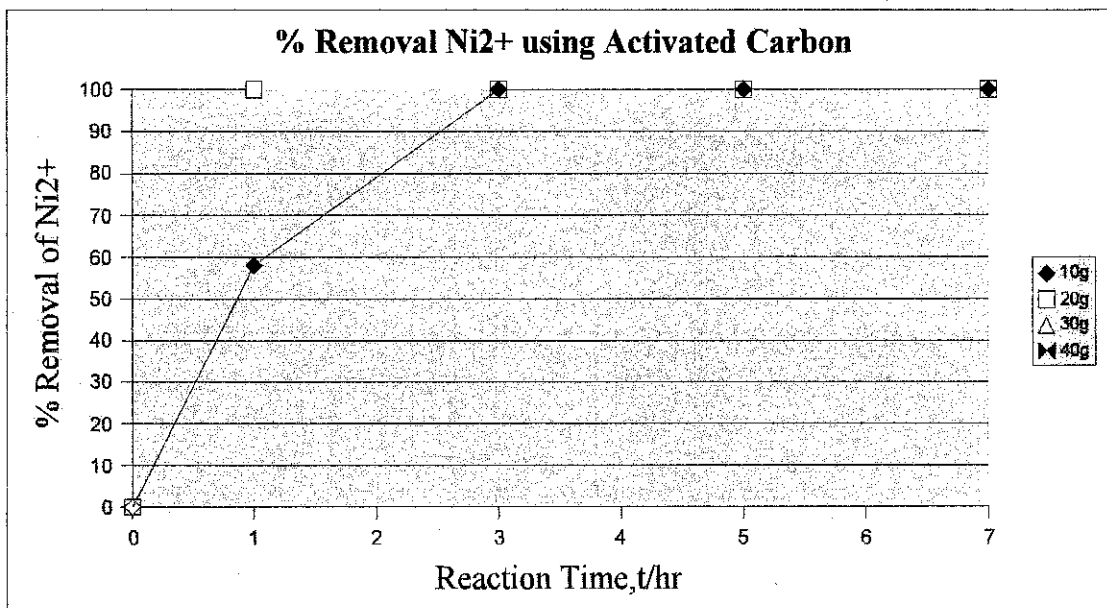


Figure 4.2.4: % Removal of Ni<sup>2+</sup> using Activated Carbon

Figure 4.2.4 shows that 100% Ni(2+) in the effluent is removed when using Activated Carbon as adsorbent.

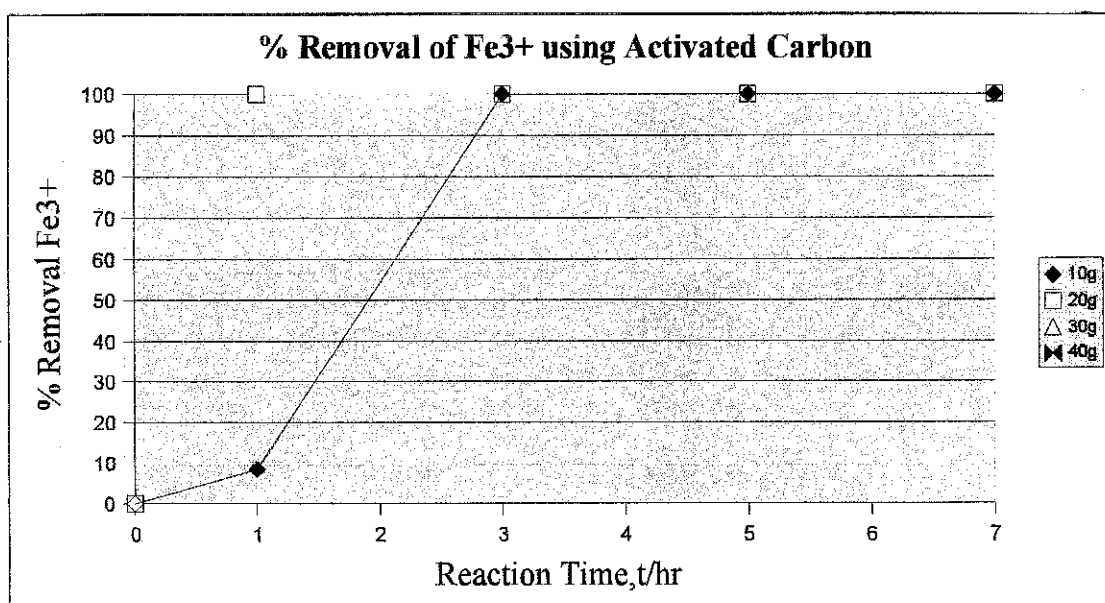
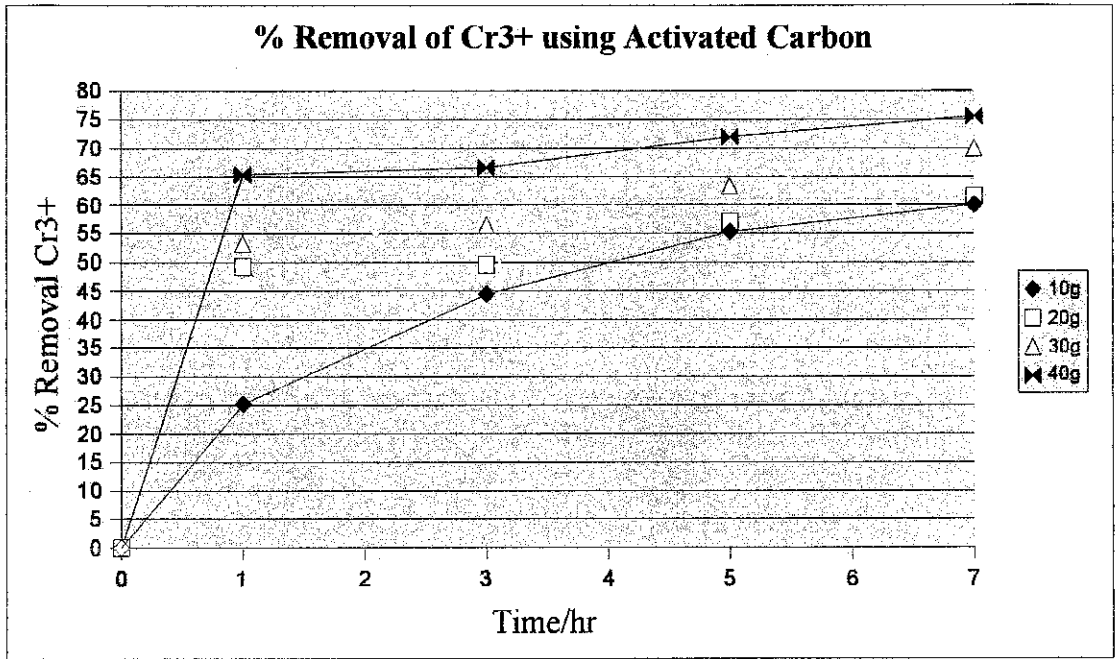


Figure 4.2.5: % Removal of Fe<sup>3+</sup> using Activated Carbon

Figure 4.2.5 shows also that 100% Fe(3+) is removed from the effluent using Activated Carbon



**Figure 4.2.6: % Removal of Cr<sup>3+</sup> using Activated Carbon**

Figure 4.2.6 shows up to 75% of Cr(3+) is removed from the effluent using Activated Carbon.

Overall, it is shown that up to 7 hours Ni(2+) and Fe(3+) shows equilibrium state. Cr(3+) shows positive increment of percentage removal for 7 hours as the amount of resin used is increased. Summary of the comparison of using both resins is shown in the table below taking 40g of resin at 7 hour as references:

	Activated Carbon	Amberlyst 15 wet resin
Ni(2+)	100%	100%
Fe(3+)	100%	97.84%
Cr(3+)	75.65%	59.81%

Table 4.2: Summary of % removal of heavy metals

## CHAPTER 5

### CONCLUSIONS

Activated Carbon	Amberlyst 15 wet resin
100% removed Ni(2+)	100% removed Ni(2+)
100% removed Fe(3+)	98% removed Fe(3+)
76% removed Cr(3+), with increased amount of AC use, all the metals may be effectively removed and AC is a low cost adsorbent to be used in the wastewater treatment.	60% removed Cr(3+), increased amount of resin use may effectively removed all the metals but is not cost efficient as ion exchange resin is expensive.

Based on the results shown in previous section, using Amberlyst 15 wet resin can successfully removed the Ni(2+) and up to 99% Fe(3+) is removed in the effluent. When using Activated carbon as the alternative resin, chromium shows more affinity to activated carbon than using Amberlyst 15 wet resin. Both ion exchange resin can removed Nickel(Ni2+) and Iron(Fe3+) in the effluents, thus abide to the EQA requirement(refer to Standard A; EQA). Affinity of the 3 metals :  
 Ni2+ > Fe3+ > Cr3+ towards both resins.

Both resins used in this study show impressive result in order to acquire the objectives of these study Thus, the study of removal of heavy metals in the effluent using ion exchange resin is relevant and accomplished within the time frame.

In conclusion, positive result from this study although experimental work seems to indicate further developments could take this process to commercialization.

## RECOMMENDATIONS

According to the literature and study that had been made until now, it could be concluded that objectives of these project which is to remove heavy metals in the effluent using ion exchange resin is relevant and possible to be achieved.

1. More experimental works(increase the weight of the resins) should be conducted to get the optimum result of removing heavy metals in the effluent.
2. Test for other type of heavy metals contaminants (Zn,Pb,Cu,Mg etc.) in the effluent to get the affinities of other type of heavy metals cation towards the ion exchange resin.
3. Test for other type of resins such as silica gel or zeolites for the study of the effective method to treat effluent.
4. Analysis for different variables such ad pH range, temperature range, varying stirring speed, and varying samples volume.
5. Conduct continuous separation process for comparison analysis.
6. Reduced human error such as wind disruption when taking the weight of the samples by using closed weighing machine.
7. Human error when transferring the samples into the test tubes so that the effluent is not contaminated by other contaminants that may intrude the result of the experiment.
8. Minimize time of doing experimental work by doing simulation program based on the batch process and calculate for the optimum value with respect to time.

## APPENDICES

### Table Result for Amberlyst 15 wet resin

#### Result for Nickel, Ni

Reaction time,t/hr	10g	20g	30g	40g
0	0	0	0	0
1	100	100	100	99.49
2	100	100	99.59	99.7
3	100	100	99.49	99.39
4	100	100	99.19	100
5	100	100	100	100
7	100	100	100	100

#### Result for Iron, Fe

Reaction time/hr	10g	20g	30g	40g
0	0	0	0	0
1	21.14	57.33	67.1	57.17
2	25.06	83.22	89.74	75.57
3	28.57	90.39	92.83	91.86
4	48.37	91.04	93.32	95.93
5	82.25	92.02	93.81	96.91
7	92.3	93.01	94.21	97.84

#### Result for Chromium, Cr

Reaction time,t/hr	10g	20g	30g	40g
0	0	0	0	0
1	3.58	10.86	14.14	44.17
2	13.03	22.22	26.37	46.21
3	24.43	29.29	28.25	52.99
4	29.29	29.91	32.52	54.06
5	30.7	32.13	33.79	57.75
7	31.4	34.1	35.87	59.81

## Table result for Activated Carbon;

### Result for Nickel,Ni

Reaction Time,t/hr	10g	20g	30g	40g
0	0	0	0	0
1	58	100	100	100
3	100	100	100	100
5	100	100	100	100
7	100	100	100	100

### Result for Iron,Fe

Reaction Time,t/hr	10g	20g	30g	40g
0	0	0	0	0
1	8,47	100	100	100
3	100	100	100	100
5	100	100	100	100
7	100	100	100	100

### Result for Chromium,Cr

Reaction time,t /hr	10g	20g	30g	40g
0	0	0	0	0
1	25.19	49.3	53.21	65.38
3	44.44	49.54	56.43	66.6
5	55.24	57.01	63.31	71.97
7	60.01	61.45	70.01	75.65



**BP PETRONAS ACETYLS SDN BHD (448334-P)**



ate: 12<sup>th</sup> May 2008

niversiti Teknologi Petronas,  
andar Seri Iskandar,  
1750 Tronoh,  
erak Darul Ridzuan,  
lalaysia

ear Sir/Madam,

**re: Waste Acid Project Meeting with BP Petronas Acetyls Sdn. Bhd.**

eferring to the above matter, BP Petronas Acetyls Sdn. Bhd is very honoured that Universiti  
eknologi Petronas(UTP) is willing to co-operate in this Waste Acid Project.

ve wish to invite you to have further discussion with our team regarding this project. Details of the  
isit are as follows:

ate : 15 May 2008  
ime : 10.00 am  
venue : KIPC Building, Kerteh

ve are looking forward to have you with us. Should you need further assistance, please do not hesitate  
o contact Asikhin/Kiki at 09-8305315(O) or 012-6515913(M).

hank You.

egards,

**MEOR SUZURUDIN SULAIMAN**

ISSE Manager

BP Petronas Acetyls Sdn. Bhd

'A BP Chemicals and PETRONAS joint venture company'

Universiti Teknologi PETRONAS  
Bandar Seri Iskandar  
31750 Tronoh  
Perak Darul Ridzuan, Malaysia.

Meor Suzurudin B. Sulaiman  
Manager,  
HSE Department,  
BP Petronas Acetyls Sdn. Bhd.  
Kompleks Pentadbiran Petrokimia,  
24300 Kertih  
Terengganu Darul Iman

23<sup>rd</sup> November 2008

Through:  
Assoc. Prof. Dr. Thanabalan Murugesan  
Final Year Project Supervisor  
Chemical Engineering Programme  
Universiti Teknologi PETRONAS  
Bandar Seri Iskandar  
31750 Tronoh  
Perak Darul Ridzuan, Malaysia.

*Supported*  
*M. D. M.*  
*25/11/08*  
*Dr. T. Murugesan*

Dear Sir,

**RE: PERMISSION TO TAKE EFFLUENTS SAMPLES and RESIN**

I'm Siti Nurul Asikhin Bte Shaaran, final year student of Universiti Teknologi PETRONAS (UTP) undergoing Bachelor of Engineering (Hons.) in Chemical Engineering. I'm now in the progress of completing my final year project.

Doing my internship at BPPA for 8 months lead me to do my final year project related to the effluents. The title of my project is which is **Removal of Heavy Metals from Effluent Using Ion Exchange Resin**. The ion exchange resin which will be used in my research is **Amberlyst 15 (Wet) Resin**. Below are the quantity i would like to take :

Chemicals	Quantity
Effluents Sample	20-30 litres
Amberlyst 15 (Wet) resin	1 bag

I hope to seek your utmost attention to this matter as i plan to take the samples from BPPA laboratory on 21<sup>st</sup> December 2008. If you have any enquiry regarding this, don't hesitate to contact me. I look forward to hearing from you soon. Thank you for your consideration.

Thank you and best regards.

*Taken CMB Resin & Sample.*  
*on 12/11/08 at 1200 hrs.*

*Rafiqi*  
RAFIQI

BPPA  
BP PETRONAS Acetyls Sdn. Bhd.  
Kompleks Pentadbiran Petrokimia PETRONAS  
24300 Kertih, Terengganu Darul Iman.



Yours sincerely,



**SITI NURUL ASIKHIN BTE SHAARAN** (Student ID : 6995)

Chemical Engineering Student,  
Chemical Engineering Department,  
Universiti Teknologi PETRONAS

Tel:012-6515913/ [asikhin.utp@gmail.com](mailto:asikhin.utp@gmail.com)

C/C:

**Assoc. Prof. Dr Anita Binti Ramli**  
Final Year Project Coordinator,  
Chemical Engineering Programme,  
Universiti Teknologi PETRONAS,  
Bandar Seri Iskandar,  
31750 Tronoh,  
Perak Darul Ridzuan,  
Malaysia.

Universiti Teknologi PETRONAS  
Bandar Seri Iskandar  
31750 Tronoh  
Perak Darul Ridzuan, Malaysia.

M. Amiruddin Mukhtar  
Lab Executive  
Chemical Engineering Department  
Universiti Teknologi PETRONAS  
Bandar Seri Iskandar  
31750 Tronoh  
Perak Darul Ridzuan.

*Approved*  
*[Signature]*

Muhammad Amiruddin b. Mukhtar  
Executive (Chemical Engineering)  
Lab Facilities & Services Unit  
Academic Central Services  
Universiti Teknologi PETRONAS

*subject to  
technician availability*

30<sup>th</sup> January 2009

Through:  
Assoc. Prof. Dr. Thanabalan Murugesan  
Final Year Project Supervisor  
Chemical Engineering Programme  
Universiti Teknologi PETRONAS  
Bandar Seri Iskandar  
31750 Tronoh  
Perak Darul Ridzuan, Malaysia.

Dear Sir,

**RE: PERMISSION TO USE LABORATORY DURING WEEKEND**

I'm Siti Nurul Asikhin Bte Shaaran, final year student of Universiti Teknologi PETRONAS (UTP) undergoing Bachelor of Engineering (Hons.) in Chemical Engineering. I'm now in the progress of completing my plant project under the supervision of AP Dr Thanabalan Murugesan. The title of my project is **Removal of Heavy Metals from Effluent Using Ion Exchange Resin.**

1. I kindly request for your permission to let me use the laboratory in Block 3, Ground floor on Saturday starting on 31<sup>st</sup> January throughout this semester.

Your cooperation is highly appreciated.

Thank you and best regards.

Yours sincerely,

*[Signature]*

Siti Nurul Asikhin bte Shaaran  
(Student ID : 6995)  
Chemical Engineering Department  
Universiti Teknologi PETRONAS

Tel: 019-7299661/  
[asikhin.utp@gmail.com](mailto:asikhin.utp@gmail.com)

Endorsed by

*[Signature]*  
20/01/09

AP Dr Thanabalan Murugesan  
Final Year Project Supervisor  
Chemical Engineering Department,  
Universiti Teknologi PETRONAS

Tel: 605-368 7620  
[murugesan@petronas.com.my](mailto:murugesan@petronas.com.my)

# Flame Atomization Analysis for Atomic Absorption Spectrometry

FYP / ETP / FYDP



sample test form 001

UNIVERSITI  
TEKNOLOGI  
PETRONAS

No.	Flame	stds. solution mg/L			Graphite	Hydride
1	Ag	1.0	2.0	4.0	Ag	-
2	Al	1.0	2.0	4.0	Al	-
3	-	-	-	-	As	-
4	Au	2.0	4.0	8.0	Au	-
5	B	200	400	800	B	-
6	Ba	2.5	5.0	10.0	Ba	-
7	Be	0.25	0.5	1.0	Be	-
8	Bi	5.0	10.0	20.0	Bi	-
9	Ca	0.5	1.0	2.0	Ca	-
10	Cd	2.0	4.0	8.0	Cd	-
11	Co	1.0	2.0	4.0	Co	-
12	Cr	1.0	2.0	4.0	Cr	-
13	Cu	1.0	2.0	4.0	Cu	-
14	Fe	1.0	2.0	4.0	Fe	-
15	Ge	10.0	20.0	40.0	Ge	-
16	-	-	-	-	-	Hg
17	In	5.0	10.0	20.0	In	-
18	K	0.25	0.5	1.0	K	-
19	Li	1.0	2.0	4.0	Li	-
20	Mg	0.1	0.2	0.4	Mg	-
21	Mn	0.5	1.0	2.0	Mn	-
22	Mo	10.0	20.0	40.0	Mo	-
23	Na	0.2	0.4	0.8	Na	-
24	Ni	1.0	2.0	4.0	Ni	-
25	Pb	4.0	8.0	16.0	Pb	-
26	Pd	2.0	4.0	8.0	Pd	-
27	Pt	10.0	20.0	40.0	Pt	-
28	Rh	2.0	4.0	8.0	Rh	-
29	Sb	5.0	10.0	20.0	Sb	-
30	Si	20.0	40.0	80.0	Si	-
31	Sn	10.0	20.0	40.0	Sn	-
32	Sr	1.0	2.0	4.0	Sr	-
33	Ti	5.0	10.0	20.0	Ti	-
34	V	10.0	20.0	40.0	V	-
35	W	100	200	400	-	-
36	Zn	0.2	0.4	0.8	Zn	-

Project: .....

Title: .....

Name: .....

i.d. ....

contact no. ....

Supervisor: .....

Name of Sample: .....

Measurement Ion: .....

No. of sample: 20 tubes  
( maximum sample : volume-5ml : 20 tubes )

Sample Measurement:-  
date:        /        / 2008  
day: .....

time:        am / pm

Standard Solution:-  
i. .... ppm  
ii. .... ppm  
iii. .... ppm

Cylinder/Oxidant Gas Pressure:-  
flame: air+C2H2   
N2O+C2H2

pressure before: .....

pressure after: .....

note:

standart solut. for tracing calibration curve

calculating:

eg:

standart solution of Cu = 1000mg/L

1 ppm of Cu in 250ml of water

M1 V1 = M2 V2

1 ppm x 250ml = 1000ppm x V2

V2 = 250 / 1000

= 0.25ml

calculating:

1                      2                      3

pto

remarks:

signature  
Project Requestor

signature  
FYP Supervisor

Chemist approved  
Tn Hj. Dr. Zakaria B. Man

t.t

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