Removal of heavy metals from aqueous solution using novel adsorbents

by

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the requirements for the
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(Chemical Engineering)

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CERTIFICATION OF APPROVAL

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ABSTRACT

Castor seed hulls are used as the novel adsorbent in this project, to adsorb nickel, from aqueous solution. Nickel is one of the many heavy metals that can be hazardous to human health. Nickels are found in many rivers nearby industrial area such as in China and India. In order to save the environment and to prevent the pollution from getting worse, many studies have been conducted to study on ways of removing nickel from the rivers. In this project, the adsorption technique was applied, and the adsorbent used are castor seed hulls. The usage of castor seed hulls was because of its low operating cost, high efficiency, and minimum amount of sludge to be disposed. This project tested the effect of initial concentration for the amount of Ni ions sorbed. The equilibrium sorption was studied using two widely used isotherm models i.e. Langmuir and Freundlich isotherm models. The results from isotherm models showed that the process of sorption of castor seed hulls occurred on a homogenous surface of the castor seed hulls. The highest percentage removal of nickel ion from the solution is at the initial concentration of 5ppm and dosage of 0.2g.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Heavy metals in aqueous solutions have been causing much problem to human beings. This water pollution caused by heavy metals is the result of rapid development of industry. There are a lot of heavy metals that can pose risks to human health, such as cobalt, copper, nickel, chromium and zinc.

The removal of heavy metals from aqueous solutions can be done in many ways such as using electro-chemical precipitation, ultrafiltration, ion exchange, and reverse osmosis [1]. However, there are a few issues with the said methods, for example, precipitation will cause sludge production and ion exchange is not economically appealing because of its high operational costs [2].

Another alternative for removing these heavy metals from aqueous solutions is by adsorption on agricultural waste. Abundant waste materials (or products) from industrial and agricultural activities may be a potentially inexpensive alternative for heavy metal removal [3]. In recent years, several agricultural wastes have been tested for their heavy metals removal efficiency from simulated wastewaters. Examples of agricultural wastes that have been used to remove heavy metals from aqueous solutions are sugarcane bagasse, Jatropha oil cake and maize corncobs.

In this study, using heavy metals were removed from aqueous solutions via adsorption using agricultural waste. The metal of interest was nickel, and the adsorption material was castor seed hulls.

1.2 PROBLEM STATEMENT

Heavy metals have been polluting our rivers caused by industrial and agricultural development. Many studies have been conducted to evaluate the most feasible and effective way of removing these metals. Using adsorption of agricultural waste to remove the heavy metals is one of the alternatives. In this study, the usage of agricultural waste to remove heavy metals from aqueous solutions was used. The agricultural waste used was castor seed hulls and the heavy metal to be removed was nickel.

1.3 SIGNIFICANCE OF THE PROJECT

1.3.1 Objective and Scope of Study

The objective of the study was to remove heavy metals (nickel) from aqueous solution using castor seed hulls. The removal of heavy metals using agricultural waste is also to be studied if this method is more economically feasible and environmentally friendly.

The scope of study was to use castor seed hulls as the adsorbent to adsorb heavy metal (nickel) from aqueous solutions. The study was carried out based on the effect of initial concentration, and dosage.

1.3.2 Relevancy of the Project

The project's aim to remove heavy metals from aqueous solution using novel adsorbents, i.e. castor seed hulls are in line with the current concerns of environmental issues. Nickel is one of the most hazardous metals that can be found in aqueous solutions.

1.3.3 Feasibility of the Project

The time frame of this project is sufficient in order to complete the project. However, breakdowns of equipments needed to be use might delay the potential time frame and could cause the project to stall.

CHAPTER 2

LITERATURE REVIEW

2.1 DANGERS OF HEAVY METALS

At least 20 metals are classified as toxic and half of these metals are emitted into the environment in quantities that pose risks to human health. Heavy metals can be accumulated by living orgasms such as vegetables, hydrophytes and aquatic inhabitants, which are finally enriched by human beings through food chains. Examples of significant events that are caused by heavy metals pollutions are poisonous rice with high concentration of cadmium in Taiwan Province of China (Chen and Liu, 2006), drinking water containing arsenic in Bengal (Mukherjee et al., 2007) and high concentration of lead in human blood in Gansu Province of China (Wang and Zhang, 2006).

2.2 REMOVAL OF HEAVY METALS USING BIOMATERIALS AND AGRICULTURAL WASTES

Scientists are paying much attention to searching the substitutable materials, which can enhance the removal efficiency and reduce the treatment cost (Eccles, 1999; Liu et al., 2007). Many new materials have been reported to be able to remove cadmium from water system, such as white-rot fungus (Arica et al., 2001), dead biomass (Cruz et al., 2004; Zhou et al., 2007), rice or wheat milling byproducts (Tarley and Arruda, 2004;

Gao et al., 2007), brown seaweed biomass (Vanela and Verma, 2006), chitin (Benguella and Benaissa, 2002) and so on.

These biomaterials and agricultural wastes are of low cost, or even the waste from industrial or agricultural byproducts. Compared with the conventional methods, the biosorption process has its superiorities, due to its low operating cost, high efficiency and minimized amount of sludge to be disposed of (Kratochvil and Volesky, 1998; Naja and Volesky, 2006).

Natural materials that are available in large quantities or certain waste from agricultural operations may be potential to be used as low cost adsorbents, as they represent unused resources, widely available and are environmentally friendly [4].

2.3 METALS OF INTEREST

2.3.1 Nickel

Nickel is a silvery white metal that takes on a high polish. It belongs to the transition metals and is hard and ductile. Nickel is a very reactive element but is slow in air at normal temperatures and pressures, similar to chromium. The most common oxidation state for nickel is +2 although 0, +1, +3 and +4 are observed.

2.4 USES OF CHROMIUM AND NICKEL

Nickel has a wide range of applications. Below are examples of nickel uses:

- Nickel is used for plating and as a green tint in glass.
- Raney nickel is usually used in the lab to act as a catalyst for hydrogenation.
- Nickel (III) oxide is used as the cathode in many rechargeable batteries.
- Nickel is used in coinage and for armor plating.
- Nickel and its alloys are used as an essential element in chemical and aerospace industries for its heat resistance and a combination of high-melting point, a face-centered cubic crystal structure, an adherent oxide and good alloying ability.

2.5 EFFECTS OF CHROMIUM AND NICKEL

2.5.1 Health Effects

Nickel can be found in drinking water, air and food. Similar with other heavy metals, uptakes of nickel are hazardous to the human health. The effects of high uptakes of nickel may cause lung cancer, prostate cancer, larynx cancer and nose cancer. It may also cause respiratory failure, birth defects, asthma, chronic bronchitis, skin rash and heart disorder.

The most common effect of nickel to human beings is an allergic reaction. 10-20% of human population is allergic to nickel. A brief skin contact with nickel, i.e. when wearing jewellery can cause skin irritation to the wearer. In some people who have skin eczema, the effect of skin irritation may not be at the place where the contact happens. In fact, the allergy may develop in area where the skin is away from the site of contact.

It has also been found that the effect of nickel is much sensitive to women than men due to women are more exposed to skin contact with nickel by wearing jewellery.

2.5.2 Environmental Effects

Nickel compound is released to the environment mainly from power plants and trash incinerators. The release of nickel to the air will eventually settle on the ground. The period of time for nickel to settle to the ground is usually long. Nickel that has settled on the ground will then enter the soil. As a result, the soil particles will become immobile. High nickel concentrations of nickel in the soil will cause damage to plants while high concentration of nickel in the water will diminish the growing rate of algae. Although nickel is essential for normal growth and reproduction of some animals, the excess amount of it can cause cancer on different part of their body.

2.6 EQUILIBRIUM ADSORPTION ISOTHERM

The purpose of adsorption isotherm experiment is to relate the adsorbate concentration in the bulk and the adsorbed amount at the interface [5]. The simplest adsorption isotherm is based on the assumptions that every adsorption site is equivalent and the ability of a particle to bind is independent of whether or not adjacent sites are occupied [6].

In order to study the adsorption isotherm of Nickel Solution on Castor Seed Hulls, two equilibrium isotherm models, Langmuir and Freundlich isotherms were employed [7].

2.6.1 Langmuir Isotherm Model

The monolayer of coverage of the sorbate on the sorbent surface is represented by Langmuir Isotherm Model. The consideration behind the Langmuir Isotherm is that sorption is a chemically equilibrated phenomenon [7]. There are four basic assumptions made from the Langmuir Isotherm Model:

1. The surface of adsorbent is uniform, that is, all the adsorption sites are equivalent.
2. Adsorbed molecules do not interact.
3. All adsorption occurs through the same mechanism.
4. At the maximum adsorption, only a monolayer is formed: molecules of adsorbate do not deposit on other already adsorbed molecules of adsorbate. Only on the free surface of the adsorbent.

The Langmuir Isotherm Model is represented in the equation below:

$$Q_e = \frac{KC_e}{1 + Q_L C_E}$$

The linearized Langmuir Isotherm Model is represented in this equation:

$$\frac{C_E}{Q_E} = \frac{1}{KQ_M} + \left[\frac{1}{Q_M}\right] C_E$$

Where,

Q_E = Amount of metal ions sorbed per unit mass of sorbent (mg/g)

C_E = Concentration of sorbate at equilibrium

Q_M = Theoritical adsorption monolayer capacity

K = Adsorption equilibrium constant

The monolayer coverage can be obtained from a plot of C_E/Q_E versus C_E, which should give a straight line. The slope and intercept of this line gives the value of K and Q_M.

2.6.2 Freundlich Isotherm Model

The Freundlich Isotherm Model is purely an empirical isotherm with no theoretical basis and its validity extends to non-uniformity of the adsorption surfaces [8].

The linearized form of the isotherm is represented in the following equation:

$$\ln Q_E = \ln K_f + \frac{1}{n}\ln C_E$$

Where,

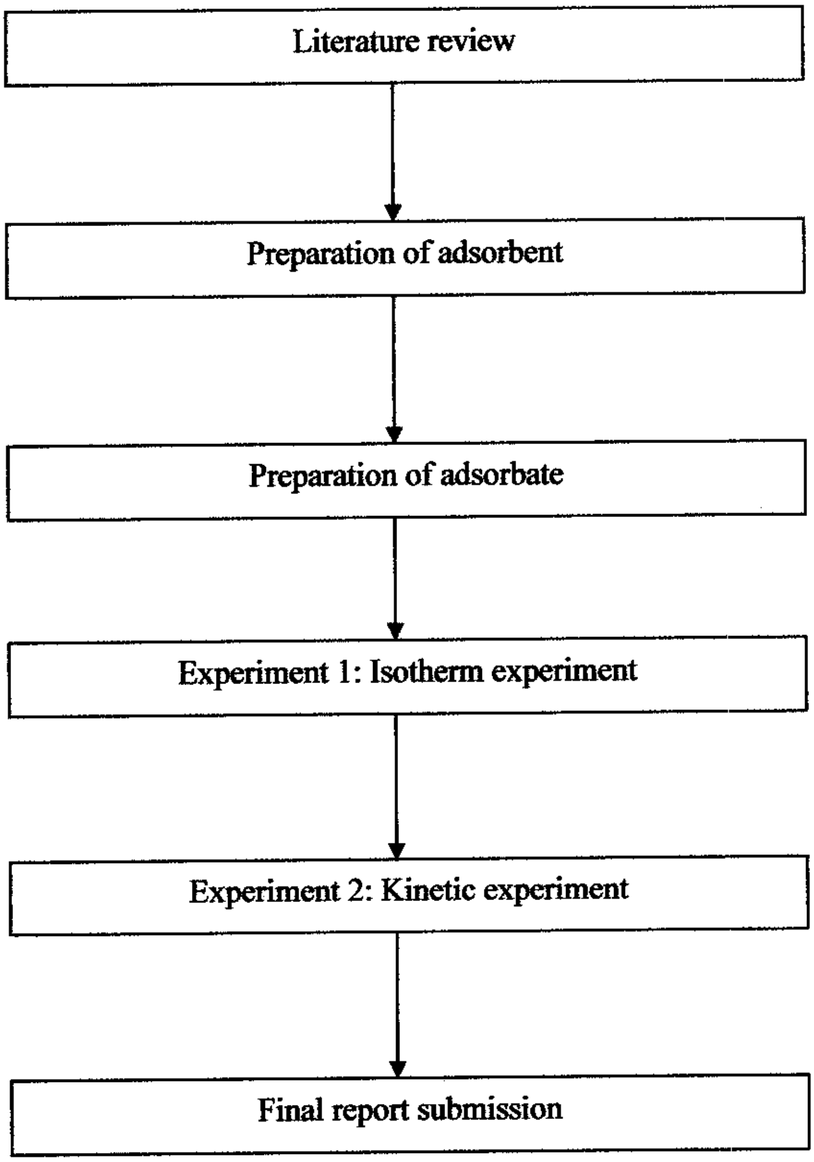
K_f and n = Freundlich coefficients.

The values of K_f and n can be obtained from the plots of ln Q_E versus ln C_E.

CHAPTER 3

METHODOLOGY

3.1 PROCEDURE IDENTIFICATION



3.2 PROJECT ACTIVITIES

3.2.1 Sorbent Preparation

The castor seed hulls were washed with distilled water, dried, grounded and sieved. The particle sizes employed for the sorbent is 118 μm. The grounded and sieved powder was kept in an airtight plastic container pending usage.

3.2.2 Sorbate Preparation

Nickel ion is used as the model sorbate in this experiment. A stock solution of Nickel sorbate of 1 M was prepared by dissolving 4.9530 g of nickel nitrate (Ni $(NO_3)_2.6H_2O$) in 1 litre of distilled water. The experimental solutions were prepared by diluting the stock solution with distilled water to give the appropriate concentration for respective experimental solutions.

3.2.3 Kinetic Studies

3.2.3.1 Effect of Initial Concentration

The effect of initial concentration of Nickel ion was studied using a range of Nickel ion concentrations of between 5-50 mg/L. A typical experimental procedure was conducted by measuring 100 mL of Nickel solution, followed by the addition of 0.1 g of castor seed hulls and the mixture was agitated at 160 rpm for 1,2,4,6 and 7 hours. The experiment was carried out at room temperature (25°C). Samples were withdrawn at fixed time intervals and analysed for residual Nickel ion using Atomic Adsorption Spectrophotometry (AAS). The amount of Nickel ion sorbed per unit mass of the castor seed hulls (Q_E, in mg/g) using the equation expressed below:

$$Q_E = \frac{C_i - C_E}{m} \times V$$

Where,

C_i = Initial concentration of sorbate (mg/L)

C_E = Final concentration of sorbate (mg/L)

m = Mass of sorbent (g)

V = Volume of sorbate (L)

3.3 TOOLS REQUIRED

In conducting the experiment, there are a few apparatuses that are needed to be used. They are:

1. Sample bottles,
2. Filter syringe,
3. Pipette,
4. Spatula,
5. Beaker,
6. Volumetric flasks,
7. Conical flask,

8. Burette,
9. Glove,
10. Tissue,
11. Funnel,
12. Filter paper,
13. Measuring cylinder, and
14. Test tubes.

CHAPTER 4

RESULTS AND DISCUSSION

For nickel solution adsorbate, 0.1 g of castor seed hulls was mixed together with 5, 10, 20, 30 and 50 ppm of nickel solution respectively. Each of the solution was mixed for 1, 2, 4, 6 and 7 hours, at room temperature and at pH of 5.

After the mixing hour ended, the solutions were carefully filtered in order to get the mixed solution which was free of adsorbent. Filtration was done by using filter paper.

The filtered solutions were then analyzed for the concentration of nickel using AAS. The results for the analysis are shown in Table 4.1:

Table 4.1 Data of nickel solution analysis

Sample no.	Initial Concentration, Ci (mg/L)	Mass of Adsorbent, m (g)	Volume of Adsorbate, V (L)	Contact Time, (hours)	Final Concentration, Ce (mg/L)
1	2.46	0.1	0.096	1	1.79
2	2.46	0.1	0.096	2	1.67
3	2.46	0.1	0.096	4	1.67
4	2.46	0.1	0.096	6	1.55
5	2.46	0.1	0.096	7	1.44
6	5.71	0.1	0.098	1	5.2
7	5.71	0.1	0.098	2	5.16
8	5.71	0.1	0.098	4	4.56

9	5.71	0.1	0.098	6	4.54
10	5.71	0.1	0.098	7	4.47
11	11.58	0.1	0.098	1	10.31
12	11.58	0.1	0.098	2	10.27
13	11.58	0.1	0.098	4	10
14	11.58	0.1	0.098	6	9.89
15	11.58	0.1	0.098	7	9.35
16	16.07	0.1	0.098	1	15.02
17	16.07	0.1	0.098	2	14.98
18	16.07	0.1	0.098	4	14.68
19	16.07	0.1	0.098	6	14.59
20	16.07	0.1	0.098	7	13.93
21	19.73	0.1	0.098	1	18.83
22	19.73	0.1	0.098	2	18.31
23	19.73	0.1	0.098	4	18.29
24	19.73	0.1	0.098	6	18.2
25	19.73	0.1	0.098	7	17.95

4.1 ISOTHERM STUDIES

4.1.1 Langmuir Model

The first isotherm model conducted is Langmuir Isotherm Model. Based on linearized Langmuir Isotherm equation,

$$\frac{C_E}{Q_E} = \frac{1}{KQ_M} + \left[\frac{1}{Q_M}\right] C_E$$

A plot of C_E/Q_E versus C_E is constructed to obtain the values of K and Q_M.

Data for constructing the plot is tabulated in Table 4.2.

Table 4.2: Data for Langmuir Isotherm Model Plot

Sample no.	**Initial Concentration, Ci (mg/L)**	**Mass of Adsorbent, m (g)**	**Volume of Adsorbate, V (L)**	**Contact Time, (hours)**	**Final Concentration, Ce (mg/L)**	**Amount of Metal Ions Sorbed per unit mass of Adsorbent, Qe (mg/g)**	**Ce/Qe**
5	2.46	0.1	0.096	7	1.44	0.98	1.47
10	5.71	0.1	0.098	7	4.47	1.22	3.68
15	11.58	0.1	0.098	7	9.35	2.19	4.28
20	16.07	0.1	0.098	7	13.93	2.10	6.64
25	19.73	0.1	0.098	7	17.95	1.74	10.29

The Langmuir Isotherm Model plot is shown in Figure 4.1.

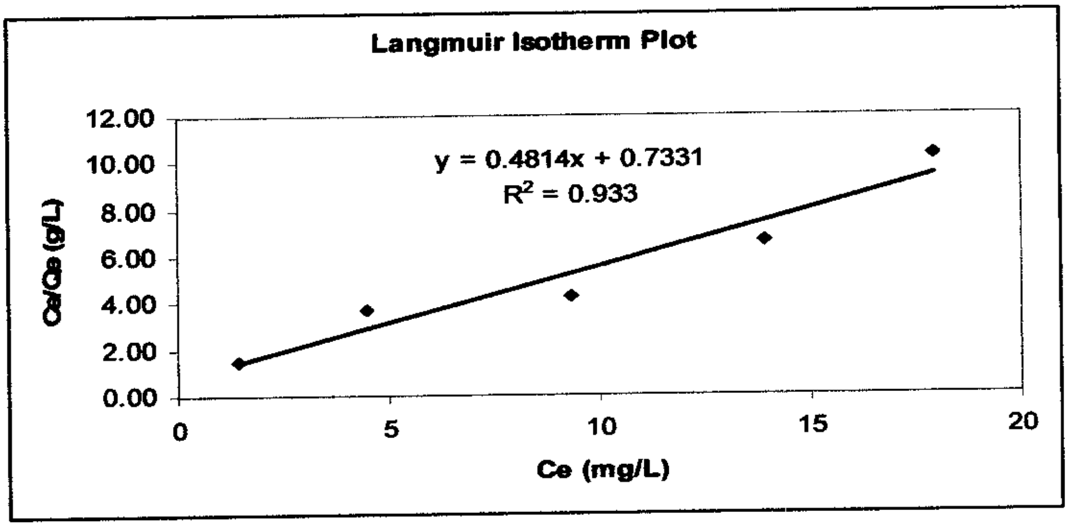


Figure 4.1: Plot of C_E/Q_E versus C_E

The values of K and Q_M are tabulated in the **Table 4.3**. The values are obtained from the equation $y = 0.0717x + 0.0046$, from the plotted graph.

Table 4.3: Langmuir Isotherm values

Langmuir Isotherm	**Values**
Slope, 1/Q_m	0.4814
Q_m	2.0773
y-intercept, 1/KQ_m	0.7331
K	0.6567
R^2	0.9330

4.1.2 Freundlich Isotherm Model

The second isotherm model used in this experiment is the Freundlich Isotherm Model. The linearized equation for the model is expressed below:

$$\ln Q_E = \ln K_f + \frac{1}{n} \ln C_E$$

A plot of *ln* Q_E versus *ln* C_E is constructed in order to obtain the values of K_f and *n*.

Data of the Freundlich Isotherm plot is tabulated in the Table 4.4:

Table 4.4: Data for Freundlich Isotherm Model Plot

Sample No.	**Initial Concentration, Ci (mg/L)**	**Mass of Adsorbent, m (g)**	**Volume of Adsorbate, V (L)**	**Contact Time, (hours)**	**Final Concentration, Ce (mg/L)**	**Amount of Metal Ions Sorbed per unit mass of Adsorbent, Qe (mg/g)**	**Percentage Removal of Ni ions (%)**	**ln Qe**	**ln Ce**
5	2.46	0.1	0.096	7	1.44	0.979	-0.02	0.36	5
10	5.71	0.1	0.098	7	4.47	1.215	0.19	1.50	10
15	11.58	0.1	0.098	7	9.35	2.185	0.78	2.24	15
20	16.07	0.1	0.098	7	13.93	2.097	0.74	2.63	20
25	19.73	0.1	0.098	7	17.95	1.744	0.56	2.89	25

The Freundlich Isotherm Model plot is shown in Figure 4.2:

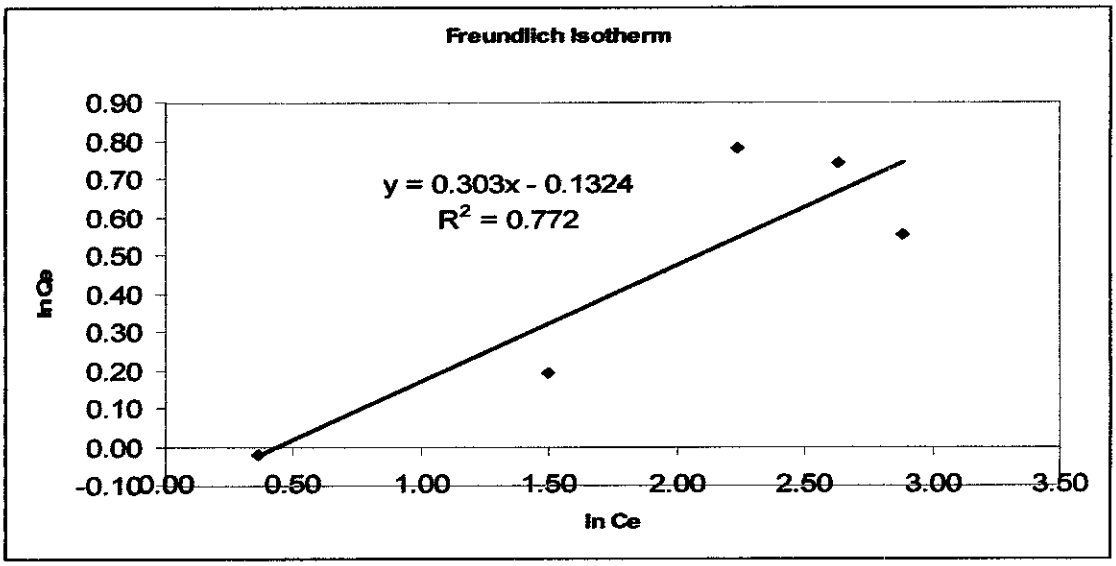


Figure 4.2: Plot of ln Qe versus ln Ce

The values of K_f and n are tabulated in the **Table 4.5.** The values are obtained from the equation $y = 0.4141x + 2.8916$, from the plotted graph.

Table 4.5: Freundlich Isotherm Values

Freundlich Isotherm	**Values**
Slope, 1/n	0.3030
n	3.3003
y-intercept, ln K_f	-0.1324
K_f	0.8760
R^2	0.772

The results obtained showed that the adsorption obeys the Langmuir model. The results from both plots are presented in Table 4.6:

Table 4.6: Slope, y-intercept and R^2 for Langmuir and Freundlich models

Model	Parameters		
	slope	**y-intercept**	**R^2**
Langmuir	0.4814	0.7331	0.9330
Freundlich	0.3030	-0.1324	0.772

Since the calculated correlation coefficients are consistent and closer to unity for Langmuir Isotherm, therefore, the adsorption isotherm could be well explained and approximated more favorably by Langmuir Isotherm model for castor seed hulls adsorbent.

Other important parameters from Langmuir Model are represented in the Table 4.7.

Table 4.7: Langmuir isotherm parameters and values

Model	Parameters	Values
Langmuir	$1/Q_m$ (theoritical monolayer adsorption capacity)	0.4814
	Q_m	2.0773
	K (adsorption equilibrium)	0.6567

4.2 KINETICS STUDIES

4.2.1 Effect of Initial Concentration

The initial concentration of the nickel solution was varied between 5 and 50 mg/L at a fixed sorbent dosage (0.1g/98 mL), agitation speed (160 rpm) at room temperature. The amount of castor seed hulls sorbed varied with its initial concentration at different contact time.

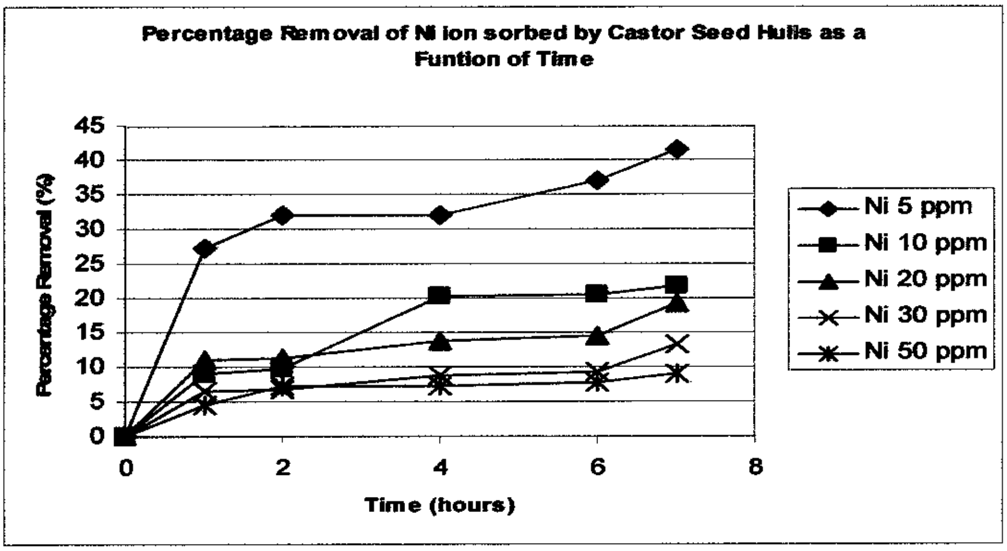


Figure 4.3: Percentage removal of Ni ion sorbed by castor seed hulls as a function of time

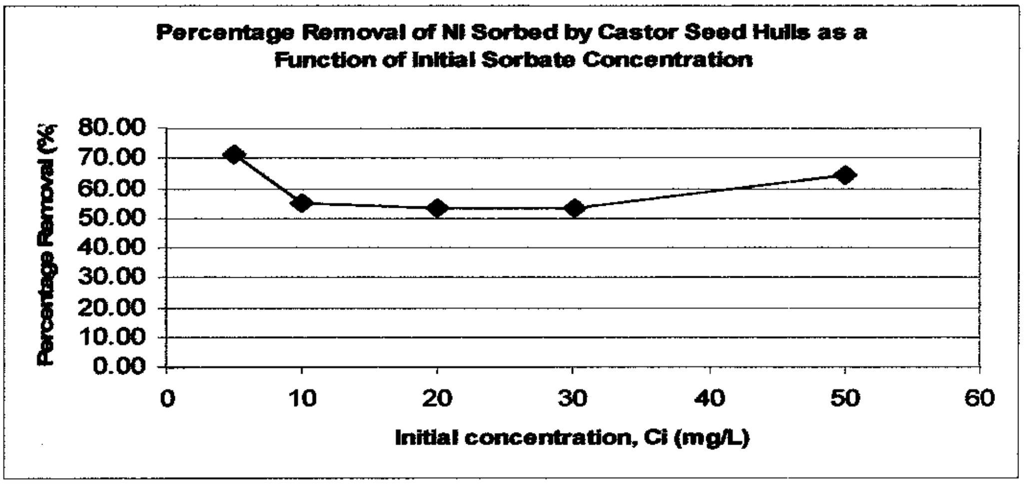


Figure 4.4: Percentage removal of Ni ion sorbed by castor seed hulls as a function of initial sorbate concentration

Based on Figure 4.3, it shows that the amount of Nickel ion sorbed increases with time. The amount of Nickel ion sorbed nearly reached equilibrium at fourth to fifth hours of contact time. Highest amount of Nickel ion sorbed by castor seed hulls is when the initial concentration is 5 ppm. Based on this observation, 5 ppm of initial concentration is identified as the optimum initial concentration for Ni ion adsorption by castor seed hulls.

From Figure 4.4, the percentage removal of Nickel is also the highest at initial concentration of 5 ppm. This shows that, at lower initial concentration, the amount of Nickel removed from the solution is higher.

4.2.2 Effect of Dosage

The dosage of castor seed hulls was varied between 0.2 and 1.0 g at a fixed initial concentration of 30 ppm, agitation speed (160 rpm) at room temperature. The amount of castor seed hulls sorbed varied with its dosage at different contact time.

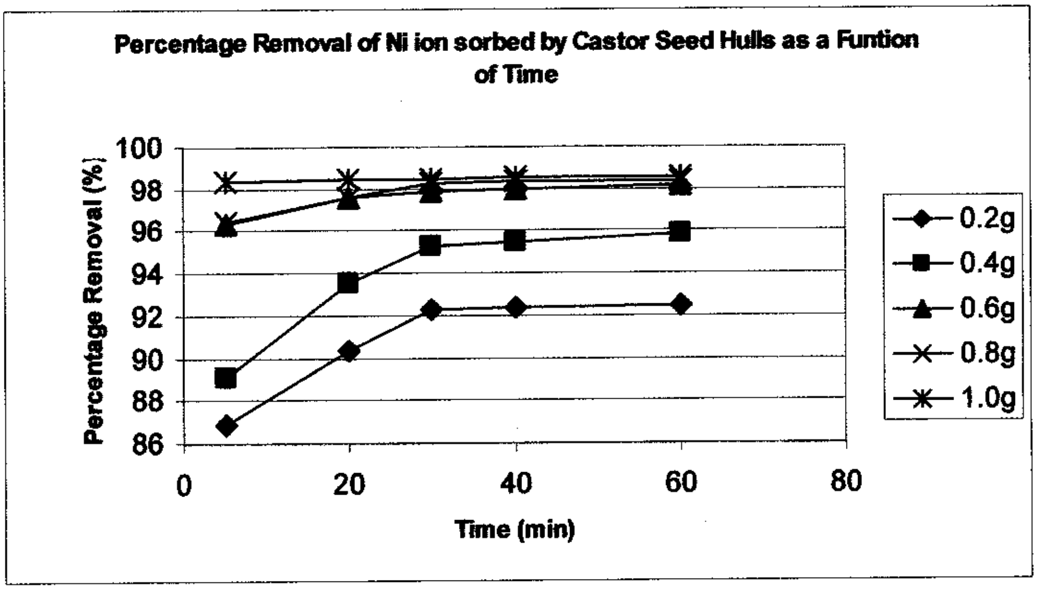


Figure 4.5: Percentage removal of Ni ion sorbed by castor seed hulls as a function of time

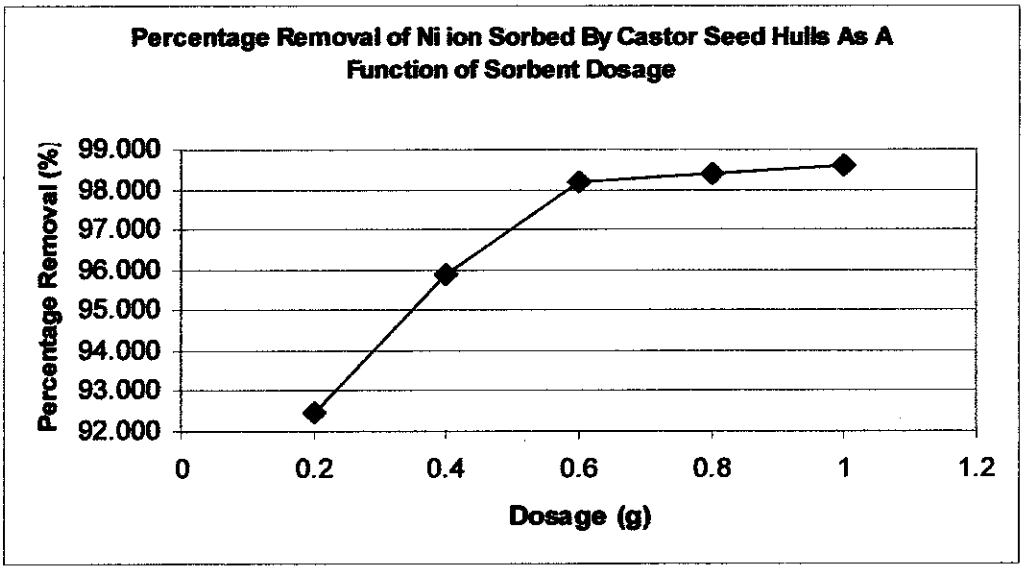


Figure 4.6: Percentage removal of Ni ion sorbed by castor seed hulls as a function of sorbent dosage

Based on Figure 4.5, it shows that the amount of Nickel ion sorbed increased with increasing time. The amount of Ni ion sorbed nearly reached equilibrium at 30 to 50 minutes of contact time. Highest amount of Nickel ion sorbed by castor seed hulls is at dosage of 1.0 g. Therefore, it can be said that, at higher adsorbent dosage, the amount of Nickel ion sorbed will increase.

From Figure 4.6, it also shows that at adsorbent dosage of 1.0 g, the percentage removal is the highest, at 98.569%. This shows that with increasing adsorbent dosage, the amount of Nickel ion sorbed will also increase.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The potential use of castor seed hulls as an adsorbent for nickel was studied. Castor seed hulls were able to remove the nickel ions from aqueous solution. The experimental data fitted both Langmuir and Freundlich Isotherm model but Langmuir was chosen as the isotherm model because its correlation coefficient is closer to unity than that of Freundlich.

The results from the equilibrium adsorption isotherm studies showed that the capacity of castor seed hulls for nickel ion was 2.0773 mg/g and that the sorption took place on homogeneous surface of the castor seed hulls.

The amount of Ni ions sorbed by castor seed hulls was highest at initial concentration of 5 ppm with the percentage removal of 71.20%.

For effect of dosage, the amount of Ni ion sorbed by castor seed hulls was highest at dosage of 1.0 g with the removal percentage of 98.569%.

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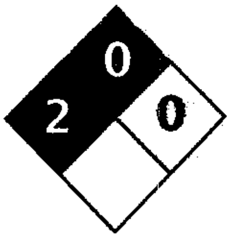
APPENDICES

MSDS OF NICKEL NITRATE

MSDS OF DISTILLED WATER

ScienceLab.com
Chemicals & Laboratory Equipment



Health	2
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Nickel metal MSDS

Section 1: Chemical Product and Company Identification

oduct Name: Nickel metal

italog Codes: SLN2296, SLN1342, SLN1954

\S#: 7440-02-0

TECS: QR5950000

SCA: TSCA 8(b) inventory: Nickel metal

#: Not applicable.

monym: Nickel Metal shot; Nickel metal foil.

iemical Name: Nickel

iemical Formula: Ni

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call:
1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

omposition:

lame	CAS #	% by Weight
lickel metal	7440-02-0	100

oxicological Data on Ingredients: Nickel metal LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

otential Acute Health Effects:
izardous in case of inhalation. Slightly hazardous in case of skin contact (irritant, sensitizer), of eye contact
ritant), of ingestion.

otential Chronic Health Effects:
ightly hazardous in case of skin contact (sensitizer), of ingestion, of inhalation (lung sensitizer).
\RCINOGENIC EFFECTS: Classified 2B (Possible for human.) by IARC. Classified 2 (Some evidence.) by
TP.
JTAGENIC EFFECTS: Not available.
:RATOGENIC EFFECTS: Not available.
:VELOPMENTAL TOXICITY: Not available.
ie substance is toxic to skin.
ie substance may be toxic to kidneys, lungs, liver, upper respiratory tract.
ipeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

/e Contact:
ıeck for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at ast 15 minutes. Get medical attention if irritation occurs.

‹in Contact:
case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated othing and shoes. Cover the irritated skin with an emollient. Wash clothing before reuse. Thoroughly clean ıoes before reuse. Get medical attention.

erious Skin Contact: Not available.

halation:
inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get edical attention.

erious Inhalation: Not available.

gestion:
o NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an ıconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight othing such as a collar, tie, belt or waistband.

erious Ingestion: Not available.

Section 5: Fire and Explosion Data

lammability of the Product: Non-flammable.

uto-Ignition Temperature: Not applicable.

lash Points: Not applicable.

lammable Limits: Not applicable.

roducts of Combustion: Not available.

ire Hazards in Presence of Various Substances: Not applicable.

xplosion Hazards in Presence of Various Substances:
isks of explosion of the product in presence of mechanical impact: Not available.
isks of explosion of the product in presence of static discharge: Not available.

ire Fighting Media and Instructions:
ammable solid.
MALL FIRE: Use DRY chemical powder.
ARGE FIRE: Use water spray or fog. Cool containing vessels with water jet in order to prevent pressure uild-up, autoignition or explosion.

pecial Remarks on Fire Hazards: Material in powder form, capable of creating a dust explosion. This material is flammable powder form only.

pecial Remarks on Explosion Hazards:
laterial in powder form, capable of creating a dust explosion.
lixtures containing Potassium Perchlorate with Nickel & Titanium powders & infusorial earth can explode.
dding 2 or 3 drops of approximately 90% peroxyformic acid to powdered nickel will result in explosion.
owdered nickel reacts explosively upon contact with fused ammonium nitrate at temperatures below 200 deg. C.

Section 6: Accidental Release Measures

mall Spill:
se appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by)reading water on the contaminated surface and dispose of according to local and regional authority quirements.

ırge Spill:
se a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water ı the contaminated surface and allow to evacuate through the sanitary system. Be careful that the product is not esent at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

recautions:
əep locked up.. Do not breathe dust. Wear suitable protective clothing. In case of insufficient ventilation, wear iitable respiratory equipment. If you feel unwell, seek medical attention and show the label when possible. Keep vay from incompatibles such as oxidizing agents, combustible materials, metals, acids.

torage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

ngineering Controls:
se process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below commended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to rborne contaminants below the exposure limit.

ərsonal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. loves.

ərsonal Protection in Case of a Large Spill:
ɔlash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist EFORE handling this product.

xposure Limits:
/VA: 1 (mg/m3) from ACGIH (TLV) [United States] Inhalation Respirable.
/VA: 0.5 (mg/m3) [United Kingdom (UK)]
/VA: 1 (mg/m3) from OSHA (PEL) [United States] InhalationConsult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

ıysical state and appearance: Solid. (Metal solid. Lustrous solid.)

dor: Odorless.

ıste: Not available.

olecular Weight: 58.71 g/mole

olor: Silvery.

ɪ (1% soln/water): Not applicable.

oiling Point: 2730°C (4946°F)

elting Point: 1455°C (2651°F)

ritical Temperature: Not available.

ecific Gravity: Density: 8.908 (Water = 1)

por Pressure: Not applicable.

por Density: Not available.

latility: Not available.

dor Threshold: Not available.

ater/Oil Dist. Coeff.: Not available.

nicity (in Water): Not available.

ispersion Properties: Not available.

lubility:
soluble in cold water, hot water.
soluble in Ammonia.
luble in dilute Nitric Acid.
ightly soluble in Hydrochloric Acid, Sulfuric Acid.

Section 10: Stability and Reactivity Data

ability: The product is stable.

stability Temperature: Not available.

onditions of Instability: Incompatible materials

compatibility with various substances: Reactive with oxidizing agents, combustible materials, metals, acids.

orrosivity: Non-corrosive in presence of glass.

ecial Remarks on Reactivity:
compatible with strong acids, selenium, sulfur, wood and other combustibles, nickel nitrate, aluminum,
uminum trichloride, ethylene, p-dioxan, hydrogen, methanol, non-metals, oxidants, sulfur compounds, aniline,
drogen sulfide, flammable solvents, hydrazine, and metal powders (especially zinc, aluminum, and magnesium),
nmonium nitrate, nitryl fluoride, bromine pentafluoride, potassium perchlorate + titanium powder + indusorial
rth.

ecial Remarks on Corrosivity: Not available.

lymerization: Will not occur.

Section 11: Toxicological Information

outes of Entry: Inhalation. Ingestion.

xicity to Animals:
50: Not available.
50: Not available.

hronic Effects on Humans:
RCINOGENIC EFFECTS: Classified 2B (Possible for human.) by IARC. Classified 2 (Some evidence.) by
TP.
auses damage to the following organs: skin.
ay cause damage to the following organs: kidneys, lungs, liver, upper respiratory tract.

ther Toxic Effects on Humans:

ızardous in case of inhalation.
ightly hazardous in case of skin contact (irritant, sensitizer), of ingestion.

ɔecial Remarks on Toxicity to Animals:
ıwest Published Lethal Dose/Conc:
)L [Rat] - Route: Oral; Dose: 5000 mg/kg
)L [Guinea Pig] - Route: Oral; Dose: 5000 mg/kg

ɔecial Remarks on Chronic Effects on Humans: May cause cancer based on animal test data

ɔecial Remarks on other Toxic Effects on Humans:
:ute Potential Health Effects:
‹in: Nickel dust and fume can irritate skin.
/es: Nickel dust and fume can irritate eyes.
halation: Inhalation of dust or fume may cause respiratory tract irritation with non-productive cough,
ıarseness, sore throat, headache, vertigo, weakness, chest pain, followed by delayed effects, including
chypnea, dyspnea, and ARDS. Death due to ARDS has been reported following inhalation of high
ıncentrations of respirable metallic nickel dust. Later effects may include pulmonary edema and fibrosis.
gestion: Metallic nickel is generally considered not to be acutely toxic if ingested. Ingestion may cause nausea,
ımiting, abdominal , and diarrhea. Nickel may damage the kidneys(proteinuria), and may affect liver function. It
ay also affect behavior (somnolence), and cardiovascular system (increased comary artery resistance,
ıcreased myocardial contractility, myocardial damage, regional or general arteriolar or venus dilation).
ıronic Potential Health Effects:
‹in: May cause skin allergy. Nickel and nickel compounds are among the most common sensitizers inducing
ergic contact dermatitis.
ıalation: Chronic inhalation nickel dust or fume can cause chronic hypertrophic rhinitis, sinusitis, nasal polyps,
ırforation of the nasal septum, chronic pulmonary irritation, fibrosis, pulmonary edema, pulmonary eosinophilia,
ıeumoconiosis, allergies (asthma-like allergy), and cancer of the nasal sinus cavities, lungs, and possibly other
gans. Future exposures can cause asthma attacks with shortness of breath, wheezing, cough, and/or chest
htness. Chronic inhalation of nickel dust or fume may also affect the liver (impaired liver function tests), and
ɔod (changes in red blood cell count).
gestion: Prolonged or repeated ingestion of nickel can be a source chronic urticaria and other signs of allergy.
ıronic ingestion of Nickel may also affect respiration and cause pneumoconiosis or fibrosis.
ɔte: In the general population, sensitization occurs from exposure to nickel-containing coins, jewelry, watches,

Section 12: Ecological Information

:otoxicity: Not available.

)D5 and COD: Not available.

oducts of Biodegradation:
ıssibly hazardous short term degradation products are not likely. However, long term degradation products may
se.

ıxicity of the Products of Biodegradation: The products of degradation are as toxic as the original product.

ıecial Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

aste Disposal:
aste must be disposed of in accordance with federal, state and local environmental
ntrol regulations.

Section 14: Transport Information

)T Classification: Not a DOT controlled material (United States).

entification: Not applicable.

›ecial Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

ːderal and State Regulations:
ılifornia prop. 65: This product contains the following ingredients for which the State of California has found to use cancer, birth defects or other reproductive harm, which would require a warning under the statute: Nickel ətal
ılifornia prop. 65: This product contains the following ingredients for which the State of California has found to use cancer which would require a warning under the statute: Nickel metal
›nnecticut hazardous material survey.: Nickel metal
nois toxic substances disclosure to employee act: Nickel metal
nois chemical safety act: Nickel metal
›w York release reporting list: Nickel metal
ıode Island RTK hazardous substances: Nickel metal
›nnsylvania RTK: Nickel metal
chigan critical material: Nickel metal
ıssachusetts RTK: Nickel metal
ıssachusetts spill list: Nickel metal
›w Jersey: Nickel metal
›w Jersey spill list: Nickel metal
ıuisiana spill reporting: Nickel metal
ılifornia Director's List of Hazardous Substances: Nickel metal
ƷCA 8(b) inventory: Nickel metal

ːher Regulations:
ƷHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).
NECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

ːher Classifications:

HMIS (Canada): CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

ƷCL (EEC):
ł0- Possible risks of irreversible ects.
ł3- May cause sensitization by skin ntact.
ː2- Do not breathe dust.
ł6- Wear suitable protective clothing.

ИIS (U.S.A.):

ɬealth Hazard: 2

ᷓire Hazard: 0

ƹeactivity: 0

›ersonal Protection: E

ıtional Fire Protection Association (U.S.A.):

ɬealth: 2

ᷓlammability: 0

ƹeactivity: 0

Specific hazard:

otective Equipment:
oves.
b coat.
ust respirator. Be sure to use an
proved/certified respirator or
uivalent. Wear appropriate respirator
hen ventilation is inadequate.
afety glasses.

Section 16: Other Information

eferences: Not available.

ther Special Considerations: Not available.

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A.C.N. 008 671 127
2 Rawlinson Street O'Connor PO Box 2084 Palmyra DC
Western Australia 6961
Ph (08) 9337 4933 Fax (08) 9337 8316
Internet: www.davidgray.com.au (MSDS's & Company Information)
Emergency Telephone Number (08) 9337 4933 (During Office Hours)

Date of Issue: January 2006

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

CLASSIFIED AS NOT HAZARDOUS ACCORDING TO CRITERIA OF WORKSAFE AUSTRALIA

PRODUCT NAME:	**David Gray Distilled Water**
OTHER NAME:	None allocated
MANUFACTURERS CODE:	(02508) 2L (02969) 4L
PROPER SHIPPING NAME (ADG Code):	None allocated
UN NUMBER:	None allocated
DANGEROUS GOODS CLASS:	None allocated
SUBSIDIARY-RISK:	None allocated
PACKING GROUP:	None allocated
HAZCHEM CODE:	None allocated
POISONS SCHEDULE:	None allocated
USE:	Industrial/Domestic applications

PHYSICAL DESCRIPTION / PROPERTIES

APPEARANCE:	Clear
MELTING POINT:	0°C
BOILING POINT:	100°C
VAPOUR PRESSURE:	760mm Hg (100°C)
DENSITY:	1.00 @ 25C
FLASH POINT:	Not applicable
FLAMMABILITY LIMITS:	Not applicable
SOLUBILITY IN WATER:	Soluble
CORROSIVENESS:	Not corrosive
OTHER PROPERTIES:	Not applicable

INGREDIENTS

CHEMICAL NAME	CAS.NO.	PROPORTION
Water (Purified)	7732-18-5	100%

HEALTH HAZARD INFORMATION

HEALTH EFFECTS

HAZARD CLASSIFICATION (In accordance with criteria of Worksafe Australia): Classified as not hazardous

RISK PHRASES: Not required

SAFETY PHRASES: Not required

GENERAL:
No adverse health effects are expected when the product is used in accordance with label directions.

SWALLOWED:
The acute oral toxicity is extremely low.

EYE:
Very slight eye irritant.

SKIN:
Not harmful if spilt onto skin.

INHALED:
The acute inhalation toxicity is extremely low although excessive inhalation may cause drowning.

FIRST AID

GENERAL:
In every case of suspected poisoning contact a doctor or a Poisons Information Centre immediately.

SWALLOWED: Not harmful if swallowed although the product is not intended for human consumption.

EYE: May cause slight discomfort. If discomfort persists seek medical advice.

SKIN: Is not harmful on the skin.

INHALED: Not harmful when inhaled unless in excessive amounts.

FIRST AID FACILITIES: Eyewash

ADVICE TO DOCTOR:

Treat symptomatically

PRECAUTIONS FOR USE

EXPOSURE STANDARDS:
Worksafe Occupational Exposure Standard (TWA – Time Weighted Average)
None allocated

Time Weighted Average (TWA) means the average airborne concentration of a particular substance when calculated over a normal eight-hour working day, for a five day working week.

ENGINEERING CONTROLS: Not required

PERSONAL PROTECTION: Not required

FLAMMABILITY: Not flammable

SAFE HANDLING INFORMATION

STORAGE

Keep water in its original plastic packaging, tightly sealed and in cool conditions to retain its purity.

TRANSPORT

Product is not classified as a dangerous good in accordance with the Australian Code for the Transport of Dangerous Goods by Road and Rail.

SPILLAGE

If spilt, wipe up with a mop.

DISPOSAL

Bottles are recyclable. Dispose of in the recycling bin.

FIRE/EXPLOSION HAZARD

Not a fire or explosion hazard.

HAZARDOUS DECOMPOSITION PRODUCTS: None

FIRE FIGHTING EQUIPMENT: Product will not burn.

OTHER INFORMATION

ECOTOXICITY DATA: Product is not hazardous

ENVIRONMENTAL FATE: Not applicable

CONTACT POINT

TITLE: Technical Department

TELEPHONE NUMBER: (08) 9337 4933

AUTHORISED:

DATE: 6 January 2006

NOTICE:
This Material Safety Data Sheet has been developed according to the Worksafe Australia/NOHSC Codes of Practice.

The information contained herein is given in good faith however and is considered to be accurate at the specified issue date. No warranty expressed or implied is made to the accuracy or completeness of the data and information contained herein.
No person, other than an authorised representative of David Gray & Company Pty Ltd, has the authority to make any alterations to this MSDS.

Contact David Gray & Co Pty Limited for further product information on (08) 9337 4933 during normal business hours.