

# Elimination of Ni(II) from Spiked solutions by Natural adsorbent – flow study

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## Abstract

Discharge of heavy metals from metal process industries is known to have adverse effects on the environment. Conventional treatment technologies for removal of heavy metals from aqueous solutions are non - economical and generate huge quantities of chemical sludge. Bio-sorption of heavy metals by chemically inactive non-living biomass of microbial of plant origin is an innovative and technology of these pollutants from aqueous solutions.

The operating conditions such as pH, dose required, initial metal concentrations and treatment performance are presented, recovery adsorbent was also discussed. The efficiency of fixed bed system depends on the initial concentration of influent rate and bed height. The effects of parameters on the adsorption of Ni(II) on Date nuts dust were examined. A simpler approach to fixed bed adsorption has been proposed by Hutchin which is called bed – depth - service time. (BDST) Model service time with parameters, initial concentrations, flow rate and bed heights. A bed height of 3.0 cm having 2.0 gm adsorbent was used, to study the effects of initial metal ion concentration. The metal ion concentration varied from 20 - 40 ppm and flow rate of 10 ml/min, at required pH. The effects of flow rate on adsorption of Ni(II) was studied with 20 ppm of Ni(II) solution was allowed to pass through the column of an adsorbent 3.0 cm at different flow rates. Effects of metal initial concentration of 20 ppm, flow rate of 10 ml/min, bed heights contains different weights were used to study.

**Key words:** *Date nut dust*, Heavy metals. Wastewater treatment, Removal, Advanced techniques.

**Adsorbent :** *Date nut dust*

The *Date nut dust* were collected at shop vendor, Visakhapatnam, Andhra Pradesh, cleaned thoroughly with water and soaked in distilled water for 24 hours and again washed with double distilled water and dried under sun light. The dried drupes were pulverized and the pulverized material was screened for various particle sizes like 0.430, 0.600 and 0.800 mm.

**Adsorbate:** Nickel Ammonium Sulphate solution

Analytical reagent grade Nickel Ammonium sulphate was used to prepare Ni(II) solution. A stock solution of 1000 mg/L of Ni (II) was prepared by dissolving 6.7280 g of Nickel Ammonium sulphate in 5 ml of 1% HNO<sub>3</sub> solution to prevent hydrolysis and diluted with doubled distilled water and made up to 1000 ml.

## Introduction

Nickel is used in electroplating industry, in the making of coins, chemical reagents, alloys preparation, nickel compounds, house wear utensils, machine parts, preparation of stainless steel, spare parts in automobiles, leather and textile industries.

Nickel and its compounds are naturally present in the earth's crust and releases to the atmosphere occur from natural discharges such as windblown dust and volcanic eruptions, as well as from anthropogenic activities. It is estimated that 8.5 million kg of nickel are emitted into the atmosphere from natural sources such as windblown dust, volcanoes and vegetation each year. Five times that quantity is estimated to come from anthropogenic sources.

Ni(II) is a well-known toxic heavy metal, which pose serious threat to the fauna and flora of receiving water bodies when discharged from industrial wastewaters. Ni(II) presents in the effluents of silver refineries, electroplating, zinc base casting and storage battery industries. Kadirvelu *et al.*, (2000a). As it resists corrosion even at high temperature, it can also be used in gas turbines, rocket engines and distillation plants. It is also used in coinage and costume jewelry. Skin contact with nickel causes a painful disease called 'nickel itch' which leads to death (Abbasi and Soni, 1990). The acceptable limit of nickel in drinking water in India is 0.01 mg/l and for discharge of industrial wastewater is 2.0 mg/l (Kadirvelu, 1998). At higher concentrations, Ni(II) causes cancer to the lungs, nose and bones. Dermatitis (nickel itch) is the most frequent effect of exposure to nickel, such as coins and costume jewelry. Nickel carbonyl  $[\text{Ni}(\text{Co})_4]$  has been estimated as lethal in humans at atmospheric exposures of 30 ppm for 30 min (Namasivayam and Ranganathan, 1994). Acute poisoning of Ni(II) causes headache, dizziness, nausea, tightness of the chest, chest pain, and shortness of breath, dry cough, cyanosis and extreme weakness (Parker, 1980).

## Column Study

The efficiency of a fixed bed system depends on the initial concentration of the influent, flow rate and the bed height. The effects of these parameters on the adsorption of Ni(II) were examined. A simpler approach to fixed bed adsorber has been proposed by Hutchin (Equation-1) which is called Bed-Depth-Service- Time (BDST) model which correlates service time ( $t$ ) with the parameters; initial concentration, flow rate and bed heights (Hutchin., 1973).

## Effects of Metal ion Concentration on Ni(II) Adsorption

A bed height of 3.0 cm having 2.0 g of the adsorbent was used to study the effects of initial metal ion concentration. The initial Ni(II) concentrations were varied from 20 to 40 mg/l at constant bed height of 3.0 cm and flow rate of 10ml/ min and adjusted to pH 5.0. The efficiency of the fixed bed method depends on the shape of the breakthrough curves obtained by plotting  $C_t/C_o$  vs volume or time. *Breakthrough volume is defined as the maximum volume of effluent required to reach  $C_t/C_o = 0$  or  $C_t/C_o = 0.5$  (ml) (50% breakthrough).* The plots of  $C_t/C_o$  vs effluent volume for different Ni(II) concentrations are shown. The plots are traditional "S" shape but the steepness of the curve varies with the concentrations of Nickel

The breakthrough volumes at ( $C_t/C_o = 0$ ) for Ni(II) concentrations of 20, 30 and 40 mg/l were found to be 300, 200 and 100 ml respectively. The time for 50 percent breakthrough ( $t_{0.5}$ ) decreased from 52.5 to 22.5 min for Ni(II) concentrations of 20 mg/l to 40 mg/l. The results are shown in Table-1.

**Table-1**

Breakthrough volumes for Ni(II) Adsorption for different concentrations

Particle size : 0.800 mm

Initial pH : 5.0

Bed height : 3.0 cm

Flow rate : 10 ml/min

Initial concentration (mg/l)	Breakthrough volume		Time for 50 % break through $t_{0.5}$ (min)
	$C_t / C_o = 0$ (ml)	$C_t / C_o = 0.5$ (ml)	
<b>20</b>	400	525	52.5
<b>30</b>	300	350	35.0
<b>40</b>	200	225	22.5

Effects of Flow Rate on Ni(II) Adsorption

The effects of flow rate on adsorption of Ni(II) was studied with 20 mg/l concentration of Ni(II) solution at pH 5.0 and solution was allowed to pass through a column of adsorbent (Bed height 3.0 cm) at different flow rates of 5, 10 and 15 ml/min. The plots of  $C_t/C_o$  vs effluent volume for different flow rates are shown. The flow rate has been considered to study the Ni(II) removal; when flow rate is low the breakthrough volume is high. The results indicate that breakthrough volume at ( $C_t/C_o = 0$ ) was higher for 5 ml/min than for 10 and 15 ml/min. The results are shown in Table-2.

**Table-2**

Breakthrough volumes for Ni(II) Adsorption for different flow rates

[Ni(II)] : 20 mg/l

Bed height : 3.0 cm

Initial pH : 2.0

Particle size : 0.800 mm

Flow rate (ml/min)	Breakthrough volume		Time for 50 % break through $t_{0.5}$ (min)
	$C_t / C_o = 0$ (ml)	$C_t / C_o = 0.5$ (ml)	
<b>5</b>	400	600	120.00

<b>10</b>	300	525	52.50
<b>15</b>	250	475	31.67

### Effects of Bed height on Ni(II) removal

The experiment was carried out with an initial Ni(II) conc. of 20 mg/l, flow rate of 10 ml/min at pH 5.0. The beds of different heights (3.0, 3.8 and 4.6 cm) of 2.0, 2.6 and 3.2 g were used to study the effects of bed height on  $C_t/C_o$  vs effluent volume is shown in Fig-3. The breakthrough volumes at ( $C_t/C_o = 0$ ) increased from 300 to 525 ml when bed height was increased from 3.0 to 4.6 cm. The results are shown in Table-3.

**Table-3**

#### Breakthrough volumes for Ni(II) adsorption for different Bed heights

[Ni(II)] : 20 mg/l

Flow rate : 10 ml/min

Initial pH : 2.0

Particle size : 0.800 mm

Bed height (cm)	Breakthrough volume		Time for 50 % break through $t_{0.5}$ (min)
	$C_t / C_o = 0$ (ml)	$C_t / C_o = 0.5$ (ml)	
3.0	300	525	52.5
3.8	400	650	65.0
4.6	525	825	82.5

### Application of BDST model

As predicted from Hutchin's equation for BDST (Equation-1), the plot of  $C_o t$  vs  $\ln [(C_o/C_t) - 1]$  should be a straight line. The data for BDST equation are given in Tables-15, 16 and 17 for different Ni(II) concentrations, different flow rates and different bed heights respectively. The plots of  $C_o t$  vs  $\ln [(C_o/C_t) - 1]$  are linear (Fig-1, 2 and 3) obeying Hutchin's (1973) equation. The constants  $K_a$  and  $N_o$  namely the rate constants of adsorption and adsorption capacity respectively were obtained from the

slope and intercepts of the plots (Fig-1, 2 and 3). From the data it is evident that increase in initial concentration of Ni(II) solutions from 20 to 40 mg/l increased the adsorption capacity from 1040 to 1100 mg/l and decreased the rate constant from  $8.0 \times 10^{-3}$  to  $6.13 \times 10^{-3}$  l/min/mg. Similar behavior has been observed by Ranganathan and Namasivayam (1998).

At fixed influent concentration and bed heights, smaller flow rate of 5 ml/ min showed better adsorption capacity of 2400 mg/l than 10 and 15 ml/min. The  $K_a$  values in Table-4 shows that higher flow rates saturate the bed more quickly than slower flow rates. The data obtained for different bed heights, reveals that increase in bed height from 3.0 to 4.6 cm increases the breakthrough volumes ( $C_t/C_o = 0$ ) increased from 300 to 525 ml and  $N_o$  from 1050 to 1550 mg/l. Increase in bed height increased the adsorption capacity. This is due to the fact that the number of adsorption sites increases with increase in adsorbent dosage (Kannan *et al.*, 2003).

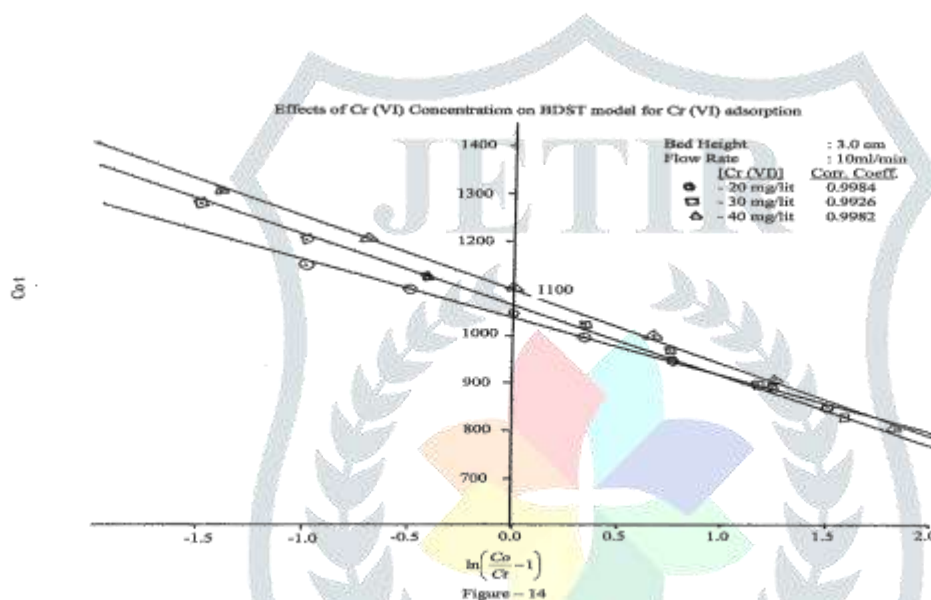


Fig- 1



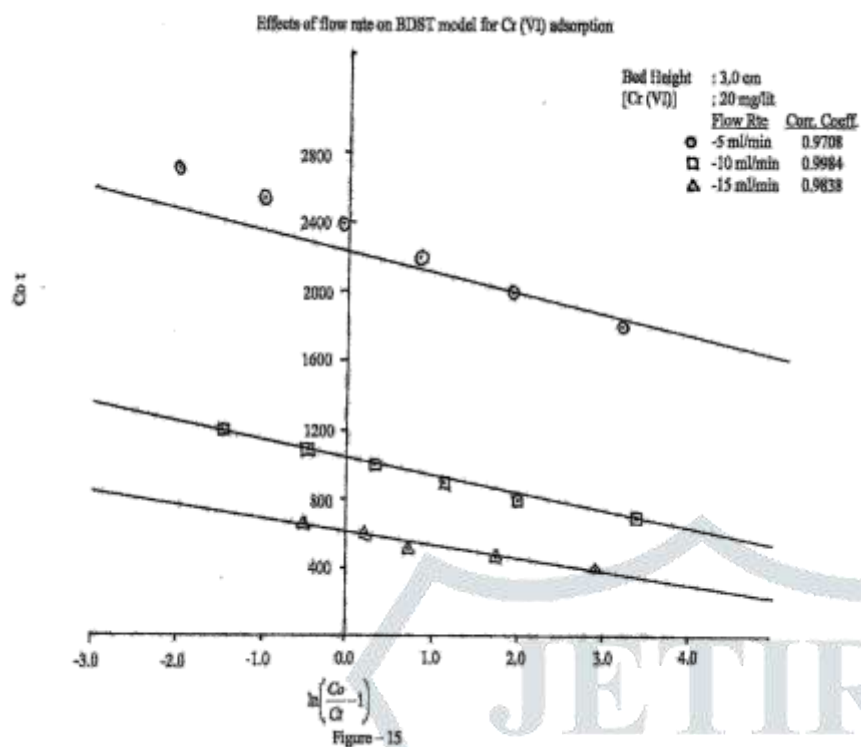


Fig- 2

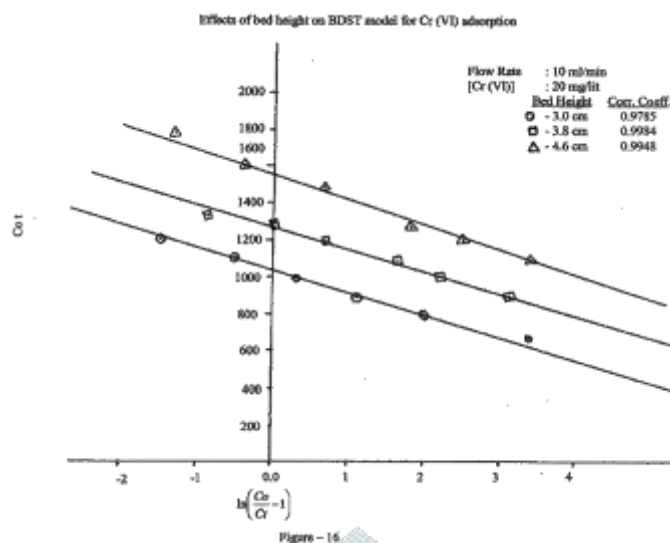


Fig - 3

Table - 4

BDST Constants for Ni(II) Adsorption

BDST Constants	Concentration (mg/l)			Flow rate (ml/min)			Bed height (cm)		
	20	30	40	5	10	15	3.0	3.8	4.6
$K_a$ (l/min/mg) $\times 10^{-3}$	8.00	6.45	6.13	4.32	4.53	8.25	8.53	8.34	7.42
$N_0$ (mg/l)	1040	1070	1100	2400	1040	620	1050	1280	1550

## Conclusion

Collection of adsorbent is cheap and easy to collect, which are agricultural wastes and non- toxic in nature. Flow methods good efficient for the purification of bulky waters like wastewater collected form industries and bulky wastewater collected from towns. Adsorbent was recollected form metal adsorbed adsorbent and reuse for further purification. From the data it is evident that increase in initial concentration of metal Ni(II) solutions increased the absorption capacity and decreased in the rate constant. At fixed influent concentration and bed heights, smaller flow rates shows better adsorption capacity. Data shows that higher

flow rates saturate the bed more quickly than slower flow rates. Increase in bed heights increased the adsorption capacity. This is due to the fact that the number of adsorption sites increased with increase in adsorbent dosage.

## References

- 1 *Srinivasan K and Geetamani G (2004)*. Studies on Chromium(VI) removal by activated Tamarind Nut Carbon. **Oriental Journal of Chemistry**, Vol.20(2), pp 335- 340.
- 2 *Tiravanti G, Petruzzelli D and passion R (1997)*. Pretreatment of tannery wastewaters by an ion-exchange process for Cr(III) removal and recovery. **Water Sci. Technol.** 36, 197.
- 3 *Vasanty M, Sangeeta M and Kavita C (2003)*. Removal of Chromium from aqueous solutions using a mixture of flyash and activated carbon, **Indian J. Environmental Protection** 23(12): pp 1321-1325.
- 4 *Zhou X, Korenaga T, Takahashi T, Moriwake T and Shinoda S (1993)*. A process monitoring/controlling system for the treatment of wastewater containing Chromium(VI). **Water Res.** 27, 1049.
- 5 *Chakravarti AK, Chowdhury SB, Chakrabarty S, Chakrabarty T and Mukherjee DC (1995)*. Liquid membrane multiple emulsion process of Chromium(VI) separation from wastewaters. **Colloids Surf. A: Physicochem. Eng. Aspects** 103,59.
- 6 *Dahbi S, Azzi M and Guardia M (1999)*. Removal of Hexavalent Chromium from wastewaters by bone charcoal. **Fresenius J. Anal. Chem.** 363, 404.
- 7 *Hutchin RA (1973)*. New method simplifies design of activated carbon system. **Chem. Engg.** 80, pp 133-138.
- 8 *Kongsricharoern N, Polprasert C (1996)*. Chromium removal by a bipolar electrochemical precipitation process. **Water Sci. Technol.** 34, 109.
- 9 *Lin CF, Rou W and Lo KS (1992)*. Treatment strategy for Cr(VI)-bearing wastes. **Water Sci. Technol.** 26, 2301.
- 10 *Manonmani (2002), Ph. D Thesis, Bharathiar University (2002), Coimbatore, India.*
- 11 *Mousumisen, Manisha GD and Pradeep Roy Chowdary K (2005)*. Biosorption of Cr(VI) by non living fusarium Sp. Isolated from soil. IIT, New-Delhi.
- 12 *Kannan N and Raja Kumar A (2003)*. Suitability of various indigenously prepared activated carbons for adsorption of Mercury(II) ions. **Toxicol. Env. Chem.**, 84 (1-4): pp 7-19.
- 13 *Pagilla K and Canter LW (1999)*. Laboratory studies on remediation of Chromium contaminated soils. **J. Environ. Eng.** 125(3), 243.
- 14 *Ranganathan K and Namasivayam C (1998)*. Utilization of waste Fe(III)/Cr(III) hydroxide for the removal of Cr(VI) and Fe(II) by fixed bed system. **Hungarian Journal of Industrial Chemistry**, 26, pp 169-172.
- 15 *Seaman JC, Bertsch PM and Schwallie L (1999)*. In-situ Cr(VI) reduction within coarse-textured, oxide-coated soil and aquifer system using Fe(II) solutions. **Environ. Sci. Technol.** 33, 938.
- 16 *Sawada A, Mori K, Tanaka S, Fukushima M and Tatsumi K (2004)*. Removal of Cr(VI) from contaminated soil by electrokinetic remediation. **Waste Management.** 24(5), pp 483-490.