Research Article
AMERICAN JOURNAL OF PHARMACY AND HEALTH RESEARCH
www.ajphr.com
2014, Volume 2, Issue 3
ISSN :2321–3647(online)

# Fixed Bed Column Study for Ni(II) Removal from Aqueous Solution by Slag

**M.K.Dwivedi[1*], Rashmi Agarwal[2]**
*1. Chemistry Department, Govt. Holkar Science College, Indore 452017*
*2. Pharmaceutical chemistry Department, Govt. Holkar Science College, Indore 452017.*

## ABSTRACT

Adsorption isotherms are normally used for obtaining the operational parameters but in practice the treatment plants use column type operations. The recycling of adsorbent is not practically possible by batch process and the physical and biological changes are not predictable by the adsorption isotherms. Consequently the practical applicability of the product for column operations has been studied to obtain some parameters necessary for a factual design model. The fractional capacity ‘f’ of the column in the adsorption zone at break point to continue to remove solute from solution is 0.84. The percentage saturation at break point is 50.09. BDST model is found to be suitable to fixed bed of slag. The breakthrough capacity of the column is 66.0 mg $g^{-1}$ which reflects the affinity of the slag quite well.

**Keywords :**Nickel, Slag, Adsorption, Column Studies.

*Corresponding Author Email:dwivedimk12@gmail.com
Received 05 March 2014, Accepted11March2014

Please cite this article in press as: Dwivedi MK.*et al.*,Fixed Bed Column Study for Ni(Ii) Removal from Aqueous Solution by Slag. American Journal of Pharmacy & Health Research 2014.

## INTRODUCTION

The use of heavy metals in different industrial processes as well as the risk of metal pollution has increased to a large extent over the last few decades. Industrial discharges from electroplating units, battery manufacturing plants, paint formulation, mining and metallurgy[1] are considered as main source of nickel. Nickel occurs in small quantities in plants and animals. It is present in trace amounts in seawater, petroleum and coal. Common nickel compounds have produced toxic effects in humans and other animals. Exposure to large amounts of nickel can lead to toxicity. Ni (II) ions get bind to nucleic acids and produce significant genetic effects. A common recognized local reaction to nickel is dermatitis[2].It has also been reported that inhaled nickel powder or fumes from roasting of nickel ores may be carcinogenic.

To reduce this metal pollution problem, the options available are either removal and /or recovery methods or the use of substitutes of metallic compounds. Conventional removal methods may be ineffective or extremely expensive for treating effluents with low heavy metal concentrations. In search of new economically viable but effective contaminated removal methods, adsorption of metal ions present in low levels onto the solid can prove to be a cost-effective and better option for treating industrial effluents and wastewater streams[3].

Low cost adsorbents including solid wastes, slag, flyash, leaves, bones, soils, hairs, agricultural wastes etc. have been identified as economical substitutes to the activated carbon[4,5].

On the other hand, the disposal of huge quantity of slag generated from steel plants is a serious problem. The only application of this substance is in the preparation of slag cement or else as filler in road construction. One of possible uses can be its use as a low cost adsorbent material to remove various kinds of pollutants from water and wastewater[6,7].

In the present investigation a column study experiment has been carried out to evaluate performance of a fixed bed adsorption column and also to gather some characteristic information from the pertinent breakthrough curve.

## MATERIALS AND METHOD

In the Present investigation, slag was obtained from TISCO Jamsedpur (Jharkhand).Chemicals used were A.R. grade, Solutions were prepared in double distilled water. The operation of a fixed bed adsorber is carried out by a method which depends to a large extent on the shape of break through curves .Various parameters like solute concentration, pH, rate limiting mechanism of adsorption, nature of equilibrium conditions, depth of column, particle size and velocity of flow etc. affect the actual shape of the curve.

**Design of fixed bed adsorption column (Down flow):**

Glass column (40x0.5cm) filled with known amount of slag (meshsize 200-250) was used for nickel ion. Effluent flow was adjusted with a clip at the bottom of the column investigations were carried out by feeding the column with solution of $Ni^{2+}$ ($4.25x10^{-3}$m). On the basis of mathematical analysis and prediction of the shape of break through curve, a number of models have been developed for designing fixed bed adsorber. Two main models viz. MTZ model and HETP model were proposed by Michaels[8] and Johnston[9]respectively. A review on designing methods, has been presented by Mckay[10] who opines that the BDST model provides the simplest approach and most practical and rapid predictions of adsorber column. he mass transfer kinetic approach involves the rate of mass transfer while the BDST model utilizes some rational extensive data. These two approaches have been utilized in these investigations.

**Mass transfer kinetic approach:**

This approach is found to be applicable to a concave isotherm. It involvesthe attainment of equilibrium between the solution and adsorbent. It also provides a prior knowledge of the rate of mass transfer from solution to adsorbent in a fixed bed adsorber.

**Bed Depth Service Time (BDST) Model:**

Many models have been proposed to correlate the service time of fixed adsorption bed with operational variables. The BDST model proposed by Hutchins[11] states that bed depth and service time have a linear relationship. This is described by the following equation

$t=ax+b$

Where t= service time at break through (minutes) , x=bed-depth (cm), a= slope (mm $cm^{-1}$) $=N_0/C_0$ V

Here $N_0$ = Adsorption capacity ;mgadsorbate per $cm^3$ of adsorbent, $C_0$ = initial conc. mg L-$^1$, V= linear flow rate, L $mm^{-1}$ $Cm^{-1}$

b=coordinate intercept= 1/k $C_0$ln ($C_0/C_{B-1}$) minutes

Here K= rate constant of adsorption, ml $mg^{-1}$ $min^{-1}$, $C_B$= Eluent Conc. mg $L^{-1}$, $C_0$= Initial Conc. mg $L^{-1}$

## RESULTS AND DISCUSSION:

The break through curve obtained by plotting mass concentration of solute in the effluent C and the total quantity of the solute free water 'Ve' for Nickel is given in figure 1.The values of the parameters Vx, Vb, Cx and Cb as obtained from the graph are given in Table 1. These values areas used to calculate $t_x$, $t_f$, $t_s$, f, $\delta$ and percentage saturation and are given in Table 2.

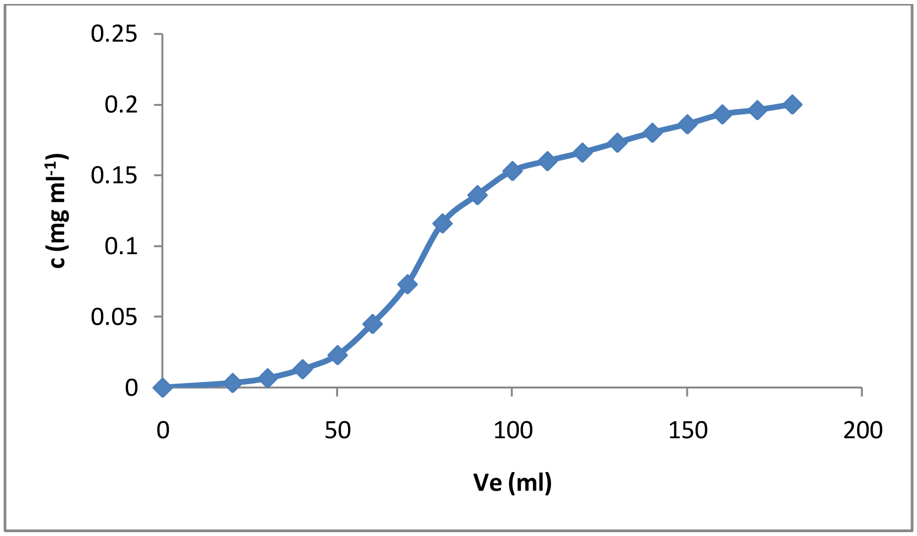


**Figure 1:Breakthrough curve of $Ni^{2+}$**

The total time $t_x$ involved for the primary zone to establish itself move down the length of the column and out of the bed range is between 1.3 to 3.4 hours. The time required for the movement of zone down its own length in the column $t_\delta$is between 1.2 to 3.2 hours. The time taken for initial formation of the primary adsorption zone '$t_f$' is between 0.02 to 1.6 hours.

The fractional capacity 'f' of the column in the adsorption zone at break point to continue to remove solute from solution is 0.84.Thepercentage saturation at break point is 50.09.

**Table-1: Fixed bed adsorber calculations**

| Metal ion | $C_o$ mg $mL^{-1}$ | $C_x$ mg $mL^{-1}$ | $C_b$ mg $ml^{-1}$ | $V_x$ mg $cm^2$ | $V_b$ mg $cm^{-2}$ | $(V_x-V_b)$ mg $cm^2$ | $F_m$ mg $cm^{-2}min^{-1}$ | D cm |
|---|---|---|---|---|---|---|---|---|
| $Ni^{2+}$ | 0.200 | 0.136 | 0.021 | 62.33 | 5.34 | 56.99 | 0.38 | 6.0 |

The $(V_X-V_b)$ value shows that an additional quantity of solute load or waste load per unit cross-sectional area that will result in complete exhaustion of the capacity of adsorbent is 56.99 mg $cm^{-2}$.

**Table-2 Parameters of fixed bed adsorber**

| Metal ion | $t_x$(minute) | $t_\delta$(minute) | $t_f$(minute) | f | δ(cm) | % saturation |
|---|---|---|---|---|---|---|
| $Ni^{2+}$ | 164.02 | 149.97 | 53.98 | 0.84 | 8.17 | 50.09 |

Operational Parameters (shown in Table2) provide an idea of the time needed for break point to occur and also the quantity of additional solution loaded per unit cross sectional area of the slag that would result in a complete exhaustion of the capacity of the slag column. The date can be applied for designing a fixed bed adsorber for the treatment of adsorbatesof known concentrations.

Figure 2 Shows plot of BDST at 50% break through against bed-depth for the present system. Linear plot indicates the suitability of BDST model to fixed bed of the slag.

BDST Equation for $Ni^{2+}$ is

$t_{1/2}$ =32.0 x -10

After developing a BDST equation from the corresponding column test, at a fixed linear flow rate for $Ni^{2+,}$ the equations for other flow rates can also be calculated.

The break through curve (figure 3) was used to determine the break through capacity at complete exhaustion. It-was calculated by taking thetotal area to the point where the effluent plot joins the effluent and dividing this value by the weight of slag in the column. The column capacity of $Ni^{2+}$is 66.0

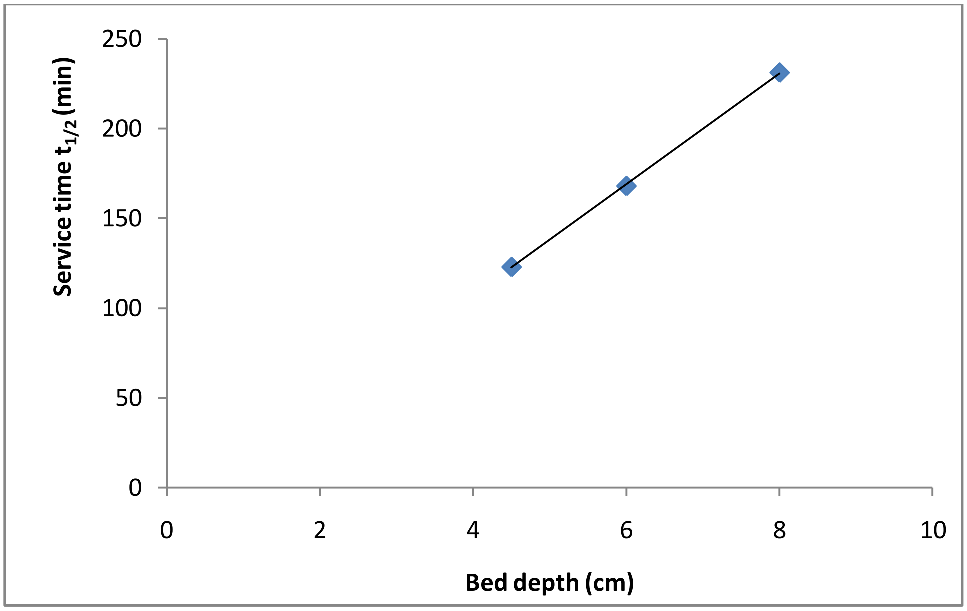


**Figure 2:Plot of time of 50% breakthrough at varying bed depths for$Ni^{2+}$**

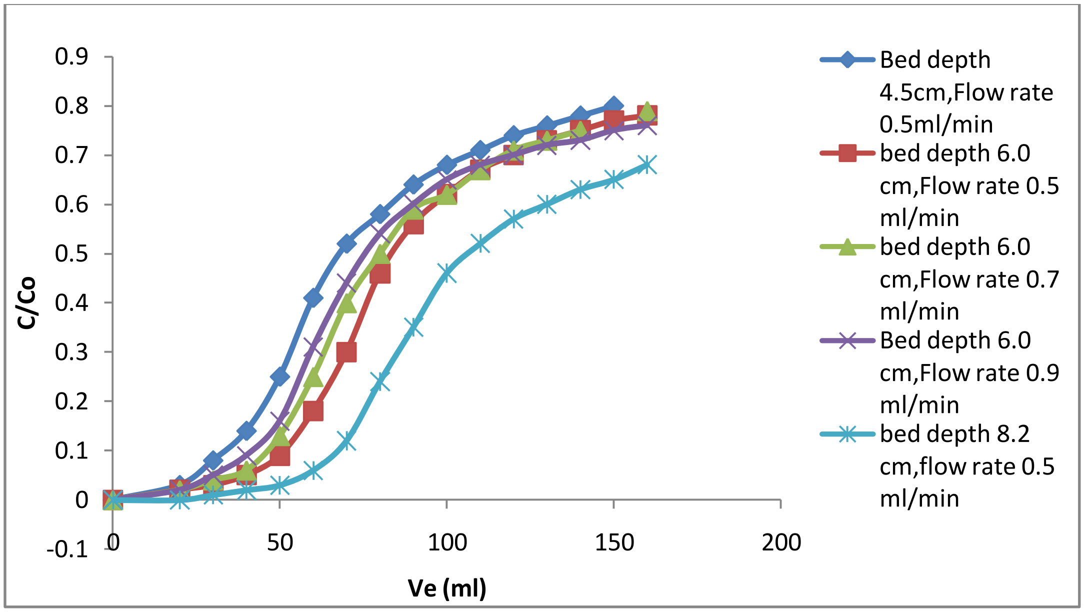


**Figure 3:Breakthrough curve of $Ni^{2+}$ at varying bed depths and flow rates**

## CONCLUSION:

From this study, activated slag was found suitable for Ni (II) removal from aqueous solution using fixed bed adsorption column. The fixed bed adsorption system was found to perform better with lower Ni (II) inlet concentration ,lower feed flow rate and higher slag bed height. The column experimental data were fitted well to the BDST model.

## REFERENCES:


1. Farooq, Kozinski JA, Khan MA, Athar M. Biosorption of heavy metal ions using wheat based biosorbents--a review of the recent literatureBioresour.Technol.2010; 101 :5043-5053.
2. Gupta VK, Rastogi A, Nayak A. Adsorption studies on the removal of hexavalent chromium from aqueous solution using a low cost fertilizer industry waste material. J Colloid Interface Sci. 2010; 324: 533-539.
3. RaoRK, KhanMA. Biosorption of bivalent ions from aqueous solution by an agricultural waste: Kinetic, Thermodynamics and Environmental effects. Colloid and surfaces: A Physico Chem. Eng. Aspects, 2009; 332: 121-128.
4. Doan HD, Lohe A, DangVB, Dang H. Removal of Zn +2 and Ni +2 by adsorption in a fixed bed of wheat straw. Process, Process Saf. Environ.Prot,2008; 86: 259-267.
5. Goyal P, Srivastava S. Characterization of novel Zea mays based biomaterial designed for toxic metals biosorption. J. Hazard. Mater.2009; 172: 1206-1211.
6. Sheng-geo Lu, ShiQiangBai, Hong-dan Shan. Characterization of novel Zea mays based biomaterial designed for toxic metals biosorption. J Zhejing University Science A, 2008; 9:125-132.
7. FengD, Van Deventer, AldrichC. Removal of pollutants from acid mine waste water using metallurgical by-product slags. Separation and Purification Technology,2007; 40(1):61-67.
8. Michaels AS. Simplified method for interpreting data in fixed-bed ion exchange. IndEngg chem.1952; 44:1922.
9. Johnston WA. Designing fixed bed adsorbersAnalyst,1972;79: 87.
10. Mckay G. Design models for adsorption systems in wastewater system. J Chem Tech Biotechnol.,1972; 31: 87.
11. Hutchins RA, New Method Simplifies Design of Activated Carbon Systems. J Am Chemfengs, 1973; 80:133.