**Research Journal of Chemical and Environmental Sciences**
Res J. Chem. Environ. Sci. Vol 4 [4S] 2016: 96-101
Online ISSN 2321-1040
CODEN: RJCEA2 [USA]

Website: www.aelsindia.com/rjces.htm

RJCES

FULL LENGTH ARTICLE

# Biosorption of Nickel (II) from Aqueous Solutions using Potato peel

**Keerti.K.Mahale, Maitreyi.M.G, Harsha .R. Mokhasi, Swathi.P.R*, H. S. Ashoka**
Department of Chemical Engineering, SDMCET, Dhavalagiri, Dharwad-580002.Karnataka, India.
* Email: prswathi23@gmail.com

**ABSTRACT**

*The paper highlights the utility of potato peel waste for treatment of Ni (II) from aqueous solution. Biosorption experiments were carried out in a batch process which includes the factors like pH, contact time, adsorbent dose and metal ion concentration. The maximum removal efficiency of Nickel (II) was 90% at pH 9.0 and contact time of 50 minutes. Langmuir and Freundlich isotherm models were applied to describe the equilibrium data. The biosorption was favourable under the experimental conditions. The biosorption rate increased as the biosorbent dosage increased. The results show that potato peel, has good potential for removal of nickel (II) as low cost biosorbent.*
***Keywords**: Biosorption, Ni (II), Potato peel waste, Langmuir Isotherm, Freundlich Isotherm*

## INTRODUCTION

Industrialization in many regions has increased the discharge of industrial wastes, especially those containing heavy metals, into natural water bodies or on land. Heavy metals such as nickel, copper, lead, chromium, etc., are hazardous to the environment. Their presence in the aquatic ecosystem poses human health risks and causes harmful effects to living organisms in water and also to the consumers of them [1]. The discharge of water containing heavy metals causes critical pollution problems. Nickel(II) ion is one such heavy metal frequently encountered in wastewater streams from industries such as electroplating, battery manufacture, mineral processing, steam– electric power plants, paint formulation, porcelain enameling, etc [2]. In India, the acceptable limit of nickel in drinking water is 0.01 mg/l and the industrial discharge limit in wastewaters is 2 mg/l [3]. The high concentration may cause headache, dizziness, nausea and vomiting, chest pain, tightness of the chest, dry cough and shortness of breath, rapid respiration, cyanosis and extreme weakness, pulmonary fibrosis, lung cancer, dermatitis renal edema, and gastrointestinal disorder [4]. Long-term exposure to high nickel concentration can cause lung, nose and bone cancer [5]. Conventional methods for removing metals from aqueous solutions include chemical precipitation, chemical oxidation or reduction, ion exchange, filtration, electro-chemical treatment, reverse osmosis, membrane technologies, and evaporation recovery. These processes may be ineffective or extremely expensive; especially when the metals in solution are in the range of 1–100 mg/l, the production of toxic chemical sludge and its disposal/treatment becomes a costly affair and is not ecofriendly [6]. Therefore, removal of toxic heavy metals to an environmentally safe level in a cost-effective and environment friendly manner was of great importance. Biological treatment, based on living or non-living microorganisms or plants, offers the reduction of toxic metal levels to environmentally acceptable limits in a cost-effective and environmentally friendly manner [7]. Biosorption is an innovative technology that employs inactive dead biomass for the recovery of heavy metals from wastewater [8]. The big advantages of biosorption are the low operating cost, minimization of the volume of chemical and or biological sludge to be disposed of, and high efficiency in detoxifying very dilute effluents [9]. The objective of the work was to investigate the potential use of potato peel waste for biosorption of nickel from aqueous solution. The factors that affect biosorption capacity such as pH, contact time, metal ion concentration and adsorbent dosage were examined.

## MATERIALS AND METHODOLGY

### Preparation of adsorbent

Potato peel waste was obtained from local potato chip making units. It was washed with HCl followed by rinsing with distilled water and dried in an oven at 60°C for 24 hours. The dried biomaterial was ground using domestic mixer and sieve analysis was performed. The particles of 0.147 mm (100 mesh no) was selected. The peel was stored in airtight bottles for further use.

**Batch experiments**

Removal efficiency was investigated by usual batch adsorption experiment. Stock solution of nickel was prepared by using by dissolving 447.9 mg of Nickel sulphate hexahydrate in 1000mL of double distilled water. Standard solutions of required concentrations were prepared by diluting the stock solution. pH of solutions was adjusted with 0.1 M HCl/0.1 M NaOH solutions as required. Batch adsorption experiments were conducted by taking 50- mL solution of Ni (II) in 350 mL of reagent bottles at desired pH value, contact time, adsorbent dose, and adsorbate concentration. The experiment was conducted with at an agitation rate of 200 rpm at room temperature. The adsorbent was separated from the aqueous solutions by centrifugation and the residual concentration of Ni (II) in each set was determined by using an UV spectrophotometer (APHA 1985).The amount of nickel ion adsorbed on biosorbent was calculated using this equation:

$$\frac{Ci - Ce}{m} V = qe$$

Where, qe is the metal ion adsorbed (mg metal ion /gm biosorbent at equilibrium) ,V is the volume of solution, Ci and Ce are the initial and equilibrium concentration of metal ion(mg/lt) and m is the dry weight of biosorbent in gm.

## RESULTS AND DISCUSSION

**Effect of pH**

As the pH increased from 4 to 11, the biosorption efficiency increased from 5 to 90 %. The optimum pH is 9 as shown in Fig 1. The low biosorption efficiency of nickel at lower pH values could be attributed to the high concentration of proton in the solution which competed with metal cations in forming a bond with active sites. At lower pH, the biomass undergoes protonation which lead to decrease in electrostatic force of attraction between the sorbent and sorbate cations. At higher pH, the biosorption increases due to deprotonation of the biosorbent surface which lead to increase in electrostatic force of attraction between the sorbent and sorbate cation. The present results coincide with [10], who has reported using pseudomonas fluoroscenes.

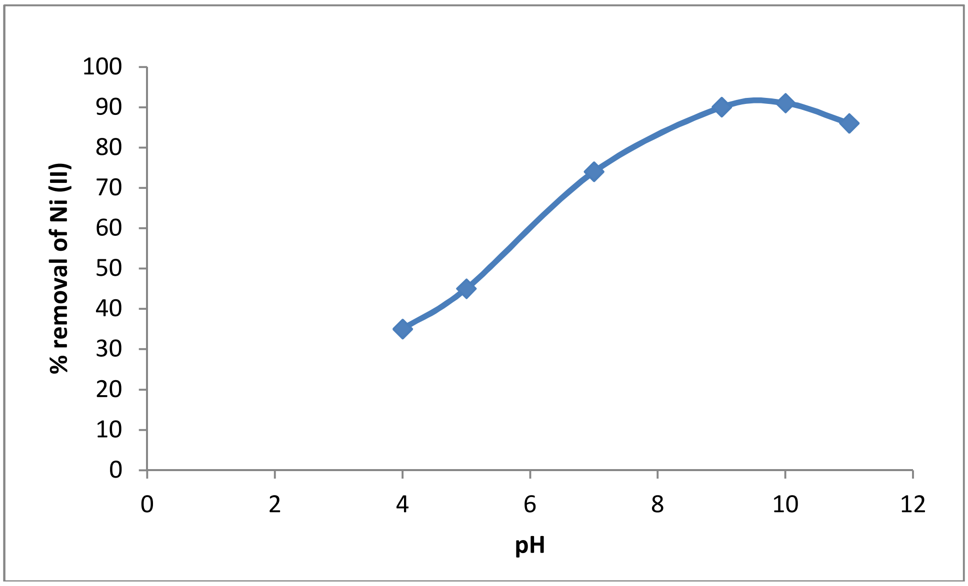


**Fig 1: Variation of % removal of Ni with pH**

**Effect of Adsorbent dosage**

Dosage is one of the important parameter for determining the adsorption of Ni (II). Different dosages ranging from 0.1 to 1.6 g of the adsorbent was taken for the removal of Ni (II). The maximum adsorption with respect to dosage was at 1.4g/L. The Fig. 2. shows the optimum dosage of adsorbent. It also shows that, the biosorption efficiency increased from 30% to 90% as the biosorbent dosage was increased from 0.2 g to 1.6 g. This can be attributed to the fact that, an increase in biosorbent dosage increases the surface area of biosorbent leading to an increase in the number of metal binding site on the biosorbent surface.

 

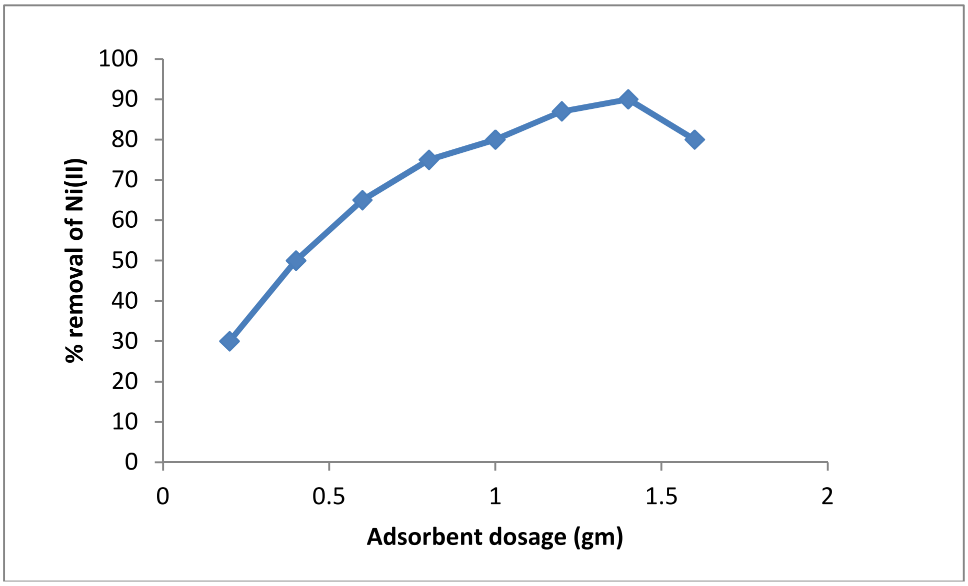


**Fig 2:** Variation of % removal of Ni with adsorbent dosage

**Effect of Initial ion concentration**

The effect of the initial ion concentration on percentage removal of nickel was studied using different values of nickel ion concentration i.e., 100 ppm, 150 ppm, 200 ppm, 250 ppm,300 ppm, 350 ppm.The percentage removal of Ni was low for the least concentration of Ni (II) and it increased as the concentration of Ni (II) increased. The maximum percentage of Ni (II) in aqueous solution was at 250 ppm at desired pH-9, contact time 50 min. As the metal ion to adsorbent ratio increases, the higher energy sites are saturated and adsorption begins on lower energy sites, resulting in decrease of adsorption efficiency.

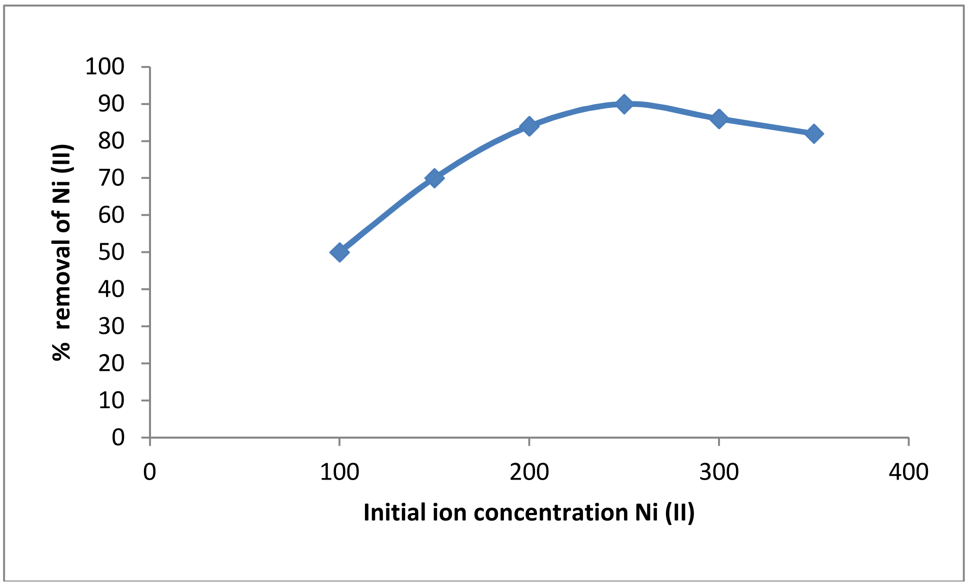


**Fig 3: Variation of % removal of Ni with Initial concentration**

**Effect of Contact time**

The adsorption capacity was studied with the effect of contact time. The time interval was from 10 to 70 min. Equillibrium time is a crucial parameter for an optimal removal of metal ions in the waste water. The maximum adsorption was attained at 50 min. After 50 min it was static throughout the experiment. The results are as shown in Fig 4. There was no significant change in Ni adsorption after 50 minutes [11]. The initial rapid rate of adsorption was may be due to the availability of positively charged surface of the adsorbent for anionic species present in the solution. The later slow adsorption rate was due to electrostatic hindrance caused by already adsorbed negatively charged adsorbate species and the slow pore diffusion of ions.

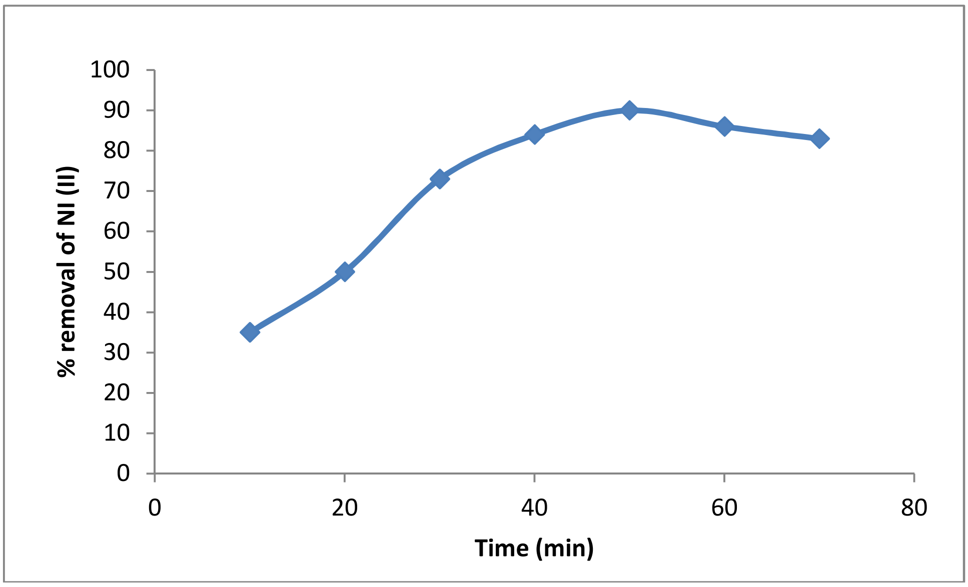


**Fig 4: Variation of % concentration of Ni with Contact time**

**ADSORPTION ISOTHERMS**

The application of adsorption isotherm models to the equilibrium data is important to optimize the design of the biosorption system for the removal of the metal ions. The most common adsorption isotherm models like Langmuir and Freundlich have been tested in the present study.

The **Langmuir adsorption isotherm** is based on the assumptions that maximum adsorption occurs when a saturated monolayer of solute molecules is present on the adsorbent surface, the energy is constant, and there is no migration of adsorbate molecules in the surface plane. Langmuir model (Langmuir, 1918) is represented as follows:

$$\frac{Ce}{qe} = \frac{1}{b\ qmax} + \frac{Ce}{qmax}$$

Where, Ce is the equilibrium concentration (mg/L), qe and qmax are the equilibrium and maximal adsorption capacity (mg/g), respectively and b is the equilibrium constant.

The graph of Ce / qe vs. Ce was plotted on contact time where, intercept and the slope can be obtained. The Coefficient correlation $R^2$ is 0.373 and qmax is 2.702 shown in Fig. 5

The **Freundlich adsorption isotherm** is an empirical model that is based on sorption on a heterogeneous surface [12].

The equation is as follows: $\ln qe = \ln Kf + \frac{1}{n} \ln Ce$

The constant n is an empirical parameter with the degree of heterogenity and Kf is a constant related to adsorption capacity. The values of n and Kf which is constant can be determined by the plot Ce and qe (Slope = 1/n, Intercept = Kf) as shown in Fig. 6.The results are represented in Table 1.

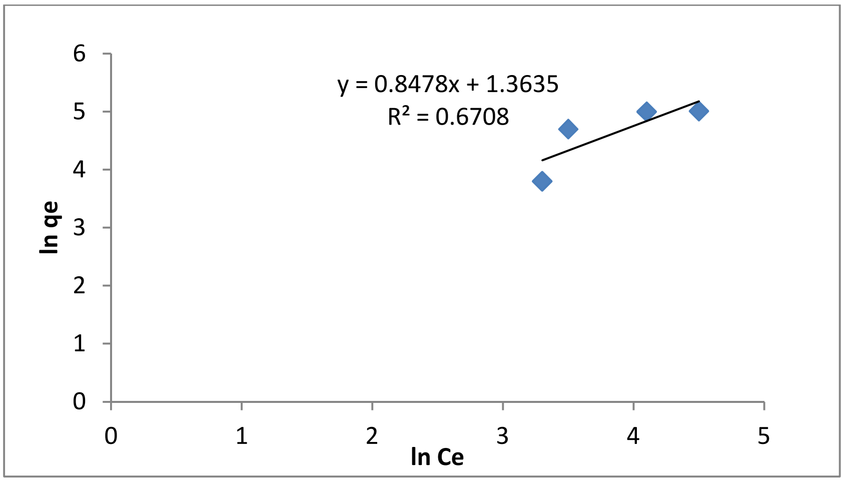


Fig 5: Freundlich plot for biosorption of Ni by potato peel

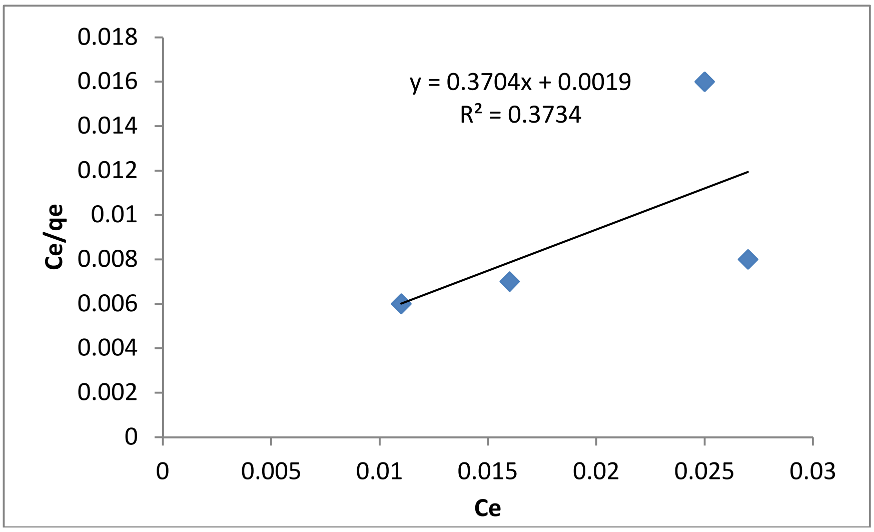


**Fig 6: Langmuir plot for biosorption of Ni by potato peel**

**Table 1: Values of Langmuir and Freundlich constants**

| Metal | Langmuir | | | Freundlich | | |
|---|---|---|---|---|---|---|
| Ni (II) | $q_{max}$ (mg/g) | b(1/mg) | $R^2$ | $K_f$ | n | $R^2$ |
| | 2.702 | 0.0370 | 0.373 | 3.907 | 1.18 | 0.67 |

## CONCLUSION

The potential of potato peel waste for the removal of nickel from aqueous solution was dependent on process parameters such as pH, initial concentration of nickel biosorbent dosage and contact time. The adsorption was found to be highly dependent on pH. Higher removal was obtained at 9.0 pH. The equilibrium was attained rapidly and the adsorption rate increased with an increase in the biosorbent dosage. The equilibrium data were tested using Langmuir and Freundlich adsorption isotherm models. The data fitted well to both isotherms. The value of n=1.18 indicates that, the adsorption efficiency is higher. Hence potato peel is better adsorbent for Ni adsorption. This study revealed that potato peel waste is promising biosorbent for the removal of nickel from aqueous water.


## ACKNOWLEDGEMENT

We are thankful to the Department of Chemical Engineering, SDMCET ,Dharwad for providing us the necessary facilities and support for completing the work.


## REFERENCE


1. Vilar, V. J. P., Botelho, C.M.S., and Boaventura, R.A.R., (2005). Influence of pH ionic strength, and temperature on lead biosorption by Gelidium and agar extraction algal waste. Process Biochemistry, 40: 3267-3275.
2. Borba, C. E., Guirardello, R., Silva, E. A, Veit, M.T, and Tavares, C. R. G., (2006). Removal of nickel(II) ions from aqueous solution by biosorption in a fixed bed coloumn: Experimental and theoretical breakthrough curves. Biochemical Engineering Journal, 30: 184-191.
3. Kadirvelue, K., Thamaraiselvi, K., and Namasivayam, C.,(2001). Adsorption of nickel(II) from aqueous solution onto activated carbon prepared from coirpith. Separation and Purification Technology, 24: 497–505.
4. Ewecharoen A, Thiravetyan P, Nakbanpote W (2008) Comparison of nickel adsorption from electroplating rinse water by coir pith and modified coir pith. Chem Eng J 137:181–188.
5. Liu, C-C., Kuang-Wang, M., and Li, Y-S., (2005). Removal of nickel from aqueous solution using wine processing waste sludge. Industrial and Engineering Chemistry Research, 44: 1438-1445
6. Nourbakhsh, M., Sag, Y., Ozer, D., Aksu, Z., Katsal, T., Calgar, A., 1994. A comparative study of various biosorbents for removal of chromium (VI) ions from industrial wastewater. Process Biochemistry 29, 1–5.
7. Volesky, B., 1994. Advances in biosorption of metals: selection of biomass types. FEMS Microbiology Review 14, 291–302
8. Yuan, H-p., Zhang, J-h., Lu, Z-M., Min, H., and Wu, C., (2009). Studies on biosorption equilibrium and kinetics of Cd2+ by Streptomyces sp. K33 and HL12. Journal of Hazardous Materials, 164: 423-431
9. Gabr, R.M., Hassan, S.H.A., and Shoreit, A.A.M., (2008). Biosorption of lead and nickel by living and non-living cells of Pseudomonas aeruginosa ASU 6a. International Biodeterioration and Biodegradation, 62: 195-203.


 

10. Lopez, A., Lazaro, N., Priego, J. et al. J Ind Microbiol Biotech (2000).Effect of pH on the biosorption of nickel and other heavy metals by pseudomonas fluoroscenes 4F39 24: 146. doi:10.1038/sj.jim.2900793
11. M.Arshadi, M.J.Amiri, S.Mosavi.,(2014).Kinetic , equilibrium and thermodynamic investigations of Ni(II), Cd(II) and Co(II) adsorption on barley straw ash.IJAST, 90-99.
12. H. Freundlich. J .Am. Chem Soc., 1939, 61, 2.

## CITE THIS ARTICLE

Keerti.K.Mahale, Maitreyi.M.G, Harsha .R. Mokhasi, Swathi.P.R, H. S. Ashoka. Biosorption of Nickel (II) from Aqueous Solutions using Potato peel. Res. J. Chem. Env. Sci. Vol 4 [4S] 2016. 96-101

 