JPIChE 50 (2) 2022: 77-81

Journal of Pakistan Institute of Chemical Engineers

Since 1969

Journal homepage: www.piche.org.pk/journal

DOI: https://doi.org/10.54693/piche.05027

Check for updates

Removal of Nickel Ions from Aqueous Solution Using Treated Rice Husk: An Adsorption Study

M.Z. Irfan[1], S. Qamar[2], U. Saeed[2], M. Ali[2], W. Aleem[3], N. Qamar[4], A. Shahid[5], Z. Rehman[4]*

Submitted: 03/08/2021, Accepted: 06/03/2023, Online: 08/03/2023

Abstract

This article deals with the biosorption of nickel metal on the surface of rice husk and its acid treated form experimentally. Various parameters were studied such as time, concentration of synthetic solution, pH and bio sorbent dose to find the effect of adsorption of nickel metal on the surface of rice husk. Equilibrium time was found to be 92 min. It has been found that the adsorption is increased with the increase in contact time. Acid treated rice husk has good ability to remove highest amount of nickel in comparison with raw form of rice husk. The percentages for the removal of nickel was achieved as 86% and 66% for treated and raw rice husk respectively. It has been observed that the adsorption efficiency was found to be increase with the increase in initial concentration of wastewater initially and then decreased because of rice husk particles saturation.

Keywords: Bio-sorption; Treated Rice Husk; Adsorbent; Metal Removal; Spectroscopy

1. Introduction:

The inorganic pollutants like metal ions which are present in our environment causes a lot of problems, like cancer, skin, blood sugar and cholesterol decrease and increase respectively, damage of liver and kidney, nausea, carcinogen and asthma [1]. The metal compounds which are very toxic in nature and continuously attacking the surface of earth not only create the problems for earth water like reservoir, seas, ponds and lakes but also contaminate the water coming from snow, rain and soil leakage [2-4]. The increase in population around the world also requires the industrial growth. This industrial growth as well as accommodating the peoples, also causing the problems like harmful industrial chemicals discharge in which heavy metals like nickel, copper, cobalt and zinc etc. are very important and dangerous to human life [5-7]. Table 1 represents the source of discharge in relation with respective metal. These heavy metals have a tendency of bioaccumulation and toxic nature which made them very effective chemicals [8].

[1] *Department of Education, Govt. of Punjab, Pakistan*
[2] *Department of Chemical Engineering, Muhammad Nawaz Sharif University of Engineering and Technology, MNSUET 60000, Multan Pakistan*
[3] *Department of Chemical, Petroleum and Petrochemical Technology, Mir Chakar Khan Rind University of Technology, Dera Gazi Khan*
[4] *Faculty of Civil Engineering, University of Engineering and Technology, UET, Lahore Pakistan*
[5] *Department of Mechanical Engineering and Technology, Muhammad Nawaz Sharif University of Engineering and Technology, MNSUET 60000, Multan Pakistan*
Corresponding Author: zahidirfan37@yahoo.com

Table 1: Sources of discharge in relation with the metals.

Metal	**Sources**
Antimony	Industries like ceramic, paint, enamel, casting, bearing and sheets.
Arsenic	Ceramic, dyes, wood and pesticides effluent industries, Mineral ores.
Chromium	Waste water of industries like leather and mining, electroplating, galvanometric, pigments and film production and dyes.
Cobalt	Mostly contaminated water
Manganese	Industries like mining, tanneries, fertilizer, electroplating and petrochemicals.
Mercury	Waste water from industries like pulp and paper, chloralkali, oil refining, battery and pharmaceutical.
Lead	Effluents of gasoline, alloys, sheets and battery production industries.
Nickel	Waste water from aircraft industries, electroplating of nickel, dyes and pigments.
Zinc	Thermoplastic and municipal waste water plants discharge.

Now a day's metal ions are considered a very important pollutant because of its toxicity nature in our ecosystem of natural water [9]. The major problems of metal ions are like non-biodegradable, highly environmentally persistent, accumulation in the living tissues of human beings. The toxicity of these heavy metals can damage our many body internal parts like tissues, liver, kidneys, blood level circulation and other functions. Table 2 represents the major body diseases caused by the heavy metals [10].

Table 2: Diseases/Problems in relation with the heavy metals.

Metal	**Problems and Diseases**
Arsenic	Cancer, skin damage and circulatory system problems.
Antimony	Blood sugar level decrease and blood cholesterol level increases.
Barium	Increase in level of blood pressure
Beryllium	Lesions intestinal
Cadmium	Damage of kidney
Chromium	Allergic diseases
Copper	Damage of liver and kidney, gastro intestinal stress.
Lead	Children problems: Mentally and physically slow growth, a very slow level of to get attention and to learn quickly. Adults problems: High level of blood pressure and kidney damage.
Inorganic Mercury	Lungs and liver damage
Selenium	Problems of circulatory system, loss of hairs and fingernails, toes or fingers numbness problems.
Nickel	Asthma, nausea, cough, carcinogen and dermatitis

Various techniques were found for the removal of metals from wastewater in the form of reverse osmosis, extraction of solvent, dialysis or membrane process. Sludge formation, high amount of chemicals along with high cost make them less effective [11]. Due to high cost, there is increase in interest of removal of heavy metals by cost effective methods are needed. Agricultural waste such as wheat straw, rice straw, sawdust, coconut husk etc. are found to be effective for the removal of metals along with the advantage of waste utilization and cost effectiveness [12-14].

From the last some years, focused has been made on the use of treated or modified form of agricultural wastes that may be acid or chemical treated form or ash form or pyrolysis form for the removal of heavy metals. In this study, a comparative analysis has been made for removal of nickel metal ions using rice husk and its modified acid treated form for the wastewater treatment under different conditions of batch experimentations.

2. Materials and Methods:

2.1 Reagents:

Nickel chloride ($NiCl_2.6H_2O$), sodium hydroxide (NaOH) and nitric acid (HNO_3) were used in the study. All the chemicals were of analytical grade and purchased form Sigma Aldrich with purity of 99%. Agricultural waste, rice husk, was obtained from Amir Rice Traders pvt. Ltd (Kamonkey, Lahore).

2.2 Preparation of Sorbent:

Initially rice husk is washed with tap water and placed in a desiccator to dry it and to avoid it form dust that may build up on the rice husk surface. The dried rice husk is then grinded to crush completely in powder form. This grinded rice husk is then sieved through 70 mesh size screens. The obtained product from the sieved form is then stored in a closed jar to safe the material form moisture attack. Modified treated rice husk was prepared by its treatment with nitric acid and adopt the same procedure as for raw rice husk discussed above.

2.3 Experimental:

100ml sample solution of nickel chloride was taken. Add 0.2 gram of rice husk absorbent in it. Put it on the vibratory shaker at 120 rpm. Filtered it and find the quantity of metal removed through the atomic absorption spectrophotometer (Shimadzu, AA-6200) against the nickel standard solutions. The metal uptake was found by the given formula [8].

$$q_e = \frac{(C_i - C_f)V}{W} \qquad (1)$$

Where

q_e = Metal uptake (mg/g)
W = Mass of the absorbent (gm)
V = Volume of the solution (liter)
C_i = Initial Concentration (ppm)
C_f = Final Concentration (ppm)

3. Results And Discussion:

3.1 Determination of equilibrium time:

Figure 1 represents the nickel metal uptake on the surface of rice husk from the aqueous solution in relation with time for both raw and treated form of rice husk. It can be noticed that the equilibrium time for uptake of nickel metal are found 92 minutes for RRH and TRH. The amount of nickel adsorbed increased with increase in their contact time. It was found that acid treated rice husk has good ability to remove highest amount of nickel in comparison with raw form of rice husk. Similar results have been found from Ahmad et al (2015) for the removal of nickel metal using coconut husk [8].

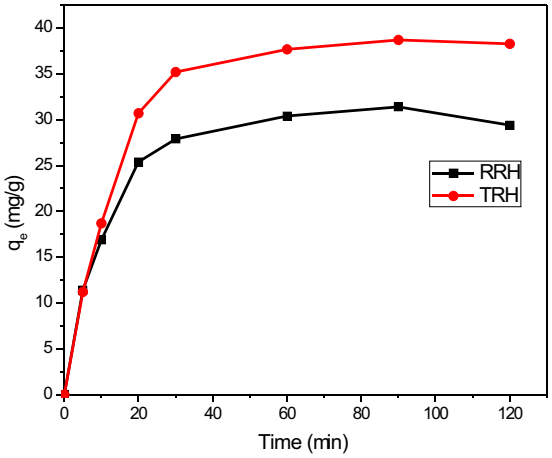

Figure 1: Nickel metals uptake vs time for raw rice husk (RRH) and treated rice husk (TRH) with 0.2gm adsorbents dose.

4.2 Effect of pH on Biosorption of Nickel:

pH of the medium plays a very important role on the biosorption of nickel metal. Figure 2 showed the relation of nickel metal uptake verses time at pH=4 of the solution. It is concluded from Figure 2 that TRH showed good performance in comparison with RRH for the removal of nickel. Figure 3 showed the nickel metal uptake verses time at pH=5. Similar behavior can be seen as for pH=4. Figure 4 showed the relation of nickel metal uptake verses time at pH=5 of the solution. It can be noticed from the Figures (2-4) that a rapid increase of nickel metal uptake was developed in starting 20 minutes and after that in 90 minutes maximum nickel metal uptake was developed. Figures (2-4) revealed the maximum uptake for the nickel metal for pH=5 in comparison with pH=4 and pH=6 respectively.

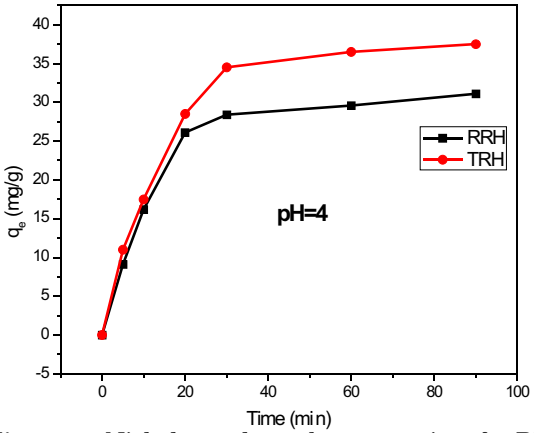

Figure 2. Nickel metal uptake verses time for RRH and TRH at pH=4 with adsorbent dosage = 0.2gm

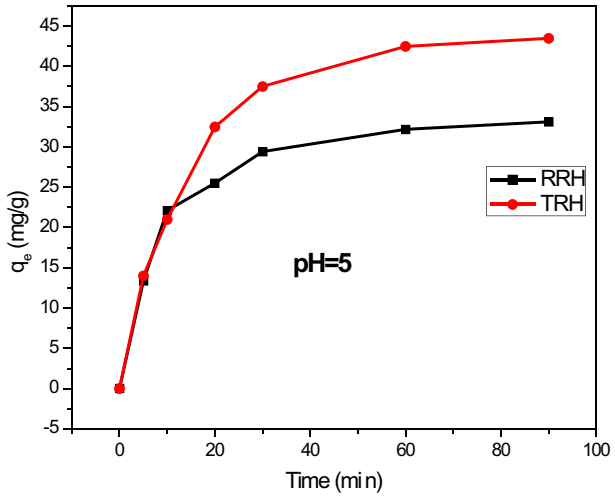

Figure 3. Nickel metal uptake verses time for RRH and TRH at pH=5 with adsorbent dosage = 0.2gm \

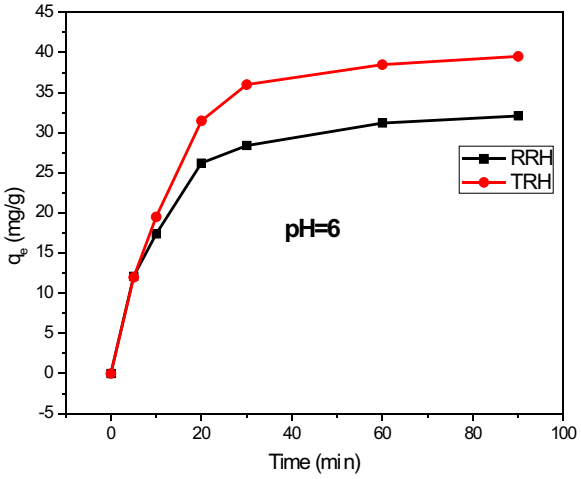

Figure 4. Nickel metal uptake verses time for RRH and TRH at pH=6 with adsorbent dosage = 0.2gm

4.3 Effect of Concentration:

The effect of initial metal concentration was found by varying the metal concentration from 50-200 ppm with the constant pH=5 and bio-sorbent dose of 0.2 gram as shown in Figure 5. The comparison between raw rice husk and treated rice husk has made for uptake of metal at different concentration. It was shown that the uptake of nickel metal was found higher with the treated rice husk as compared to raw rice husk. It can be seen that the removal of nickel was increased with the increase in the concentration of the solution.

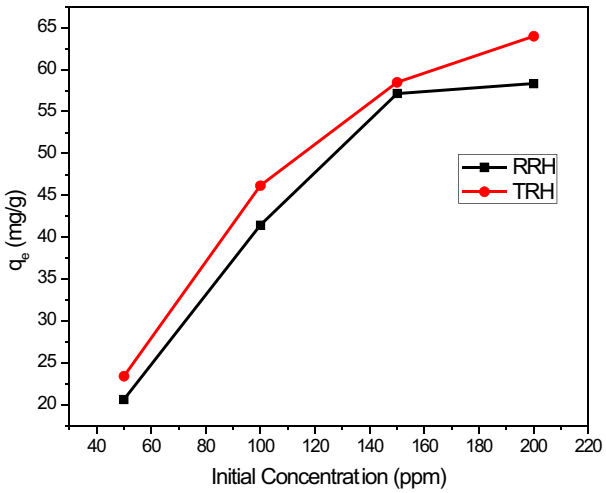

Figure 5. Nickel metal uptake verses initial concentration of solution for RRH and TRH at optimum pH with adsorbent dosage = 0.2gm

4.4 Effect of Bio-sorbent Dose:

Figure 6 denotes the nickel metal uptake with the variation of adsorbent dosage at constant pH and initial metal concentration. Maximum nickel metal uptake was found at 0.2gm of adsorbent dosage both for RRH and TRH. TRH showed higher removal of nickel metal as compared to RRH as shown in Figure 6.

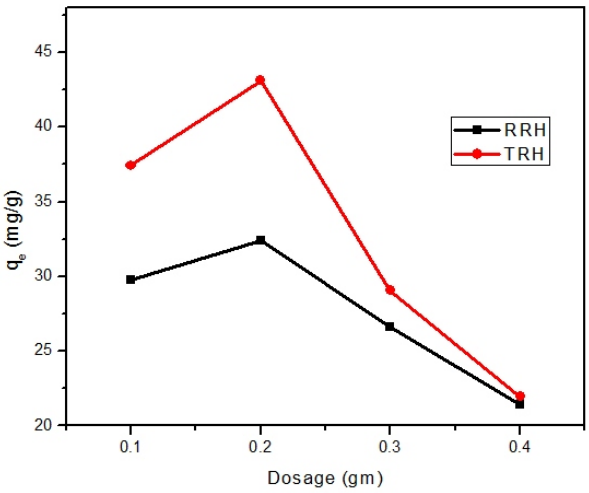

Figure 6. Nickel metal uptake verses adsorbents dosage for RRH and TRH at optimum pH and 100ppm initial metal concentration

4. Conclusions:

This study was performed to determine the adsorbing capacity of nickel metal uptake on raw rice husk in comparison with treated rice husk. This study concluded that the acid treated modified rice

husk is more efficient than the raw rice husk as an adsorbent for the removal of nickel. Maximum time duration was found for nickel bio-sorption to be 92 minutes. It has been found that 86% nickel was removed from modified rice husk and 66% was removed by raw rice husk. It is evaluated that due to the presence of mostly active forces in the treated rice husk has proven its more absorption efficiency rather than the raw rice husk.

References:

1. A. K. Meena, K. Kadirvelu, G. K. Mishraa, C. Rajagopal, P. N. Nagar. "Adsorption of Pb (II) and Cd (II) metal ions from aqueous solutions by mustard husk." J Hazard Mater 2008; 150:619-25
2. M. Kilic, C. Kirbik, O. Çepelioðullar, A. E. Putun. "Adsorption of heavy metal ions from aqueous solutions by bio-char, a by-product of pyrolysis." Appl Surf Sci 2013; 283:856-62.
3. A. Sari, O. D. Uluozlu, M. Tuzen. "Equilibrium, thermodynamic and kinetic investigations on biosorption of arsenic from aqueous solution by algae (Maugeotiagenuflexa) biomass." Chem Eng J 2011; 167:155-61
4. M. Iqbal, A. Saeed, R. G. J. Edyvean. "Bioremoval of antimony (III) from contaminated water using several plant wastes: Optimization of batch and dynamic flow conditions for sorption by green bean husk (Vigna radiata)." Chem Eng J 2013; 225:192-201.
5. V. Vinodhini, N. Das. "Relevant approach to assess the performance of sawdust as adsorbent of chromium (VI) ions from aqueous solutions." Int J Environ Sci Technol 2010; 7:85-92.
6. W. Guo, R. Chen, Y. Liu, M. Meng, X. Meng, Z. Hu. "Preparation of ion-imprinted mesoporous silica SBA-15 functionalized with triglycine for selective adsorption of Co(II). Colloids Surfaces." A Physiochem Eng Asp 2013; 436:693-703.
7. H. A. Hasan, S. R. S. Abdullah, N. T. Kofli, S. K. Kamarudin. "Isotherm equilibria of Mn2+ biosorption in drinking water treatment by locally isolated Bacillus species and sewage activated sludge." J Environ Manage 2012; 111:34-43.
8. S. Ahmad, M. A. Kazmi, N. Feroze, A. Khan, Z. Ashraf, "Ni (II) Removal by bio-sorption using the coconut husk, Sci. Int. 2015: 27:4833-4836
9. E. I. El-Shafey. "Removal of Zn(II) and Hg(II) from aqueous solution on a Carbonaceous sorbent chemically prepared from rice husk." J Hazard Mater 2010; 175:319-27.
10. EPA, National Primary Drinking Water Regulations: List of Contaminants and their Maximum Contaminant Levels (MCLs)., updated on June 2013.
11. A. Demirbas. "Heavy metal adsorption onto agro-based waste materials: A review." J Hazard Mater 2008; 157:220-9.
12. I. Alomá, M. A. Martín-Lara, I. L Rodríguez, G. Blázquez, M. Calero. "Removal of nickel (II) ions from aqueous solutions by biosorption on sugarcane bagasse." J Taiwan Inst Chem Eng 2012; 43:275-81.
13. W. W. Ngah, M. M. Hanafiah. "Removal of heavy metal ions from wastewater by chemically modified plant wastes as adsorbents: a review." Bio resource Technol 2008; 99:3935-48.
14. M. Ahmaruzzaman. "Industrial wastes as low-cost potential adsorbents for the treatment of wastewater laden with heavy metals." Adv Colloid Interface Sci 2011; 166:36-59.
15. S. Qamar, A. S. Khawaja, A. Umer, N. Ramzan, N. Ullah. "Equilibrium and Kinetic Studies on the Removal of Cu(II) from Aqueous Solution Using Acid Treated Modified Rice Husk: A Comparative Study." JPIChE 2020; 48:27-34.
16. R. Sathya, M. V. Arasu, N. A. Al-Dhabi, P. Vijayaraghavan, S. Ilavenil, T.S. Rejiniemon."Towards sustainable wastewater treatment by biological methodsA challenges and advantages of recent technologies." Urban Climate. 2023; 47:101378