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Utilization of Rice Husk for Removal of Nickel from Metal Injection Molding Industry Effluent

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Abstract: *The present study investigates the utilization of rice husk for removal of nickel from metal injection molding industry effluent. Batch adsorption process was carried out with initial concentration of nickel by varying amount of adsorbent, pH, reaction time under constant shaking of 100 ml sample in heavy rotatory shaking apparatus for 2 hours. Analysis of physicochemical parameters was also carried out. The result revealed that adsorbent was found to be efficient in removal of Nickel. About 92.32% of nickel was eliminated by 8gm of Rice husk per 100ml of 50% concentrated effluent in 2hours treatment period at pH9. Characterization of rice husk was performed by powder X- Ray diffraction and to know the size, compositions, and crystal structure SEM and BET analysis has been conducted.*

Keywords: *Atomic Adsorption Spectrometer, Brunauer–Emmett–Teller (BET), Rice husk, Scanning Electron Microscope, X- Ray diffraction*

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I. Introduction

The presence of heavy metals in water, domestic waste and industrial effluents is a subject of serious concern due to the toxic properties of materials. They affect public health to a large extent. The impact of heavy metals in drinking water containing traces of heavy metals is dangerous for health in the long-run. Nickel is one of the heavy metal which is used for the manufacturing process in Metal Injection Molding industry. It is a non-biodegradable toxic metal which causes chronic bronchitis, reduced lung function, cancer, nasal sinus, etc. Therefore it is very important to remove nickel before discharging industrial waste water into the environment.
Adsorption process is one of the best water treatment technology among various available methods. Adsorbent removes different pollutants in an easy way with very less expense and is eco-friendly in nature. Rice husk is used as adsorbent to remove nickel from metal injection molding industry effluent. In the present study the utilization of rice husk for the removal of nickel from industry waste water and effects of various parameters such as initial concentration of effluent, adsorbent dosage and pH has been investigated.

II. Materials and Methods

2.1 Adsorbent

Rice husk was collected from a rice mill in Ripponpete, Shivamogga Dist , Karnataka State. It was washed with distilled water, dried in an oven at about 60^0C for 4h and again was washed with acetone and NaOH (0.3M) to remove dirt and other contaminants. Then dried in an oven at about 60^oC for 4h and crushed until powdered fine particles are obtained. The powdered sample of Rice husk was examined by XRD (X-Ray Diffraction), SEM and BET analysis the degree of crystallization i.e. crystal structure, compositions, and size.

2.2 Instrumentation

1.	**Characterization of rice husk**	-X- Ray diffraction (Rigaku) using Cu-K$\propto$Diffractro meter radiation (105406A^o) in a $\theta - 2\theta$ configuration
2.	**The average size of rice Husk powder**	-Calculated using Debye Scherrer's formula equation
3.	**The morphology of rice husk powder**	- Scanning Electron Micrograph.

4.	**A Specific Surface Area (SSA)**	-Brunauer–Emmett–Teller (BET) at 77 K, Nitrogen adsorption–desorption (NOVA-1000-Version 3.70 Instrument).
5.	**Heavy metal analysis (Ni)**	-Atomic Adsorption Spectrometer [1]

2.3 **Batch experiment**

To determine the adsorption capacity of nickel, batch experiments was conducted and general method is explained below.

A known weight of rice husk with 100ml effluent of different concentration in a conical flask was kept for treatment in heavy rotatory shaking apparatus for 2 hours. After the treatment using whatman no41 filter paper samples were filtered and measured by AAS. Further experiments were carried out based on the results obtained.

The effect of different parameters, adsorbent, pH on the adsorption was carried out. pH was adjusted by HCL and NaOH. The percent removal of Nickel was calculated by formula

$$\text{Percent removal} = \frac{(C_o - C_i)}{C_o} \times 100 \qquad \textbf{(Eq 1)}$$

Where, Co is initial concentration and C_i is final concentration of Nickel metal.

2.4**Characterization of rice husk:**

2.4.1.**X- Ray diffraction (XRD)**

Using Cu-K$\propto$ radiation (105406A^o) in a $\theta - 2\theta$ configuration, characterization of rice husk powder was performed by X- Ray diffraction (RigakuDiffractro meter). The average crystalline size of examined powdered rice husk was found to be around **28nm** and it was calculated using Debye Scherrer's formula equation.

$$D = (K\lambda / (\beta cos\theta)) \qquad \textbf{(Eq.2)}$$

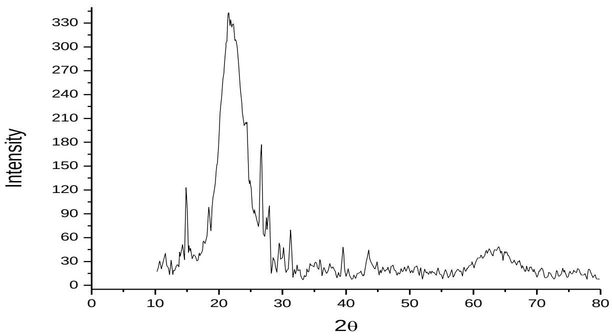


Fig 1: XRD of the powdered rice husk

2.4.2**Scanning Electron Microscope (SEM)**

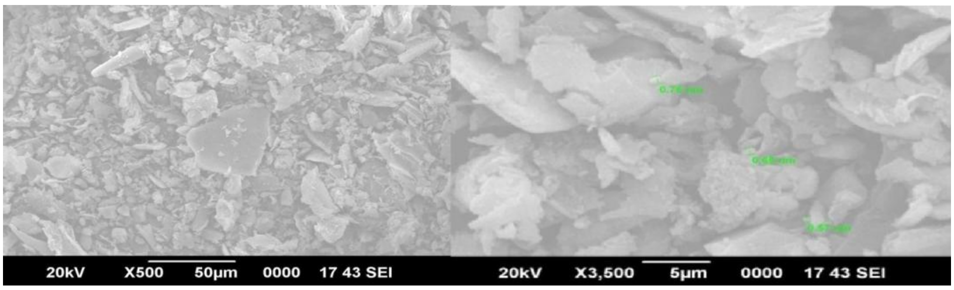


Fig 2: Scanning Electron Micrograph of powdered rice husk.

The SEM image of powdered rice husk is shown in fig: 2 indicate the aggregation particles and cluster shape with sharp edge [2]

2.4.3. **Bet Surface Analysis**

Table : 1 Surface properties of the powdered rice husk

Rice husk	Surface area	Pore volume	Average pore diameter
	13.386m^2/g	0.022cc/g	1.557nm

III. Result and Discussion

A known weight of rice husk with 100 ml effluent of different dilutions was kept for treatment in heavy rotatory shaking apparatus for 2 hours. Initial concentration of nickel was determined and found to be as follows: Nickel 14.97mg/l in 25% concentration, 17.98mg/l in 50% concentration, 20.19mg/l in 75% concentration and 23.11mg/l in raw effluent (100% concentration). After treatment samples were filtered using Whatman No. 41 filter paper and measured by AAS. The concentration of nickel reduced to 6.90mg/l (25% concentration), 5.55mg/l (50% concentration), 10.87mg/l (75% concentration) and 13.94mg/l (raw effluent) (Table 2). Maximum reduction of nickel 17.98mg/l (69.13%) was observed in 50% concentration (Fig 3) *i.e* from17.98±0.007 to 5.55±0.01 (Table 2), because of availability of more adsorption activated sites. Metal ions are easily adsorbed on vacant sites at low concentration. The percent removal of nickel was calculated by the formula (**Eq.1)**

To know the effect of adsorbent, experiment was carried out with different dosage of rice husk from 1-10g/100ml at pH7 in conical flasks in a heavy rotatory shaking apparatus for 2 hours. Maximum percentage removal nickel was 92.76% at 8gm/100ml in 50% concentration (Fig: 4).

Nickel reduced from of 17.98±0.007 to 1.29±0.005 (Table:3). It was observed that the percentage removal of nickel increased with increased adsorbent dose which means that with an increase in concentration of adsorbent, the availability of high active sites will increase the adsorption capacity which helps to remove the metal ion.

To know the effect of pH, experiment was carried out with a range of 1, 3,5,7,9 and11. The result shows that nickel increased from 30.36% to 92.32% (Table 4) (Fig 4) *i.e*, from 17.98±0.007to 1.38±0.005 in 50% effluent concentration. Maximum removal of nickel was at pH 9 with 8gms of rice husk and it slightly decreased at pH 11.The result shows that the removal of nickel by rice husk increases with increasing pH. Similar work has been reported by Mohammed *et al.*, (2013)[3] who worked on utilization of Iraqi rice husk in the removal of heavy metals from wastewater. Where nickel was reduced by 95.32%

IV. Tables And Graphs

Table:2 Concentration of nickel before and after treatment with rice husk

Concentration of Effluent	Nickel	
	Before	After
25%	14.97±0.007	6.90±0.005
50%	17.98±0	5.55±0.01
75%	20.19±0.007	10.87±0.01
100%	23.11±0.007	13.12±0.005

Fig: 3. Removal of nickel with rice husk at different effluent concentration

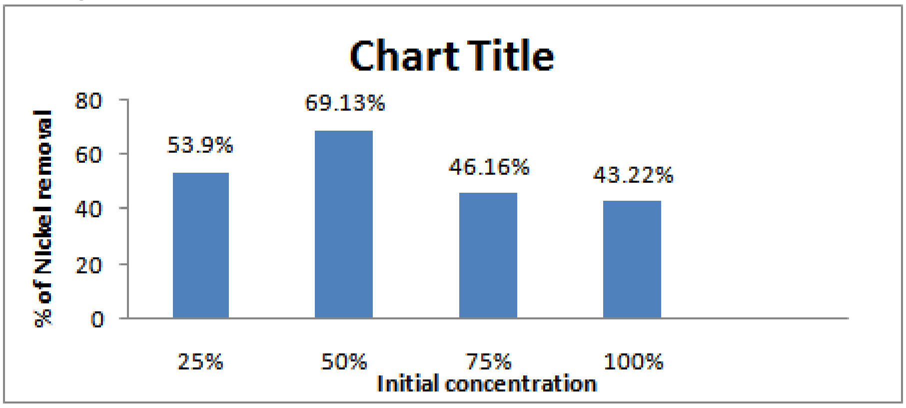


Table 3: Effect of adsorbent before and after treatment (1-10g/100ml at pH7)

Adsorbent dosage (gm)	Nickel	
	Before	After
1	17.98	9.88±0.01
2	17.98	8.96±0.01
3	17.98	7.79±0.01
4	17.98	6.96±0.005
5	17.98	5.64±0.01
6	17.98	4.40±0.005
7	17.98	2.96±0.01
8	17.98	1.29 ±0.005
9	17.98	1.40± 0.01
10	17.98	1.56± 0.01

Fig 4: Removal of nickel for different adsorbent dosage (1-10g/100ml at pH7)

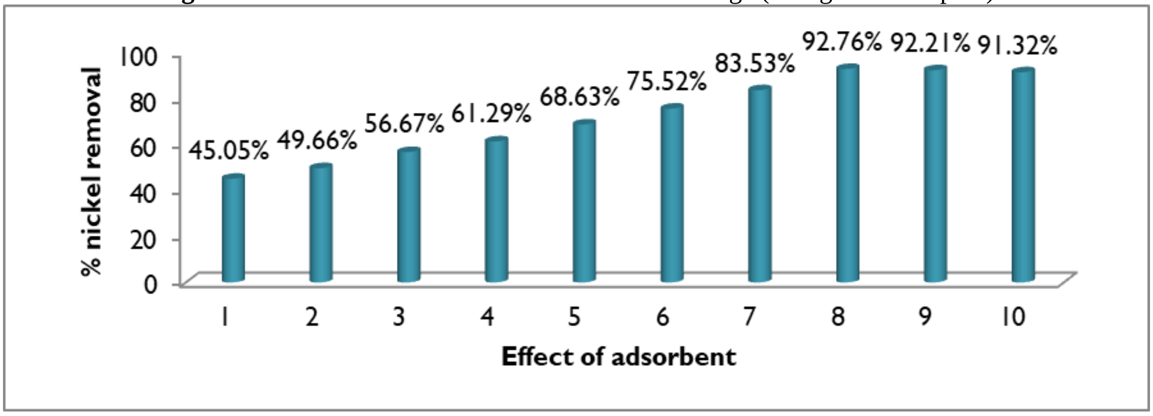
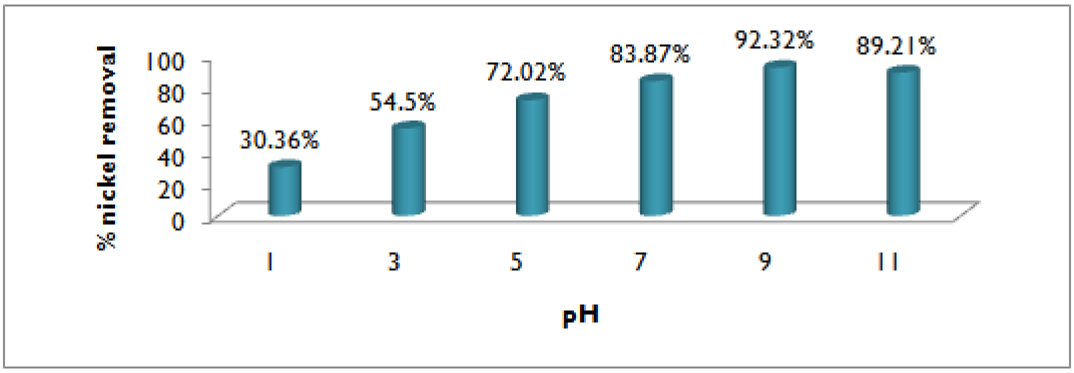


Table 4: Effect of pH on the adsorption of nickel before and after treatment with rice husk

pH range	Nickel	
	Before	After
1	17.98	12.52±0.01
3	17.98	8.18±0.01
5	17.98	5.03±0.01
7	17.98	2.90±0.005
9	17.98	1.38±0.005
11	17.98	1.94±0.005

Fig5: Effect of pH on the adsorption of nickel



V. Conclusion

Rice husk is easily available and on effective adsorbent to remove nickel from metal injection molding industry effluent. Adsorption of heavy metals is a new technology for treatment of wastewater. It is a user-friendly technique for the removal of heavy metals. Maximum removal efficiency of nickel was obtained at pH

9 in 2 hours for 8g/100ml with 50% concentration. The experiment shows that rice husk has the capacity to remove nickel from metal injection molding industry effluent without chemical treatment.

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