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COMPARATIVE ADSORPTION STUDIES OF RICE HUSK ASH AND PHOSPHATE TREATED RICE HUSK

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Abstract: Due to the discharge of large amounts of heavy metal-contaminated wastewater, industries bearing heavy metals are the most hazardous. Heavy metal removal can be achieved by conventional treatment processes but they have significant disadvantages, Adsorption has become one of the alternative treatments, in recent years; the search for low-cost adsorbents that have metal-binding capacities has intensified. One of which is the rice husk, a product of the rice industry. Rice husk ash from raw rice husk and chemically treated rice husk is used in the study for removal of heavy metals from industrial effluent. And their efficiencies are compared using the nearby electroplating industrial effluent. This attempt is to remove heavy metals from the effluent. Batch studies and column studies were performed to arrive at break through curve of the adsorbent bed and then the adsorptive capacity of the adsorbents is compared.
Key words: Adsorption, Batch studies, Column Studies, Rice husk ash (RHA), Phosphate treated rice husk (PRH)

1. INTRODUCTION

Due to the discharge of large amounts of metal- contaminated wastewater, industries bearing heavy metals, such as Cd, Cr, Cu, Ni, As, Pb and Zn, are the most hazardous among the chemical-intensive industries. Because of their high solubility in the aquatic environments, heavy metals can be absorbed by living organisms. Once they enter the food chain, large concentrations of heavy metals accumulate in the human body and cause serious health disorders. Therefore, it is necessary to treat metal-contaminated wastewater prior to its discharge to the environment. Heavy metal removal from inorganic effluent can be achieved by conventional treatment- ion exchange, chemical precipitation, and electrochemical removal. But they have significant disadvantages- incomplete removal, high-energy requirements, and production of Toxic sludge. Recently, numerous approaches have been studied for the development of cheaper and more effective technologies.

Adsorption using rice husk which is a product of the rice industry whose annual production provides 20% of husk. Rice husk ash from raw rice husk and chemically treated rice husk is used in the study for removal of heavy metals- chromium (VI) which is most toxic form and nickel (II) from industrial effluent. Presence of Chromium and nickel in human bodies above certain level may cause lung and nasal cancer, liver damage, renal damage, hyper tension and anemia.

2. METHODOLOGY

2.1 Adsorbent Preparation

2.1.1 Rice husk ash

The available rice husk was washed to remove suspended particles, dust and dirt. Further it is dried for 24hrs in an oven for 100˚c. Then it is leached in presence of HCL of 0.3% dilution. The dry husk is taken in a crucible and placed in the furnace at 900˚c for 1hr. The golden brown rice husk is turned black and as the temperature increases the carbon content is lost and silica content increases (Rice husk Ash). The material is powdered and sieved to obtain material less than 75mm size

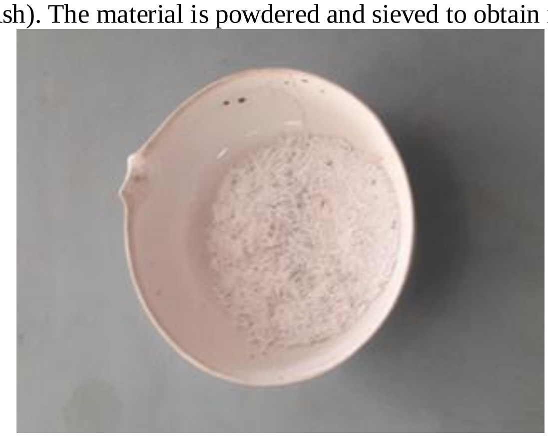

Fig 1: Rice husk ash (RHA)

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2.1.2 Phosphate treated rice husk preparation

Rice husk was obtained from a local mill, sieved (50-60 mesh) size, Washed several times with distilled water, dried at 60˚c for 2hr and preserved at room temperature. Five gram dried husk was treated with 100ml of 2.0M k2HPO4 for 24hr. The mixture was filtered and washed several times with distilled water to remove the excess phosphate from the treated husk. The resultant adsorbent was finally dried at 70˚c for 2hr and preserved at room temperature in a sealed bottle.

Fig 2: Phosphate treated rice husk (PRH)

2.3 Adsorbate

To conduct adsorption experiments on chromium, stock solution of 1000mg/l was prepared by dissolving accurately 2.86g of A.R potassium dichromate crystals in one liter of double distilled water.

To conduct adsorption experiment on Nickel, stock solution of 1000mg/l was prepared by dissolving 4.476g of nickel Sulphate in one liter of double distilled water.

The Batch studies were carried out using 10mg/l concentration of hexavalent chromium and nickel. Working solutions of 50mg/l, 100mg/l, 150mg/l and 200mg/l is prepared by diluting the 1000mg/l stock as per requirement. to obtain 100ml of different concentrations 5ml, 10ml, 15ml and 20ml of 1000mg/l is diluted in 100ml of double distilled water which gives 50mg/l, 100mg/l, 150mg/l and 200mg/l of solution.

2.3.1 Characterization Of Materials

Rice husk ash has more no. of pores and size of the pore is smaller. The maximum amount of element present is silica which is of 72%. Phosphate treated rice husk has larger surface area compared to the raw husk and silica content is very less.

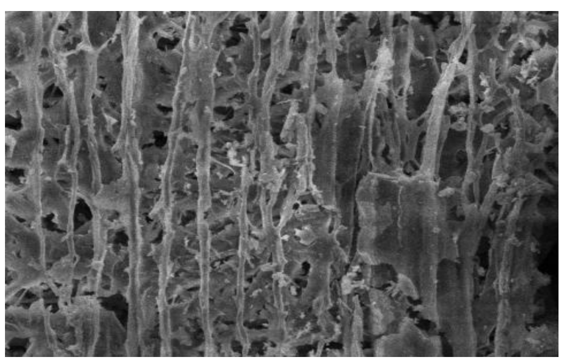


Fig 3: SEM of Rice husk ash

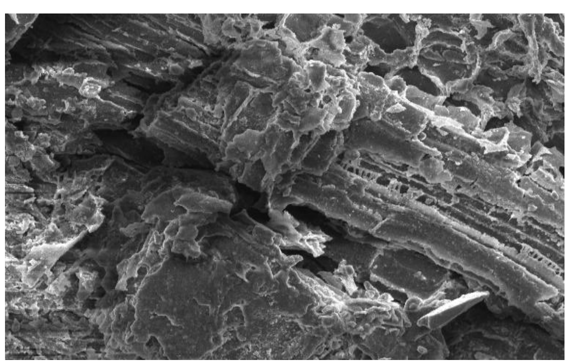


Fig 4:SEM of Phosphate treated rice husk

2.4 Batch Studies

Once the adsorbent is selected, the adsorption studies were carried out for various parameter like dosage of adsorbent, Initial concentration, pH and contact time. To start the batch studies, stock solution was prepared .The prepared rice husk ash and phosphate treated rice husk are sieved and particles below 75microns are chosen for experimental purpose. The adsorption percentage is determined by

$$\%R = \frac{Co - Cf}{Co} * 100$$

Where Co is initial concentration of metal ion and Cf is the final concentration of metal ion after adsorption. Results are plotted on a graph.

2.5 Column Studies

The column studies were carried out in a dynamic system. Rice husk ash was used as an adsorbent. This ash was filled in a glass column whose internal diameter is 2.5cm and height of 20cm. the industrial effluent is collected from a nearby industry. This is the wash water which is diluted to 30ppm. The effluent is then filled in the container kept at a certain height above the glass column. The rate of flow was set to 4ml/min. the bed height is varied to know the effects of the bed depth on adsorption of chromium. Different bed depths are considered for study purposes

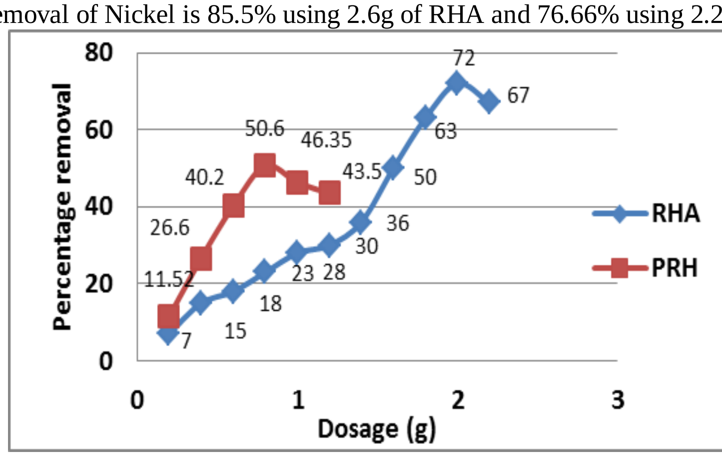
3. RESULTS AND DISCUSSIONS

3.1 Batch studies on Chromium and Nickel

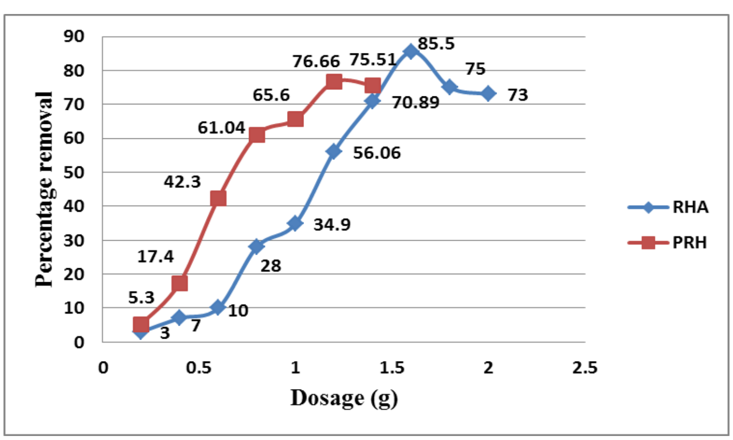
3.1.1 Effect of adsorbent dosage

Batch study was carried out using 50ml of 10mg/l of adsorbate by taking dosage from 0.2 to 2g of adsorbents run on a mechanical shaker at 150rpm. The Maximum percentage removal of Chromium is 72% using 2g of Rice husk ash (RHA) and 50.6% using 0.8g of Phosphate treated rice husk (PRH) shown graphically in graph 2.

The maximum percentage removal of Nickel is 85.5% using 2.6g of RHA and 76.66% using 2.2g of PRH shown in graph 2.



Graph 1: Variation of percentage removal of Cr with varying Dosage of adsorbents RHA and PRH

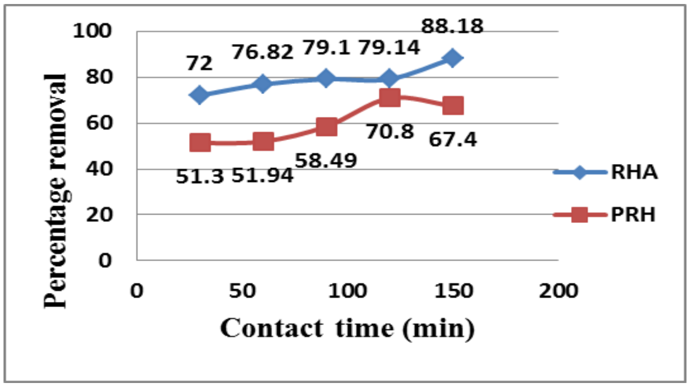


Graph 2: Variation of percentage removal of Ni with varying

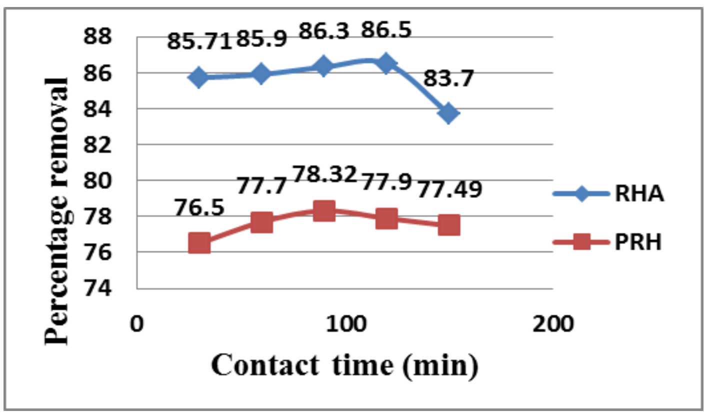
Dosage of adsorbents RHA and PRH

3.1.2 Effect of Contact Time

There is an increase in the adsorption as the contact time increases from 30min to 150min. At the end of 150 min RHA has adsorbed 88.18% of Cr and 86.5% of Ni at 120min. PRH has adsorbed 70.8% of Cr at 120min and 78.32% of Ni at 90min. hence adsorption capacity of RHA is more here.



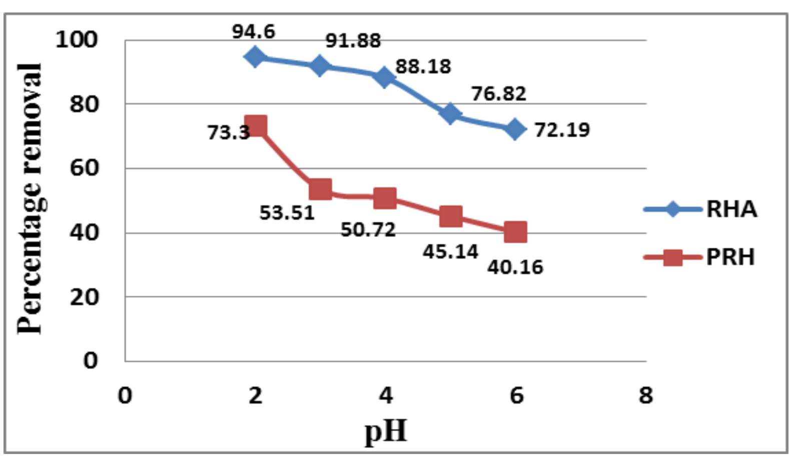
Graph 3: Variation of percentage removal of Cr with varying Contact time using adsorbents RHA and PRH



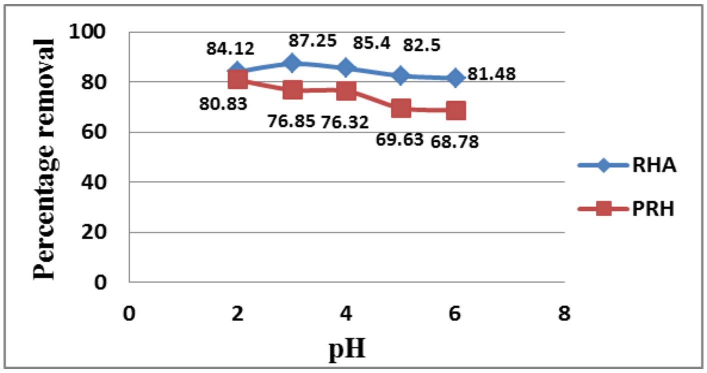
Graph 4: Variation of percentage removal of Ni with varying Contact time using adsorbents RHA and PRH

3.1.3 Effect of pH

The adsorptive capacity of the adsorbents is increased in the acidic environment. 94.6% of Cr at pH 2 has been adsorbed by RHA and 87.25% of Ni at pH 4 has been adsorbed by RHA. PRH has adsorbed 73.3% of Cr at pH 2 and 80.83% of Ni at pH 2. The effect is as shown below in the graph



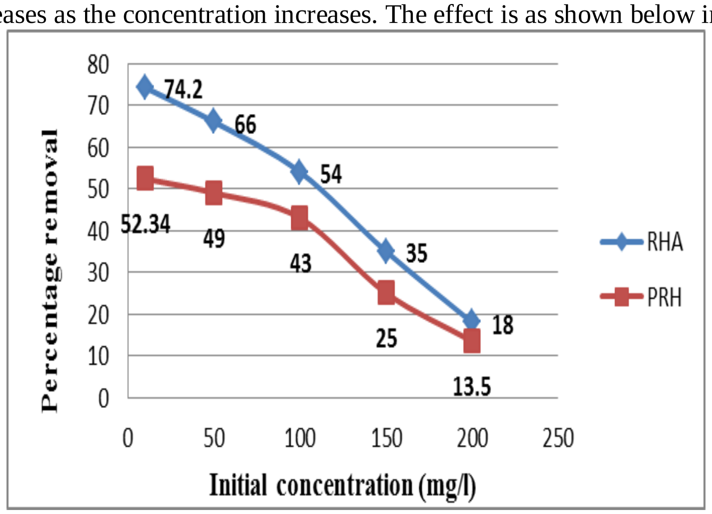
Graph 5: Variation of percentage removal of Cr with
Varying pH using adsorbents RHA and PRH



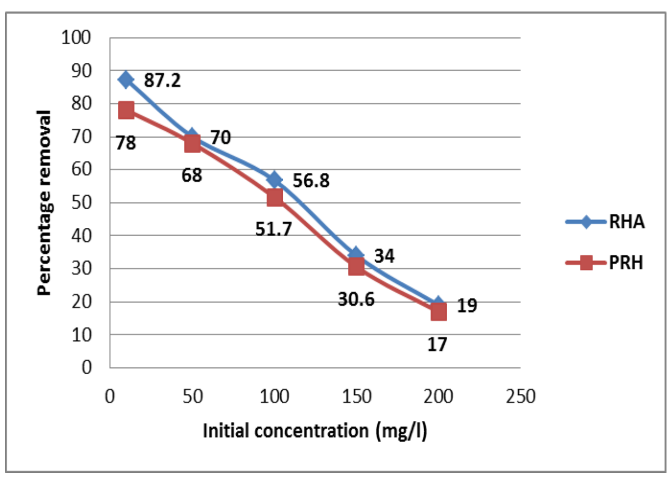
Graph 6: Variation of percentage removal of Ni with
Varying pH using adsorbents RHA and PRH

3.1.4 Effect of Initial concentration

The adsorptive capacity decreases as the concentration increases. The effect is as shown below in the graph.



Graph 7: Variation of percentage removal of Cr with
Varying initial concentration using RHA and PRH



Graph 8: Variation of percentage removal of Ni with
Varying initial concentration using RHA and PRH

3.2 Adsorption Isotherms

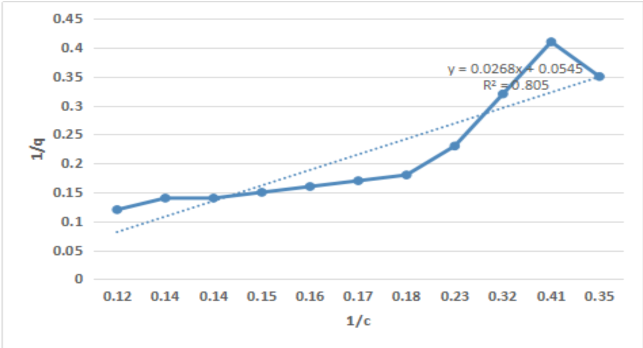
It is defined as the graphical representation which shows the relation between the amount adsorbed by unit weight of adsorbent and the amount of adsorbate remaining in a test medium at equilibrium. There are two types of isotherms: Langmuir and Freundlich isotherm.

3.2.1 Langmuir isotherm:

Langmuir isotherm assumes the monolayer adsorption onto a surface containing a finite no. of adsorption sites of uniform strategies with no transmigration of adsorbate in plane surface.

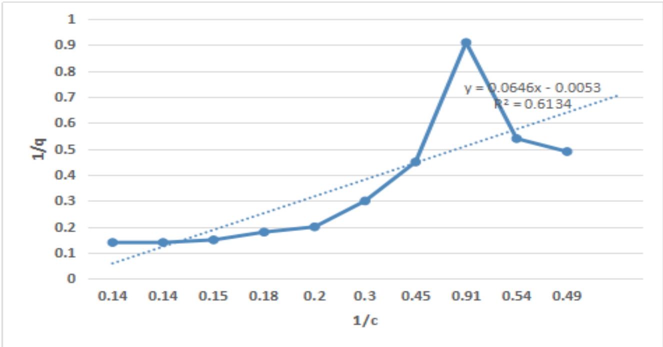
$$\theta = \frac{KP}{1+KP}$$

Where K is the equilibrium constant for distribution, ϴ is the number of sites covered and P is the pressure.



Graph 9: Langmuir isotherm plot of Cr adsorption

Using RHA



Graph 10: Langmuir isotherm plot of Ni adsorption

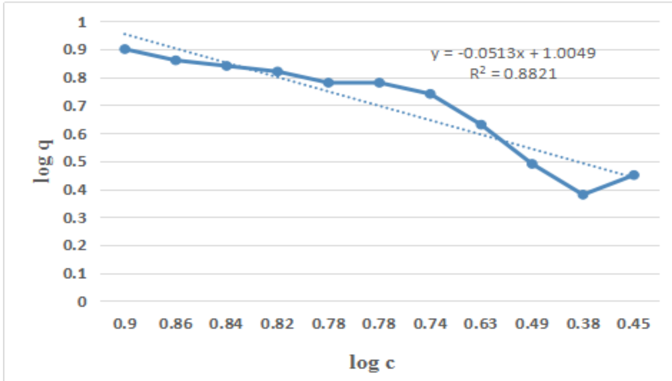
Using RHA

3.2.2 Freundlich Isotherm:

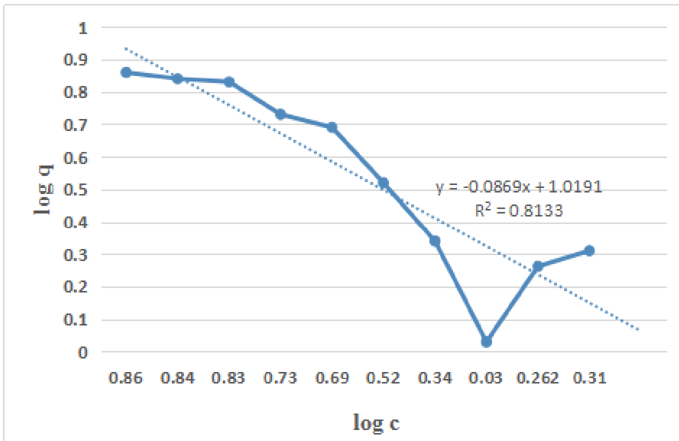
Freundlich isotherm assumes that there is a difference in affinities for different adsorbents.

$$\frac{x}{m} = kP^{\frac{1}{n}}$$

Where m is the mass of adsorbent at pressure P, x is the mass of gas adsorbed and K is the measure of affinity of adsorbent.



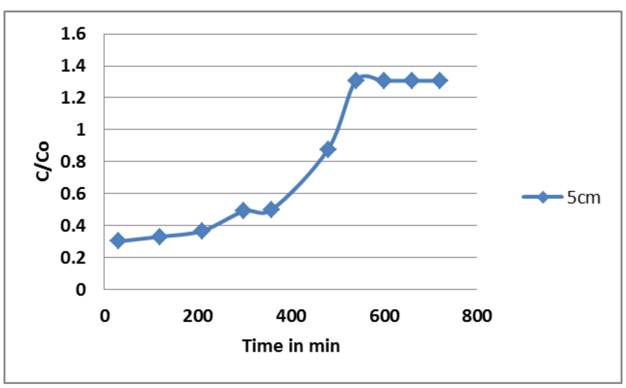
Graph 11: Freundlich isotherm plot of Cr adsorption
Using RHA



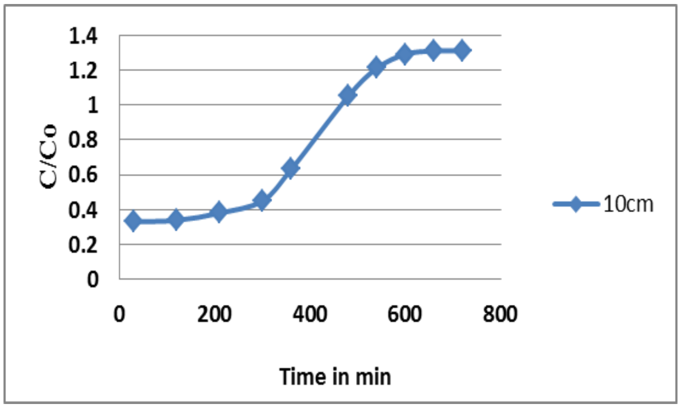
Graph 12: Freundlich isotherm plot of Ni adsorption
Using RHA

3.3 Column studies

The column studies were carried out by varying the depth of the bed. Based on Mass transfer zone flow rate was taken as 4ml/min. As shown in the graph as the depth of the bed increases the time available for adsorption increases. Hence adsorption is increased.



Graph 13: Variation of adsorption efficiency of RHA with increase in time and 5cm depth of bed



Graph 14: Variation of adsorption efficiency of RHA with increase in time and 10cm depth of bed

4. CONCLUSION

RHA was capable of adsorbing 94.6% of chromium with optimum dosage of 2g, contact time- 150min and at low pH 2 and 87.25% of Nickel with optimum dosage 2.6g , contact time- 120min and at pH 4 which is more than the PRH which has adsorbed 73.3% of Chromium with optimum dosage of 0.8g , contact time- 120min and at pH -2 and 80.83% of Nickel with optimum dosage of 2.2g, contact time-90min and at pH-2.

From the results it is found that, both the adsorbents are capble of adsorbing heavy metals.

Rice husk has 99% silica which helps in high percentage of adsorption.

The Freundlich isotherm best fitted for both the adsorbents which show that adsorption increases at low pressure.

RHA was only used to conduct the column studies since it gave better result than PRH and bed length lasted for 250hrs efficiently. Higher the bed length, better is the adsorption.

At acidic environment RHA was capable of adsorbing 95% of heavy meatl ion.

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