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Biosorption of Fe (II) Ions from Aqueous Solution using Water Hyacinth and Rice Husk as an Adsorbent

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ABSTRACT

Heavy metal contamination has attracted increasing attention due to its adverse effects on water bodies and human health. Rapid industrialization and urbanization have led to increase in heavy metal pollution. Various traditional methods are available for the treatment of heavy metals but these methods are either expensive or produce huge amount of toxic byproduct. To overcome these drawbacks, another cost-effective technique known as adsorption has been introduced. This paper presents the performance of low-cost adsorbents mainly water hyacinth and rice husk for the removal of heavy metals such as iron from the wastewater. Rice husk is by product and is easily available at rice mills whereas water hyacinth is an unwanted weed that can grow in severe polluted water. Batch studies have been conducted to study the biosorption of Fe (II) ion by using rice husk and the stems as well as leaves of water hyacinth as adsorbents. The iron removal efficiency dried water hyacinth stems and dried rice husk are observed as 47% and 69.33% respectively.

Keywords*— Adsorption, Heavy metals, Water hyacinth*

I. INTRODUCTION

The removal of heavy metals from the wastewater is a very serious environmental issue due to its toxicity and harmful impacts on human health. These heavy metals enter the ecosystem and gets accumulated throughout the food chain causing severe physiological and neurological problems. Iron is present in the form of Fe(II) ion in groundwater and has become a major issue especially in rural areas. Excess iron can cause diseases like diabetes, hormonal abnormalities, hemochromatosis, vomiting, stomach problems, nausea, skin problems, mellitus, cardiovascular diseases and dysfunctional immune systems. The presence of iron also affects the colour and taste of water. The wastewater from industries like blue print paper, laundry bluing facilities, paints and pigments contribute majorly to the contamination of iron. As per IS 10050 (2012), the permissible limit for iron for drinking water is 0.3 mg/lit.

Various conventional methods like chemical oxidation ion exchange, chemical precipitation, reverse osmosis, membrane separation, adsorption and electrodialysis are used for the removal of heavy metals from wastewater. At present, the best method available for the removal of heavy metals is adsorption. The advantages of this method are short operating time and removal of heavy metal from effluent irrespective of the toxicity. The drawback of this technique is the cost of the adsorbent and its regeneration. In the past few decades, a growing concern is shown by the researchers for the use of agricultural products and its waste as adsorbents. Various agricultural products such as rice husk have been proved to be very efficient in removing heavy metal from wastewater.

Rice husk is an outer coating of paddy and can be obtained from rice processing mills. Approximately, 18-22 million tons of rusk husk is produced in India annually. Its capability of removing the heavy metals from aqueous solution makes it an efficient and low cost adsorbent for heavy metals. In recent years, research has been carried out on the usage of unmodified and modified rice husk as an adsorbent. In order to enhance the sorption capacities for metal ion, various modification on rice husk have been reported.

Water hyacinth is perennial aquatic macrophyte having expanding roots. The plant is recognised for its fast growth as it can double its population in twelve days. Its rapid growth has caused several ecological disruptions, interference in navigation and power generation. The management of the weed is a major problem all over the world hence it has become necessary to search the alternative approach for its management. The ability of water hyacinth to absorb the heavy metals from wastewater makes it suitable to use as a bio adsorbent material.

The aim of this study is to analyse the potential of rice husk and stems of water hyacinth for the removal of Fe(II) ions from the wastewater. Batch sorption studies are conducted using various bio adsorbents such as dried leaves as well as stems of water hyacinth, dried rice husk and Phosphorous treated rice husk. A comparative study has been performed to observe the removal efficiency of various adsorbents.

II. MATERIALS AND METHOD

A. Reagents

All the chemicals used are of analytical grade. The stock solution of iron is prepared using ammonium ferrous sulphate, conc. Sulphuric acid and potassium permanganate as per procedure given in APHA. Lower concentrations of iron are prepared by diluting the stock solution with distilled water.

B. Water Hyacinth

Water hyacinth is collected from a local lake named Pashan lake in Pune, India. The leaves and stems are separated from roots, washed several times with distilled water and are kept in 0.25M EDTA solution for 24 h to remove any metal ion present in the plant. Then the leaves and stems are again washed several times with distilled water and are dried in an oven for 48 h at 110 ℃. The dried stems and leaves are converted into powdered form and stored in desiccators.

C. Preparation of activated carbon stems and leaves

In this experiment, the activated carbon obtained by chemical activation of leaves and stems of water hyacinth is used. The dried leaves and stems are dipped into conc. H_3PO_4 equal to 3 times of its weight for 2 days at room temperature and then dried in an oven for 48 h at 110. After cooling, the activated carbon stems and leaves are washed thoroughly with distilled water to remove the excess acid. After that, it is dried in an oven for 24 h at 110. The dried activated carbon stems and leaves are stored and used for further adsorption experiments.

D. Rice Husk

Rice husk is obtained from a local rice mill and is washed many times with distilled water to remove the impurities present in it. After washing, it is dried in an oven for overnight at 110. The dried rice husk is crushed and sieved with 600-micron sieve to get the uniform particle size of the adsorbent.

E. Preparation of phosphate treated rice husk

The dried rice husk is treated with 1M K_2HPO_4. 45 g of dried rice husk is impregnated in 900 ml of K_2HPO_4 for 24 h. The mixture is then washed several times with distilled water and dried in an oven for 2 h at 70. The adsorbent obtained is preserved at room temperature for further analysis.

F. Batch adsorption studies

In batch sorption studies, the various adsorbent dose is added to 100 ml of a solution containing Fe (II) ions in a 250 ml conical flask. The samples are agitated at a speed of 150 rpm in an orbital shaking machine for 2 h. The pH of the solution is adjusted by 0.1 N NaOH or 0.1 N HCL and is measured by using a pH meter. The adsorbent dose is varied from 1 to 5 g/l. The samples are then filtered and the final concentration of the solution is determined by using UV Spectrophotometer. The percentage of iron adsorbed is calculated as

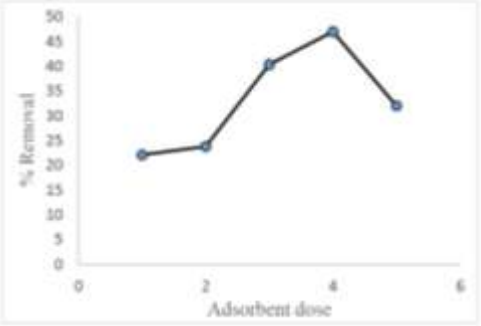

Fig 1. Effect of adsorbent dose on the uptake of Fe (II) by dried water hyacinth stems, initial concentration 2 ppm, contact time 120 mins, agitation speed 150 rpm

III. RESULTS AND DISCUSSIONS

A. Water hyacinth stems

The effect of different adsorbent doses for the removal of Fe (II) by water hyacinth stems are studied and the results are presented in fig. 1. The result indicated that the adsorptive capacity of dried water hyacinth stems increases with increasing adsorbent dose upto 4 g/l. The maximum removal of 47% is obtained at a dose of 4 g/l.

On further increasing the dose, the removal efficiency decreased. The result can be explained that when adsorbent dose increases, the availability of active sites increases providing better removal efficiency.

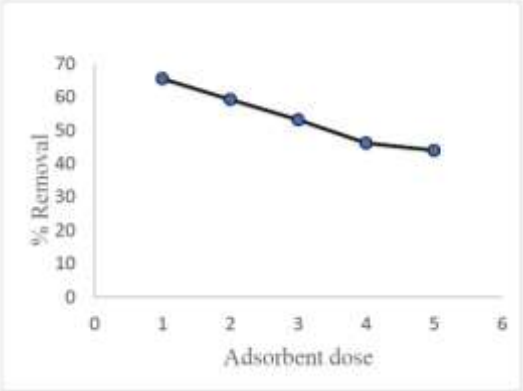

Fig 2. Effect of adsorbent dose using activated carbon water hyacinth stems, initial concentration 29 ppm, contact time 180 mins, agitation speed 150 rpm and pH 6.

B. Activated carbon water hyacinth stems

- Biosorption of Fe (II) ions by activated carbon water hyacinth stem are shown in fig. 2. A similar trend has been observed as it is shown by phosphate treated rice husk. On increasing adsorbent dose, the removal efficiency decreases. The maximum removal of Fe (II) ion is found to be 65.33% at a dose of 1 g/l. $q = (Ce - Co)/Co \times 100$ Where, q: Percentage of iron adsorbed Ce: Equilibrium concentration of iron (mg/l) Co: Initial concentration of iron (mg/l)

C. Dried rice husk

The effect of adsorption dose on Fe (II) adsorption onto dried rice husk is depicted in fig. 3. The maximum removal of Fe (II) is observed to be 69.33% at an adsorbent dose of 2 g/l. Beyond this dosage, the removal efficiency observed to be decreasing with increasing adsorbent dose. The optimum dose for the removal of Fe (II) can be taken as 2 g/l for further experiments.

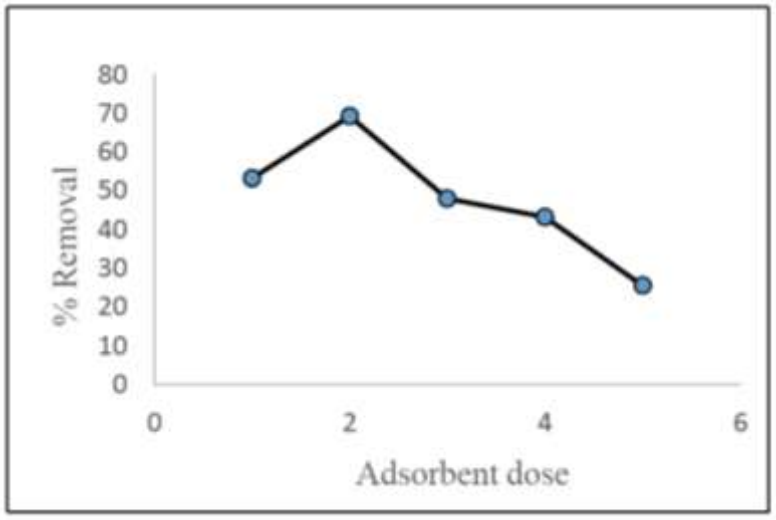

Fig 3. Effect of adsorbent dose on the uptake of Fe (II) by dried rice husk, initial concentration 1.5 ppm, contact time 120 mins, agitation speed 150 rpm and pH 6.

IV. CONCLUSIONS

In this study, batch adsorption experiments have been conducted for the removal of iron using various bioadsorbents. The conclusions obtained are

1) The rapid uptake and high sorption capacity of above adsorbents make it a very suitable and alternative sorbent material.

2) The highest adsorption of Fe(II) ion is found at pH 6 with initial concentration 1.5 ppm, contact time 120 mins and agitation speed 150 rpm by using dried rice husk as an adsorbent.

3) Activated carbon water hyacinth stems also showed a good removal efficiency of 65.33% at an adsorbent dose of 1 g/l.

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