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Removal of iron from aqueous solution using Maize corncob as adsorbent

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ABSTRACT:

The presence of iron is probably the most common water problem faced by consumers. The secondary maximum contaminant levels (MCL) of Iron is 0.3 mg/L. Hence to remove iron from water, a batch study has been conducted by adsorption process using activated carbon prepared from maize corncob as adsorbent and the removal efficiency was studied as function of the parameters such as dosage (1-6 g), pH (3-8), contact time (30-180 minutes) and initial concentration (0.5-5 mg/L). It was observed that maximum removal of iron takes place at pH 5.5. It was also observed that maximum removal of iron occurs after a contact time of 120 minutes. % removal of iron decreases with increase in the initial concentration of solution whereas it increases with the increase in the dosagesand achieved equilibrium for 3g of adsorbent dosage.The removal efficiency was found to be about 75%.This experimental study has been carried out to develop an economical method of iron removal, so that even common people could adopt this method for their water treatment.

Keywords: Iron removal, adsorption, maize corncob

INTRODUCTION:

Iron is a common metallic element found in the earth's crust. Water percolating through soil and rock can dissolve minerals containing iron and hold them in solution. Occasionally, iron pipes also may be a source of iron in water. The main anthropogenic sources of Iron are various industrial sources, including present and former mining activities, steel producing industries, foundries and smelters, and diffuse sources such as piping, constituents of products, combustion by – products, etc. These metals are also known to have adverse effects on the environment and human health and are toxic even at low concentration to human beings and other living beings.

Iron in water is normally found in the ferrous state. Oxidation of dissolved iron particles in water changes the iron to white, then yellow and finally to red-brown solid particles that settle out of the water. Iron that does not form particles large enough to settle out and that remains suspended (colloidal iron) leaves the water with a red tint. The regulations regarding iron in drinking water were established as secondary standards, which mean the limits were set because of nuisance problems and aesthetic concerns. Iron Overload or Hemochromatosis has also come into attention. The symptoms of hemochromatosis include: chronic fatigue, arthritis, heart disease, cirrhosis,

cancer, diabetes, thyroid disease, impotence, and sterility. Iron may cause conjunctivitis, choroiditis, and retinitis if it contacts and remains in the tissues. Iron also causes reddish-brown staining of laundry, porcelain, dishes, utensils and even glassware.

In some of our studies[1,2], we have observed that most of the groundwater samples in Muzaffarpur district have iron contamination much above the maximum permissible limit of 0.3 mg/L set by WHO[3]. Various techniques[4-16] have been reported for the removal of metal pollutants from drinking water and waste water. In pursuit of low cost adsorbents for the removal of metal ions from aqueous solutions, our attention was drawn towards a readily available and commonly used - maize corncob. In the present work, adsorption of Iron (II) from aqueous solutions on activated powdered carbon prepared from maize corncob was studied as a function of different parameters : pH, contact time (t), mass of the adsorbent (w) and initial concentration (Ci) of the adsorbate.

MATERIALS AND METHODS:

Preparation of adsorbent: The corncob of maize is always thrown out as a waste. These were collected and their size was reduced by breaking it into fine powder. Then they were dried in an oven for 24 hours at a temperature of 110^0C. It was then packed in an air tight in a cylindrical iron container with top completely sealed with an iron cover to prevent the entry of air during the process of charring. The sealed iron container was heated in furnace by slowly raising the temperature up to 450^0C for 45 minutes and subsequently washed with distilled water, oven dried and sieved through 100 micron mesh sieve to obtain activated carbon powder.

Preparation of regents: All the chemicals used were of analytical grade. A stock solution containing 200 mg/L of was prepared by dissolving required amount of Mohr's salt in distilled water[17]. Solutions of required concentrations were prepared by diluting the stock solutions. The pH of the solution was adjusted using 0.1 N HCl and 0.1N NaOH solutions.

Instrumentations: A UV-Visible Spectrophotometer (Systronics, model no. 2201) was used for analysis. A high precision digital balance was used for weighing and a digital pH meter (Systronics, model no. 361) was used for pH measurement.

Experimental methods:

Estimation of iron was carried out experimentally by phenanthroline method. In batch study, effect of different parameters (i.e., contact time, pH, initial concentration and doses of adsorbents) on adsorption of iron was studied. For the effect of pH, the contact time was uniformly taken as 120 minutes taking 3 mg/L initial concentration and 3 g of adsorbent dosage. For the effect of contact time, 50 ml metal ion solution of 3mg/L concentration was placed with a fixed mass of activated carbon powder (i.e., 3 g) at pH 5.5 at varying contact times of 30 min, 60 min, 90 min, 120 min, 150 min, and 180 min. For the study of the effect of initial concentration, 50 ml metal ion solutions of different concentrations (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0) were placed together with a fixed mass of activated carbonpowder (i.e., 3 g) at pH 5.5. For the study of the effect of adsorbent dosage, 50 ml metal ion solution of 3mg/L concentration was placed with varying masses of activated carbon powder (1 g, 2 g, 3 g, 4 g, 5 g, and 6 g) at pH 5.5. The experiments were carried out at room temperature (about 35^0C).

Effect of pH: pH is the key factor for the control of the adsorption of metal ions on the adsorbent. The effect of pH on removal of iron is shown in Fig. 1. The study was done in the pH range of 3 to 8. It was found that the adsorption of iron gradually increases as the initial pH of the solution is raised from 3 to 5.5. The maximum removal of iron was found to be 75 % at pH 5.5. Hence, pH of the iron solution was maintained at 5.5 for further study.

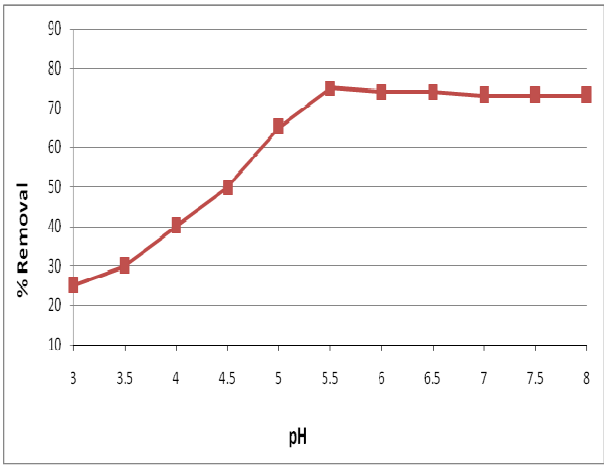

Fig. 1: Effect of pH on adsorption of iron on activated carbon of maize corncob (contact time: 120 min., iron concentration: 3 mg/L, adsorbent dosage: 3 g).

Effect of contact time:% removal was recorded at contact time of 30 min to 180 min. The results are shown in Fig. 2. Evidently, more than 15 % iron removal occurred within 30 min showing that initially the rate of uptake of iron is very fast and gradually increases attaining a steady value after reaching the equilibrium at about 120 min. Hence, 120 min contact time was fixed for further study.

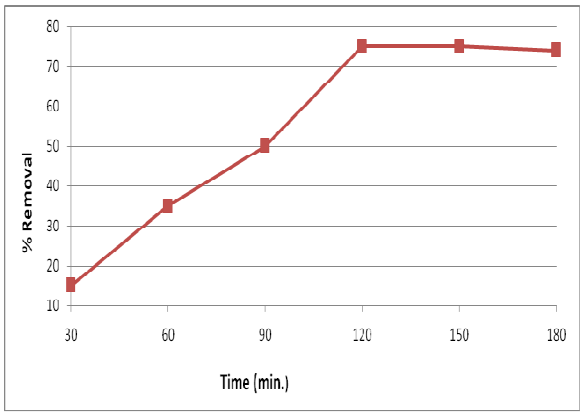

Fig. 2: Effect of contact time on adsorption of iron on activated carbon of maize corncob (pH: 5.5, iron concentration: 3 mg/L, adsorbent dosage: 3 g).

Effect of adsorbent dosage: The adsorbent doses were varied from 1 g to 6 g. It was observed that the removal of metal ion increased with the increase in dosage attaining a maximum at 3 g of dosage (Fig. 3). Obviously, higher dose of adsorbent results in higher surface area providing greater number of binding sites for the metal ions.

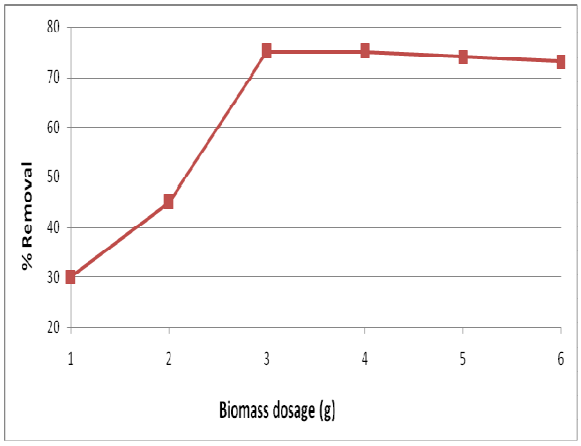

Fig. 3: Effect of adsorbent dosage on adsorption of iron on activated carbon of maize corncob (pH: 5.5, contact time: 120 min., iron concentration: 3 mg/L).

Effect of initial metal ion concentration: Experiments were performed by taking different initial concentrations of iron solution (0.5 mg/L to 5 mg/L) at pH 5.5 for a contact time of 120 min, taking 3 g of activated carbon powder as adsorbent. The results (Fig. 4) show that % removal of iron decreased with increasing initial concentration. This is because the adsorption sites become more saturated as the metal ion concentration increases.

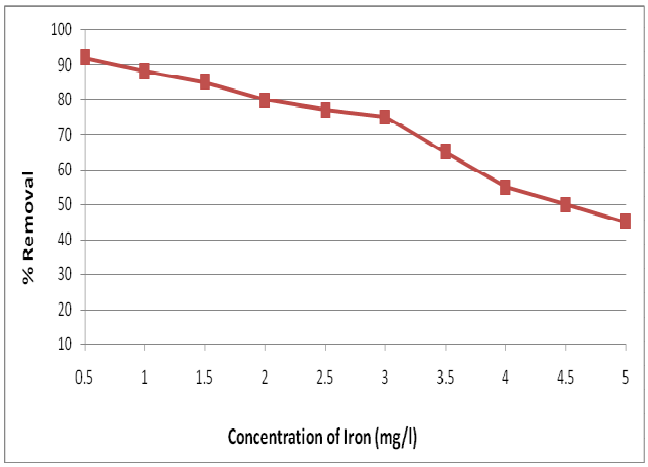

Fig. 4: Effect of iron concentration on adsorption on activated carbon of maize corncob (pH: 5.5, contact time: 120 min., 3 mg/L, adsorbent dosage: 3 g).

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