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Batch study for removal of Mn^{2+} from synthetic wastewater by using natural adsorbent

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Abstract

Among various natural resources water is the most precious one. All life on Earth depends on water. Heavy metals are considered as contaminants in many industrial effluents and constitute a significant environmental issue. Heavy metals are released into water environment by industry in a variety of concentrations and volumes. One of the main causes of water contamination on earth is manganese (Mn^{2+}) pollution. For several reasons, manganese must be removed from waterways. The abundance and low cost of these adsorbent materials make the established adsorption methods attractive sustainable solutions for the removal of heavy metals. In this study batch techniques are used with coconut coir ash as a natural adsorbent among other adsorbents for adsorption. Investigation has carried out by varying the initial concentrations, pH, contact time, and adsorbent dose values. Result shows that it took 60 minutes to reach the equilibrium contact time. Manganese removal from aqueous solution is possible with just 1 gm of adsorbent dose. Manganese adsorption onto coconut coir ash was maximum at a pH of 6. Increased initial concentrations causes an increase in adsorption capacities. The batch study also shows the maximum removal of manganese by coconut coir ash is >91%.

Keywords: *wastewater, manganese, adsorption, coconut coir ash*

Introduction

Concern has been raised about the water that comes from industrial processes. Due to the presence of contaminants including harmful metals and other compounds that need to be treated before being released. Such treatment must be carried out using procedures and techniques that accomplish the pollution concentration level required by the authorities or environmental legislation. Manganese is a frequent hazardous element that is present in the effluents of numerous industries [1].It enters the body through the mouth or respiratory system and, in large doses, can result in diseases such pneumonia, circulatory collapse, and respiratory edema, among other things, as well as permanent harm to the nervous system [2]. The removal of heavy metals from water currently uses a variety of methods, including adsorption, ion exchange, reverse osmosis, solvent extraction, flocculation, and membrane separation. [3].The most popular techniques for removing Mn^{2+} are oxidation and adsorption. Heavy metal-contaminated wastewater may now be treated with adsorption, which is a reliable and affordable technique. [4]. Agricultural wastes are used to remove metals from wastewater and have a number of advantages, including excellent removal effectiveness, low cost, and local availability. In the current work, manganese is extracted from aqueous solution by adsorption utilizing natural adsorbent ash that is created from a variety of natural adsorbents.

Materials and Techniques

Preparation of adsorbent

Various natural adsorbents were gathered from the area around the RUET.The prepared samples will be washed three times in distilled water and then dried in an oven for 24 hours at 100°C. A muffle furnace is used to transform the dried material into granular activated ash. The present study made use of BSS 100 mesh particle size [5].

Preparation metals solution

The synthetic wastewater will be prepared by diluting different concentrations of Mn^{2+} solution (20~100 mg/L) in distilled water. Manganese sulphate with a chemical formula $MnSO_4.5H_2O$ was used [6]. Analytical-grade reagents were used for all applications.

Batch Study

The adsorption of Mn onto a chosen adsorbent was investigated utilizing batch procedures. First, (20~100) mg of Mn was dissolved in 1000ml of water to create a stock solution containing (20~100) mg/L of Mn^{2+} .Manganese granules have been successfully dissolved in the solution using water. A batch experiments consisted of five 250mL beakers and Mn solution was placed of those flasks. In this experiment a measured amount of treated adsorbent was added to a series of flask. To achieve equilibrium, the samples were shaken for 1 hour at 150 rpm in a bottle shaker. All batch studies were conducted at a temperature of 30 ± 2^0C with constant pH at 7±0.2. It was determined the amount of heavy metals removal on selected adsorbent at equilibrium condition was calculated by the following formula,

$$R = (C_o-C_e)/C_o \qquad (1)$$

Where R is the removal efficiency of Mn^{2+} at equilibrium, C_o and C_e are the initial and equilibrium concentration (mg/l) [7].

Results and Discussion

Effects of pH on removal of Mn^{2+}

Due to its impact on the effectiveness of metal removal, several studies have suggested that the pH of the solution is the most crucial factor. The variation in pH that would affect the surface charge of the sorbent and degree of ionization can be used to explain this phenomenon [8]. The effect of pH on the Mn^{2+} removal efficiency has been studied in the range of 2-10 for initial concentration 20 mg/L at contact time 60 minute with room temperature. From figure 1 it is showed that with a pH increase from 2 to 6 the amount of Mn(II) adsorbed rises. However, an additional increase in pH causes the amount to decrease [9]. A larger concentration of H+ ions compete with positively charged Mn(II) ions at low pH levels. Up to pH 6, the competitive impact of H^+ ions decreases and adsorption rises. A further rise in pH reveals a reduction in the amount of Mn(II) adsorbed as a result of the emergence of soluble or insoluble $Mn(OH)_2$.

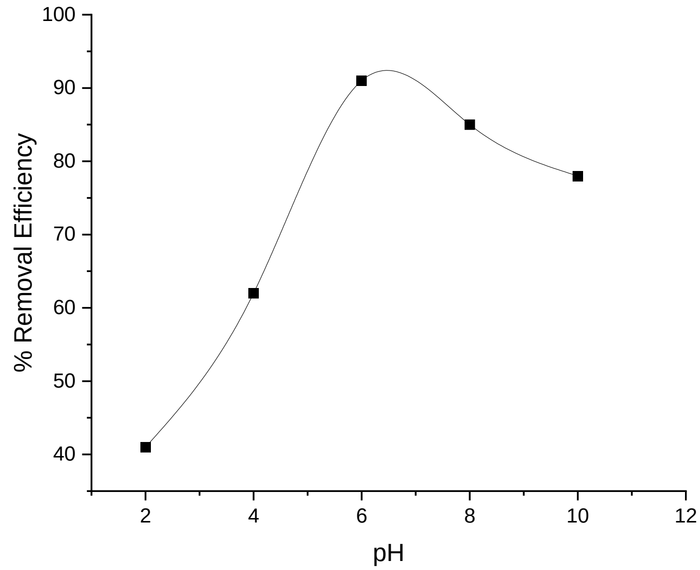

Figure 1: Effect of pH on the removal efficiency (adsorbent dosage: 1.0 g/100 mL; initial metal concentration: 20 mg/L; 140 rpm for 60 min.)

Effect of initial concentration on removal of Mn^{2+}

The outcomes demonstrated that removal of Mn was greatest at lower starting concentrations. The percentage of manganese adsorbed 96 with initial concentrations at 20 mg/L. Because there are fewer moles of manganese in a solution at lower metal concentrations compared to the available surface area and adsorption is therefore independent of the initial concentration. Later, a rise in the initial concentration decreased the percentage binding. These data can be explained by the fact that there is a higher likelihood of metal removal at very low concentrations of metal ions due to the large ratio of sorptive surface area to the total amount of metal ions accessible as shown in figure 2. Therefore, the removal capacity is greater at low initial metal ion concentrations [10].

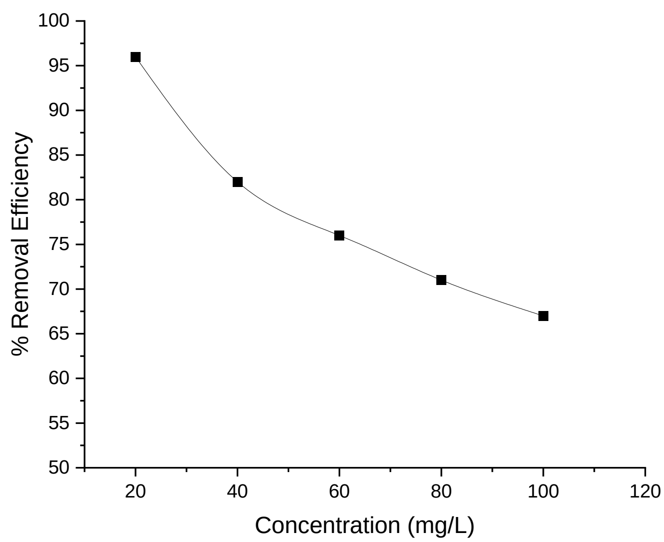

Figure 2: Effect of initial concentration on the removal efficiency (adsorbent dosage: 1.0 g/100 mL; pH: 6; 140 rpm for 60 min.)

Effect of dosage on removal Mn^{2+}

The dosage of the adsorbent affects the accessibility and availability of the adsorption site. Adsorbent loading was changed from 0.25 to 1.25g per 100ml of mixed metal ion solutions in order to study the impact of adsorbent mass on the removal of heavy metals. The result shows that the removal efficiency increases with increases the weight of adsorbent dosages from 0.25 gm to 1.0gm and decreases from 1 gm to 1.25 gm./100mL. This might be as a result of the surface area or exchangeable site availability being higher at higher doses. The figure 3 shows that the maximum removal efficiency was found to be 91% at the dose of 1.0 gm. /100mL.

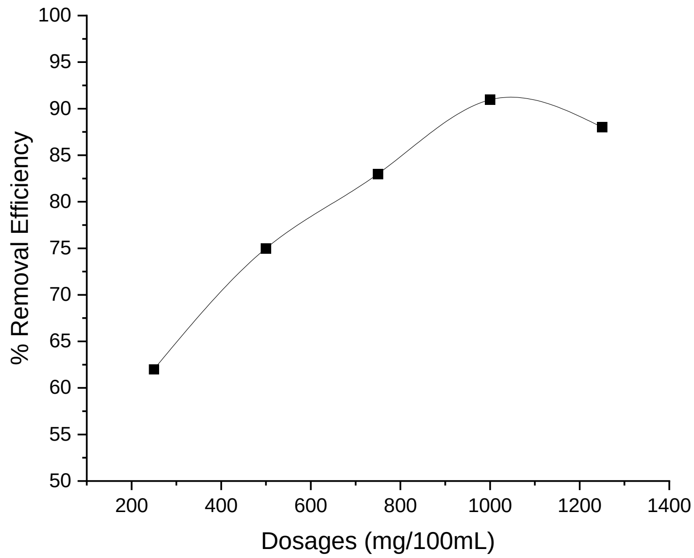

Figure 3: Effect of adsorbent dosage on the removal efficiency (initial concentration: 20 mg/L; pH: 6; 140 rpm for 60 min.)

Effect of contact time on removal Mn^{2+}

Contact time, which determines whether an adsorption system is appropriate, was tuned for maximum removal. Different time intervals were used for the adsorption experiments. Adsorption efficiency rises with increased contact duration as the adsorbent and adsorbed molecules increase the collision time and eventually equilibrium is reached. It is simple to see that the adsorption level decreases in relation to the number of ions first adsorbed via fast adsorption. From figure 4 it has been seen that maximum removal efficiency was found 92% at a time of 1 hour which was regarded as the equilibrium time.

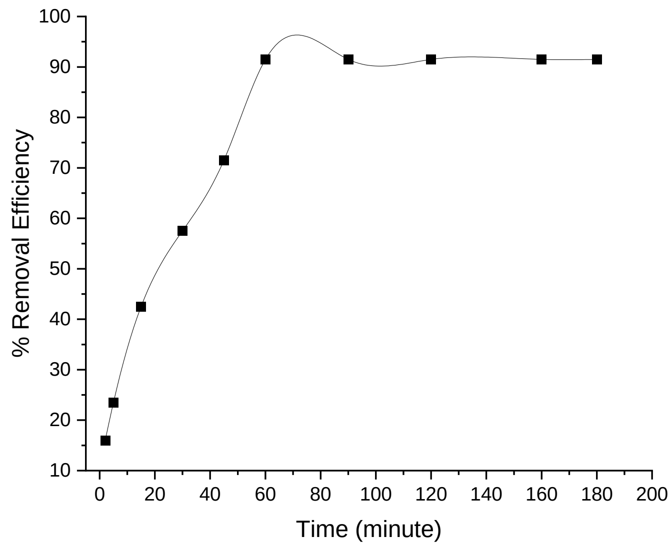

Figure 4: Effect of contact time on the removal efficiency (initial concentration: 20 mg/L; pH: 6; 140 rpm for 60 min.)

Conclusion

In batch adsorption investigations, coconut fiber ash was utilized as an adsorbent to extract Mn (II) from synthetic wastewater solutions. The results of this study show that employing coconut fiber ash as a substitute for more expensive adsorbents to remove Mn (II) metal ions from synthetic wastewater solution is feasible. This study offers a low-cost, easily accessible method for eliminating metal ions from tainted water or effluents. Coconut fiber, a waste product, is also readily available.

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