ADSORPTION OF Mn^{2+} IN SYNTHETIC WASTEWATER SOLUTION USING COCONUT COIR ASH

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ABSTRACT

This investigation examined the ability of coconut coir ash to adsorb metal ions in wastewater. The adsorption capacity of coconut coir ash to adsorb Mn^{2+} is determined by the unique composition of its components. Experimentation was carried out to study the adsorption of Mn^{2+} from an aqueous solution using coconut coir ash in a single-component system. The investigation encompassed various parameters like temperature (20°C to 40°C), contact times (2 to 180 minutes), pH (2 to 10), doses (0.5 to 1.25 gm) and initial Mn^{2+} concentrations (20 to 100 mg/L). Maxium removal efficiency (91 %) was found at dosage of 1 gm of adsorbent and it is called optimum dosage.The point of equilibrium contact time was attained at 60 minutes. Maximum adsorption capacity (1.82 mg/gm) was found at found at 40°C. The optimum pH value for the adsorption of Mn^{2+} was 6. The adsorption capacity of Mn^2+ increases together with the initial concentration from 1.92 to 6.7 mg/gm of Mn^2+ in the solution. The batch study also indicates that coconut coir ash achieves a maximum Mn^2+ adsorption of 6.7 mg/gm. The findings from this study pave the way for the utilization of natural adsorbents like coconut coir ash to efficiently absorb heavy metals i.e., Mn^{2+} which ensuring the safety and sustainability of our water ecosystems.

Keywords: *adsorption, Mn^2+, batch study, coconut coir ash, waste water.*

1. INTRODUCTION

The environmental damage caused by global industrialization is one of the most concerning issues. Numerous recent technological advancements have contributed to the gradual economic expansion of numerous nations, albeit concurrently posing significant environmental risks and causing damage (silva et al., 2012). High levels of harmful pollutants are frequently found in both drinking water and wastewater, posing a significant environmental concern, especially in densely populated urban areas with a high demand for water. Human and industrial activities have led to a significant increase in the volume and variety of toxic substances released into water resources, including dyes, pesticides, aromatic hydrocarbons, aliphatic phenols, surfactants, and heavy metals, in recent years (kusin et al., 2010). Furthermore, the detrimental effects of these compounds on the environment and human health are still not fully comprehended. The recent methods used in the water industry for removing heavy metals include precipitation, solvent extraction, ion-exchange, membrane separation reverse osmosis, and flocculation (lee et al., 2013). In recent years, adsorption has emerged as a well-established method for pollutant removal, and activated carbon is the predominant adsorbent used for purifying water with low pollutant concentrations. However, the available commercial carbons are expensive, underscoring the importance of seeking more cost-effective and efficient alternatives for use in the water industry (mestre et al., 2009). For this reason, coconut coir ash was selected as a low-cost adsorbent among different natural adsorbents used in this study. The primary goal of this study was to assess the effectiveness of coconut coir ash as a natural adsorbent in adsorbing mn^{2+} under varying experimental conditions.

2. METHODOLOGY

2.1 Preparation of Adsorbent

Different natural adsorbents were collected from the vicinity of RUET. The collected samples were subjected to a thorough washing process using distilled water, followed by 24 hours of drying in an oven at 100°C. Subsequently, a muffle furnace was employed to convert the dried material into granular activated ash. In this study, BSS 100 mesh (0.15 mm) particle size was utilized (Bhatnagar et., 2010).

2.2 Preparation of Metals Solution

The synthetic wastewater was 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. Analytical-grade reagents were used for all applications (Zadeh et al., 2022).

2.3 Batch Study

The effectiveness of Mn^{2+} adsorption onto coconut coir ash was evaluated using a number of batch studies with considerable variation. An orbital shaker (ATRS 114) set at an agitation speed of 160 rpm was consistently used during the experiment to maintain thorough mixing. The experiments were conducted at ambient room temperature. The experiment investigated the impact of factors such as contact time, pH, temperature, dosage, and concentration. Adsorption capacity of Mn^{2+} on selected adsorbent can be calculated by the following formula,

$q=(C_o-C_f)x(V/M)$ ……………………………………………………………………………….. (1)

Where q is the adsorption capacity (mg/gm), V is the volume of solution (L), M is the mass of adsorbent (gm) ,C_o and C_f is the initial and final concentration in mg/L (Alam et al ., 2020).The flow diagram of batch study is shown in below:

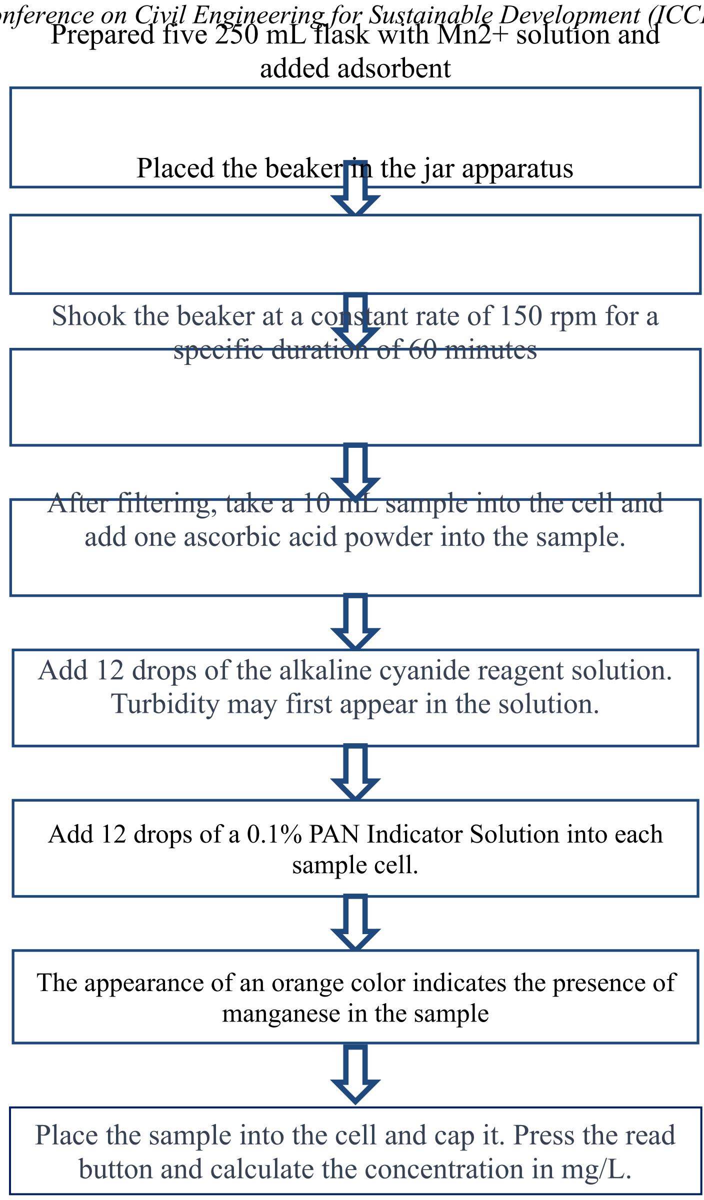

Fig: Flow diagram of batch study

3. ILUSTRATIONS

3.1 Effect of Initial Concentration on Adsorption Capacity of Mn^{2+}

In batch tests, it was verified that coconut coir ash exhibits the capacity to remove Mn^{2+} based on the observed percentage of heavy metal removal.The initial concentration is crucial in overcoming all obstacles to the mass transfer of metal from the liquid to solid state. The adsorption capacity of Mn^2+ increases from 1.92 mg/gm to 6.7 mg/gm with the initial concentration of Mn^2+ in the solution which was shown in Figure 1. As concentration increases, the number of available sorption sites becomes limited in comparison to the solute molecules present. Therefore, the extraction of metal ions greatly relies on the initial concentration of the solute (Abdullah and Hussain,2016). Same study carried out by using rice husk ash (Yeasmin et al., 2019) and obtained maximum adsorption capacity of Mn^{2+} was found 10.1 mg/gm at 100mg/L of Mn2+ solution .

Place the sample into the cell and cap it. Press the read button and calculate the concentration in mg/L

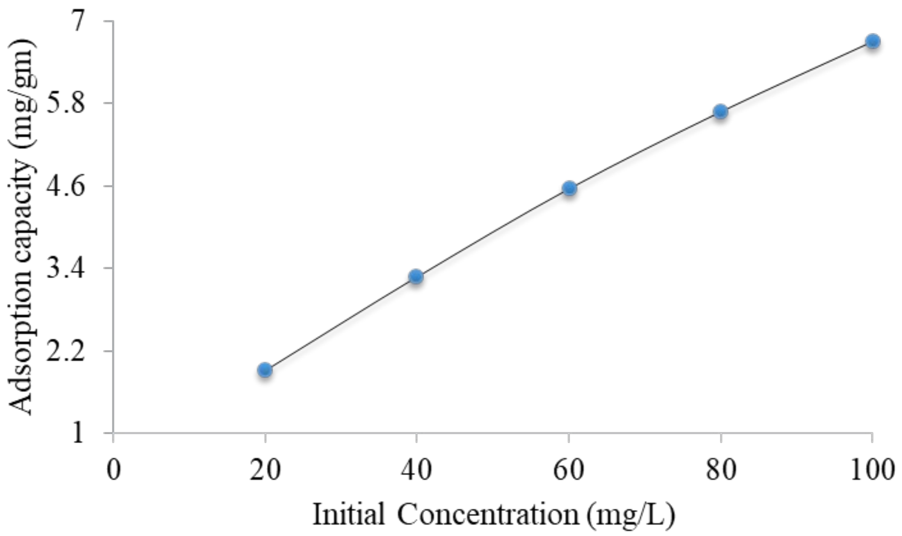

Figure 1: Effect of Initial metal concentration

3.2 Effect of Dosages on Adsorption Capacity of Mn^{2+}

The adsorption capacity of Mn^{2+} increases with an increase in the dosage of coconut coir ash and reached its maximum (1.819 mg/gm.) at 1.0 gm. The increase of adsorption capacity with the rising adsorbent dose can be attributed to the expanded surface area, which in turn leads to an increased number of active sites available for adsorption. This phenomenon could also be a result of the effective surface area increasing due to the aggregation of the adsorbent, particularly at higher doses (Adekola et al., 2016). The figure 2 showed that the maximum adsorption capacity was found 1.819 (mg/gm.) at 1 gm. dosage.

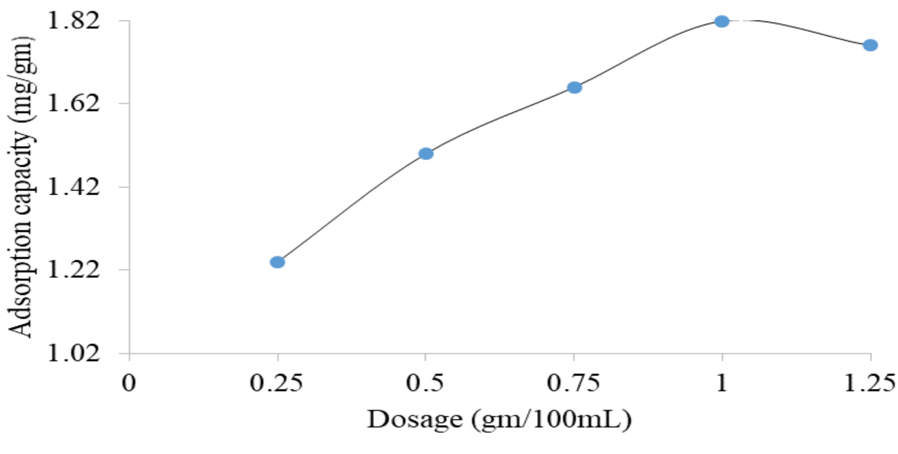

Figure 2: Effect of adsorbent dosages

3.3 Effect of Contact Time on Adsorption Capacity Mn^{2+}

The significance of the effect of contact time on adsorption lies in its influence on the adsorption capacity within the adsorption process. In this study, Mn^{2+} ion adsorption was examined for time ranging from 5 to 120 minutes and the constant pH at 6.0 and dosage at 1.0 gm/100mL. The efficiency of adsorption increases as the contact duration extends because it allows more time for the adsorbent and adsorbate molecules to collide, ultimately reaching equilibrium (Adekola et al., 2016). It's evident that the adsorption capacity decreases as more ions are initially adsorbed through rapid adsorption. It has been seen from Figure 3 that maximum adsorption capacity (1.83 mg/gm) was found at contact time 60 minute. Same study carried out by using steel slag (Zahar et al., 2015) and obtained maximum adsorption capacity of Mn^{2+} was found 0.8 mg/gm.

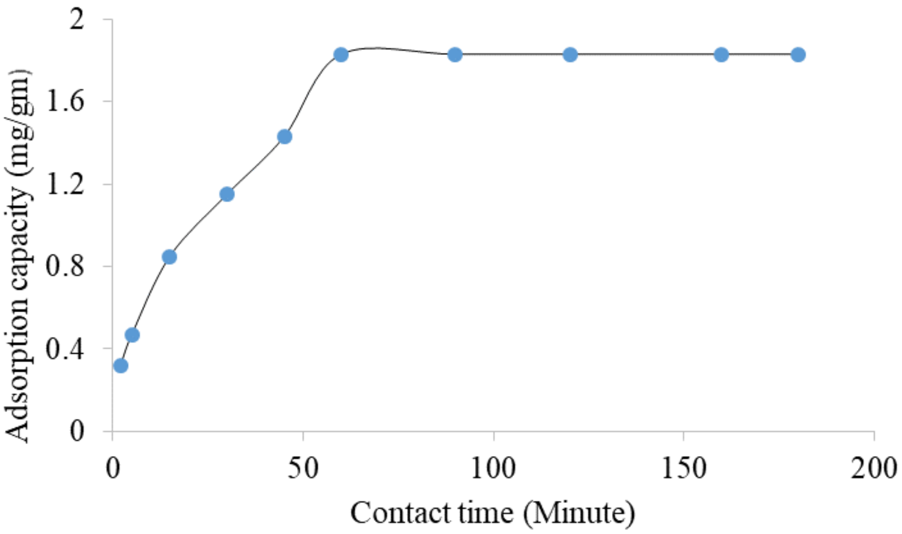

Figure 3:Effect on contact time

3.4 Effect of Temperature on Adsorption Capacity on Mn^{2+}

The temperature of the medium plays a crucial role in adsorption process as it greatly influences the rate of adsorption. The range of temperatures used in this experimental phase is 293 to 313K with a 5K difference between each. It can be explained from Figure 4 that adsorption capacity increased with increases temperature (from 1.42 to 1.82 mg/gm.). With increasing temperature, the number of available adsorption sites expands because it leads to the disruption of internal bonds near the active surface sites of the adsorbent. The percentage of ion-exchange adsorption of each metal ion increased with increasing temperature and was thus endothermic. At high temperatures, the heavy metals hydration shell was disrupted (Bhagat et al., 2018). Same study carried out by using decomposed leaf (Li et al., 2010) and obtained maximum adsorption capacity of $Mn2^{+}$ was found 2.5 mg/gm.

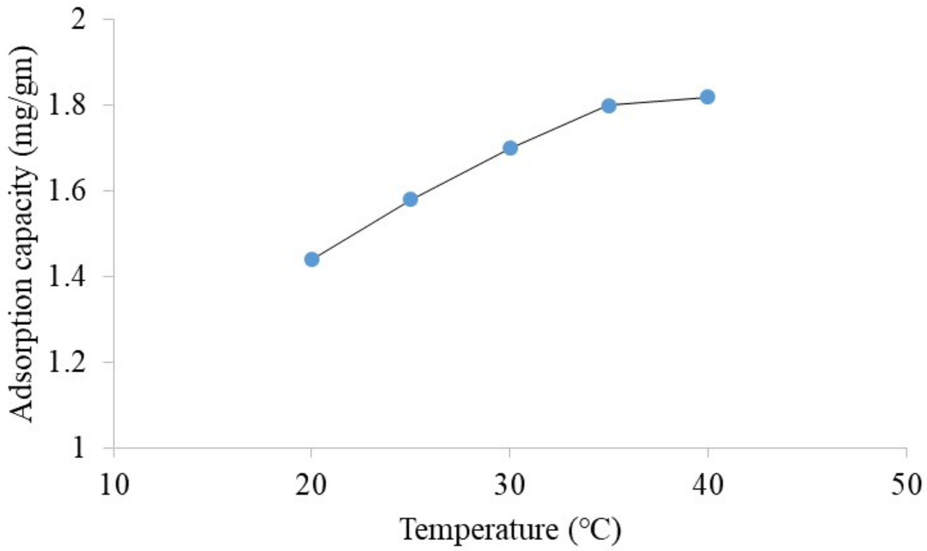

Figure 4:Effect of temperature

3.5 Effect Of p^H on Adsorption Capacity of Mn^{2+}

This study examined the impact of pH in the range of (2-10), keeping a constant coconut coir ash dosage of 1 g and an initial Mn^{2+} concentration of 20 mg/L.The pH of the solution is one of the most critical parameters in the adsorption of metal ions onto adsorbents because it affects the adsorbent's surface charge, degree of ionization, and adsorbate specification (Mestre et al, 2009). When the solution is diluted with the adsorbent, a colloidal suspension with electrical charges forms. As a result, it is critical to determine whether the adsorbent surface is positively or negatively charged depending on the pH value (Jagung, 2011). Figure 5 explained that the adsorption capacity increased (from 0.82 to 1.82 mg/gm.) at low pH 2 to 6 and afterword the adsorption capacity decreased (from 1.82 to 1.56). Manganese ions have a propensity to form hydroxide precipitates at higher pH levels, which slows down adsorption rates and reduces the effectiveness of manganese removal (Abbar et al.,2017). Maximum capacity was found 1.82 mg/gm. at pH 6. Same study carried out by using decomposed leaf (Li et al., 2010) and obtained maximum adsorption capacity of $Mn2^{+}$ was found 5 mg/gm.

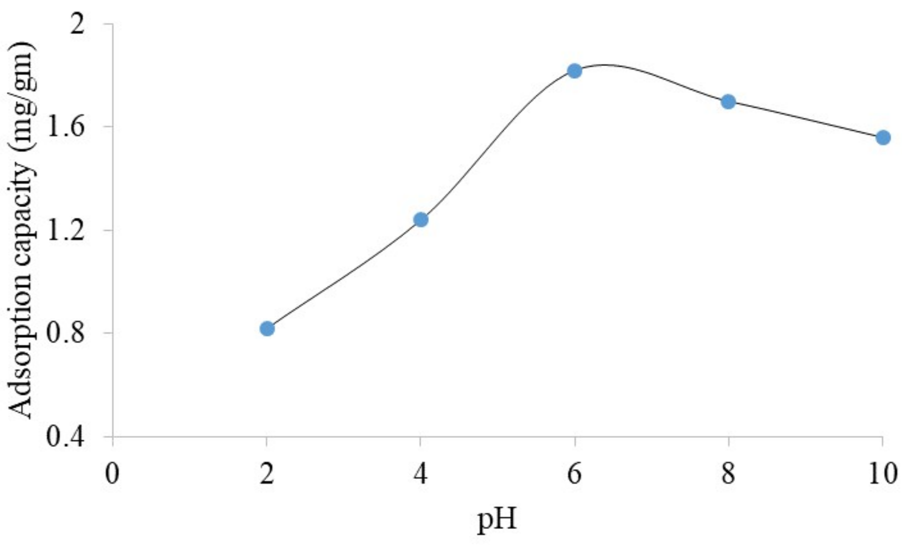

Figure 5: Effect of pH

4. CONCLUSIONS

The process of adsorption was employed to examine the elimination of heavy metals from a synthetic wastewater solution. Batch adsorption experiments were conducted using coconut coir ash to adsorption Mn^{2+} from aqueous solutions. The highest adsorption capacity was attained at pH 6 (1.82 mg/gm), dosage 1.0 gm/100mL (1.819 mg/gm), initial concentration 100 mg/L (6.7 mg/gm). The state of equilibrium in adsorption was nearly reached within 60 minutes of agitation. The findings of this study emphasize the viability of utilizing coconut coir ash which derived from coconut fibre, as a cost-effective alternative adsorbent for the removal of Mn^{2+} metal ions from aqueous solutions.

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