A LOW COST ADSORBENT MATERIAL SUCH AS HAEMATITE FOR THE REMOVAL OF CU (II) METAL IONS FROM WATER AND WASTEWATER BY ADSORPTION TECHNIQUE USING KINETIC MECHANISM

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ABSTRACT

This study evaluated the potential of Haematite to remove the Cu (II) metal ions from water and wastewater as an adsorbent. The effect of pH, metal ion concentration, temperature, and contact time were assessed using the batch adsorption technique. The maximum adsorption was achieved at optimum conditions of 40 min to adsorb Cu (II) heavy metal ions at an efficiency of 99.12%. Meanwhile, the adsorption capacity of Cu (II) was found to be 178.21mg/g. However, the adsorption capacity of adsorbent was less dependent on temperature. Such adsorbent acts as a sustainable adsorbent material to remove heavy metal ions and the potential effects of the adsorbent had been explored in this study.

KEYWORDS: Haematite as low-cost adsorbent material, Copper metal, Adsorption capacity, pH and temperature.

INTRODUCTION

Heavy metals in water systems are non-biodegradable and cause the severe problem to the environment. Consumption of heavy metal contaminated water absorbed by the plant systems and transferred to the next level of the food chain with higher concentration is referred to as bio magnifications,[1,2] Water pollution has become a serious threat to human beings, plants, and animals. The effluents coming out from the water treatment plants contain enormous amounts of heavy metals which include copper, lead, zinc, nickel and cadmium. The removal of such metals is of greater significance in water pollution control.[3] Due to the rapid rise in population, the need for freshwater for several uses would increase. The demand for freshwater would rise rapidly and the gross percapita demand of water per person would go down drastically, causes water stress.[4,5] Due to various anthropogenic reasons, the quality of water is decreasing every day and the polluted water harms aquatic systems, plants, and human beings. Several chemical components were reported in the water. Heavy metals in water are considered to be the most dangerous components and produce toxicity. The excretion of animals is also a major contributor to pollution in water.[6–8] Several water treatment techniques include, ion exchange process, reverse osmosis, flocculation, and filtration are used to remove the chemical components in the water. These technologies require higher energy, higher equipment,

and maintenance cost.[9] The major drawback of using these conventional treatment techniques were disposal of the sludge which comes out after treating the wastewater. Therefore environmental eco-friendly removal of heavy metals is of growing significance. Several investigations have been made to utilize natural waste materials to remove toxic heavy metals by adsorption process.[10] The essential components included in the phase transfer process of adsorption techniques were adsorbate and adsorbent. A material that makes the ions to adhere on a surface is known as an adsorbent and the metal ions adsorb on the surface is adsorbate.[11] Adsorption technique is widely used nowadays to remove organic, inorganic, and biological toxic components. Among the other conventional methods, the adsorption technique is considered to be most effective because of its low maintenance cost, low operational cost, and easy handling nature.[12] The metal ions which are adsorbed on the surface can be easily recovered using the adsorption technique. Several external factors include temperature, contact time, pH, adsorbent dozer, etc., affect the removal efficiency of toxic metal ions from the water.[13] The objective of the study is to utilize Haematite in the removal of heavy metals from wastewater. The effect of Haematite on adsorption capacity based on pH, metal ion concentration, temperature, and contact time were assessed using batch adsorption technique.[14]

Adsorption experiments
The adsorption experiments were carried out by mixing 100 g of powdered sample of adsorbent with 100 mL of the heavy metal aqueous solution allowed to agitate in a water bath shaker at a constant speed of 250 rpm in a constant temperature and for a constant time interval. After adsorption, the heavy metal solution was filtered and the concentration of heavy metal in aqueous solution after the filtration process was identified using atomic absorption spectrometry. The adsorption quantity q (mg/g) of low-cost materials used in this study was to be identified using the following equation

$$q = \frac{(Co - Ce)}{M} \, V \ldots\ldots\ldots\ldots (1)$$

Where, Co (mg/L) and Ce (mg/L) are the initial and final concentration of toxic metals in the aqueous solution, respectively. V and M represent the volume of water used and the weight of the adsorbent used, respectively, in this study.

The percentage metal removal in the water can be found with the help of the following equation:

$$\text{Percentage removal} = \frac{(Co - Ce)}{M} \times 100 \ldots\ldots\ldots\ldots (2)$$

RESULTS AND DISCUSSION
1: Effect of contact time
The removal efficiency and adsorption performance of the samples have been observed to increase with delay in contact time. During the adsorption process, the outer surface of the adsorbent is affected by saturated adsorbate particles. Beyond this saturation point, the efficiency of the adsorption process no longer increases and the adsorbent no longer has the ability to adsorb metal ions. Figure: 1 shows the effect on the adsorption process based on the contact time of the adsorbent in water. The adsorbent surface adsorbs Cu (II) faster ie, 95% of the heavy metals adsorbed within 15-20 min showed a clear adsorption change after adding 20 min. The maximum adsorption was reached at 40 min, and the adsorption efficiency of Cu (II) heavy metal was 99.12%.
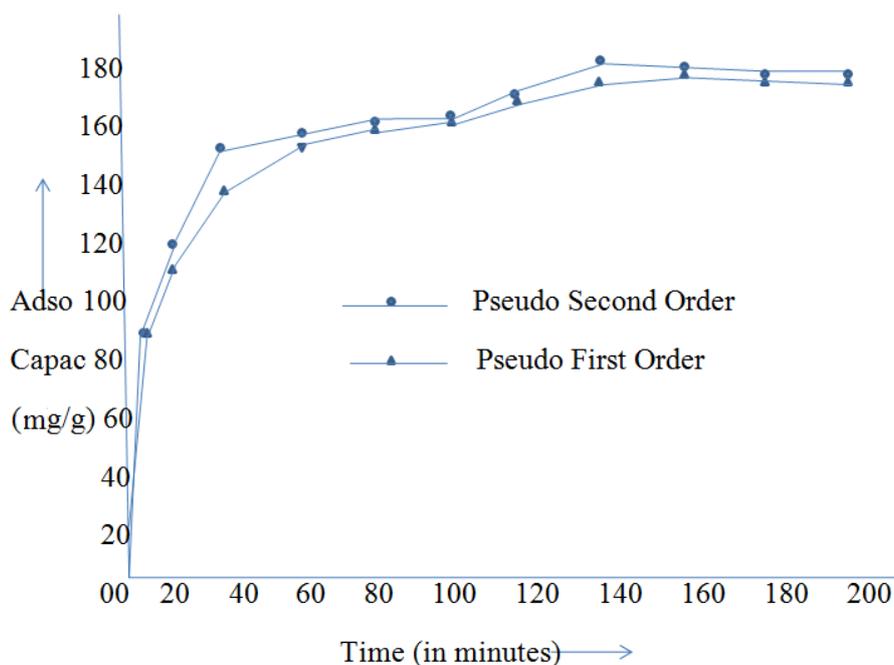

Figure 1: Adsorption kinetics of Cu (II) ions on Haematite.

2: Effect of contact time and environmental temperature
The adsorption limit of the adsorbents for the removal of heavy metals increased with increasing contact time, beyond a certain limit, the adsorption did not improve with increasing contact time (Fig. 1). Due to the good structure of adsorbent, the adsorption is very fast in the first 30 minutes. The permeability of fibers can effectively adsorb heavy metals, providing adsorbent with an ideal way to adsorb heavy metal ions.[15-16] Dynamic pseudo-first and pseudo-second order demand models allow understanding the behavior of the adsorption process in relation to contact time. Figure 2 shows the adsorption capacity of adsorbent for heavy metal ions as a function of temperature. The adsorption capacity of Haematite increased slightly with increasing temperature. In all the cases, the degree of adsorption is not exceptional due to ideal pathway of ions, making the adsorption process less dependent on temperature variation.[17-18] The powerless affectability of Haematite on adsorption process with respect to temperature is pivotal to down to earth applications. Maximum adsorption capacity occurs at 35°C.
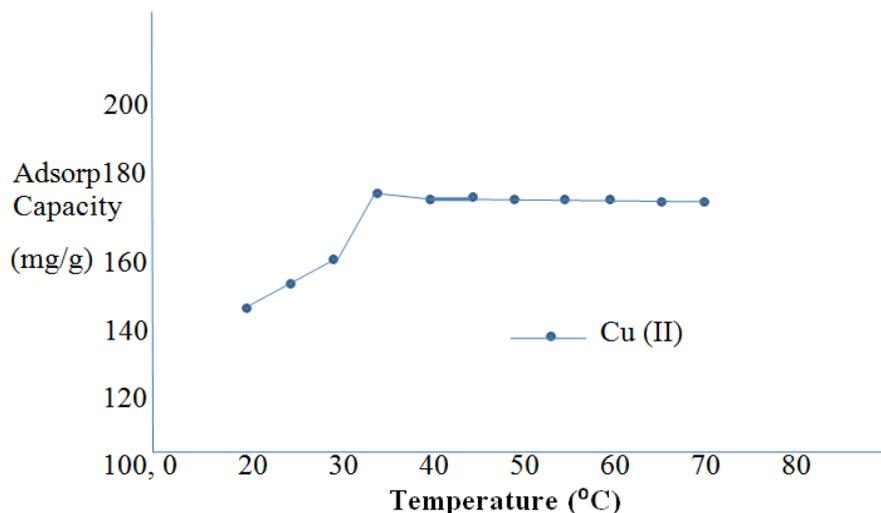
Figure 2: Adsorption capacity of adsorbent with respect to temperature.

3: Effect of solution acidity

To determine the effect of heavy metal adsorption on acidic solutions, 100 mg of cross-linked sorbent was mixed with 100 ml of 1.5 mM Cu (II) arrays at various pH ranges for 30 min. From Figure 3, it can be seen that the fficiency of the adsorption process is very low in the very low pH range, which indicates that the adsorption target has been achieved with hydrogen atoms. The unsaturated part of the adsorbent attracts hydrogen atoms and heavy metals present in the solution.[19] The adsorption efficiency of heavy metals increased with the increase of pH. In Figure 3, the maximum adsorption is reached in the pH range between 4.0 and 7.0, beyond which the adsorption process does not improve significantly.
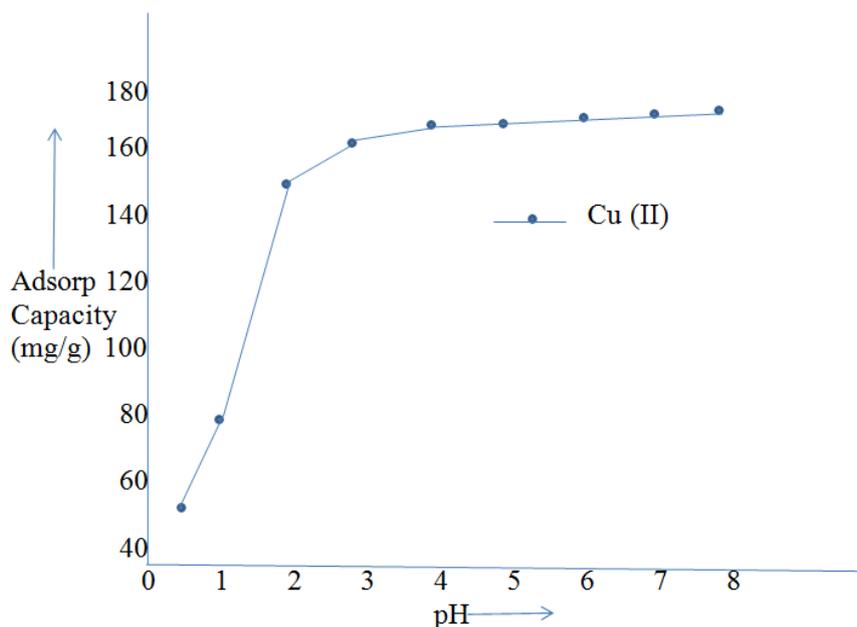

Figure 3: Effect of pH on adsorption capacity of heavy metal.

4. Maximum adsorption capacity of adsorbent

The amount of adsorbent in solution for heavy metal removal is based only on the maximum adsorption capacity of the adsorbent. Figure 4 shows the adsorption capacity of the adsorbents for different concentrations of heavy metal ions. The adsorption capacity of heavy metals increases with the concentration of heavy metals in solution and remains constant beyond a certain limit, indicating that there is no dynamic pathway available on the adsorbent surface to adsorb heavy metals and reach the saturation limit. Process.[20] The final adsorption limit of the adsorbent for Cu(II) was 179.7 mg/g. It can be seen from Figure 4 that the adsorbent can adsorb 78.15% of Cu (II).
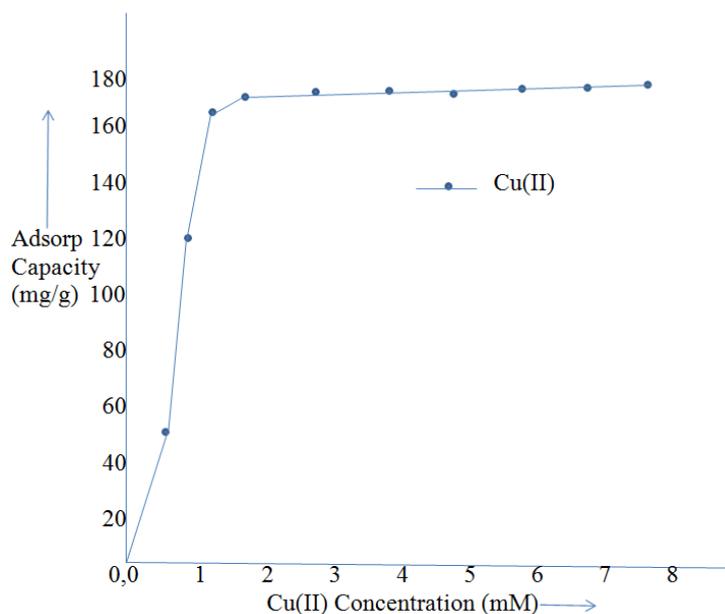
Figure 4: Adsorption capacity based on metal ion concentration.

CONCLUSION

In this study, Haematite available in the original request were collected, reused and pulverized in to fiber beaches. The adsorbents were tested for adsorption capacity of heavy essence in wastewater. Originally, the face morphology of adsorbent aesthetics pervious in nature and after subordinated to treatment, the passable nature of the adsorbent face had been incredibly dropped after adsorption of essence ions which may have happed because of the bond arrangement with the groups present on the adsorbent. In view of the issues, it veritably well may be proposed that adsorbent morphology favors essence flyspeck adsorption. The optimum contact time on adsorption of heavy essence was plant to be 40 min. The adsorption capacity of adsorbent hadn't depended on temperature. The maximum adsorption capacity of Cu (II) was plant to be178.21 mg/g. Maximum adsorption capacity was obtained at 4.0 pH.

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