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REMOVAL OF HEAVY METAL CU (II) FROM AQUEOUS WASTE USING *PARTHENIUM HYSTEROPHORUS* (WHITE TOP WEED) - A LOW COST ADSORBENT

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Abstract

In this study Activated carbon prepared from parthenium hysterophorous was used to remove Cu(II) ions from aqueous solution. The adsorbents included sulphuric acid treated Parthenium. The effects of adsorbent initial pH, initial adsorbent concentration, temperature and contact time on metal ion removal have been determined. Aqueous solutions of various concentrations (10-50 mg/L) were shaken with certain amount of adsorbent to determine the adsorption capacity. Maximum removal was sequestered from the solutions within 150 min after the beginning of all experiments. Adsorption depends on solution pH , Cu(II) concentration and contact time. Adsorption follows both Langmuir and Freundlich isotherm models. The efficiency of adsorption was found to be 80%. The optimum pH and temperature was found to be 6 and 30±2 ℃ respectively. Removal of Cu(II) ions using activated carbon is found to be favourable and hence it could be used as an adsorbent for the treatment of effluents. The results showed that sulphuric acid treated Parthenium can be considered as potential adsorbents for cu (II) removal from dilute aqueous solutions.

I. INTRODUCTION

Heavy metal pollution in wastewater has always been a serious environmental problem, because heavy metals are not biodegradable and can be accumulated in living tissues. Rapid industrialization has seriously contributed to the release of toxic heavy metals to water streams. An elevated environmental level of Cu (II) comes from variety of sources. Mining, metal cleaning, plating baths, pulp, paper and paper board mills, refineries, fertilizer industries etc., are the potential sources of Cu(II) in industrial effluents. Copper, a widely used metal in industry, is an essential trace element for human health and play an important role in carbohydrate and lipid metabolism & in the maintenance of heart and blood vessel activity. According WHO, the maximum acceptable concentration of Cu(II) in drinking water is 1.5 mg/L. The adult human body contains 100-150 mg of Cu(II), but excess amounts in the body can be toxic. According WHO, the maximum acceptable concentration of Cu(II) in drinking water is 1.5 mg/L. The adult human body contains 100-150 mg of Cu(II), but excess amounts in the body can be toxic . In aqueous environments, the speciation of the metal is dependent both on ligand concentration & pH. If the excessive amount of Cu (II) is allowed to enter into the environment, can cause serious health issues such as nausea, headache, dizziness, respiratory difficulty, hemolytic anemia, massive gastrointestinal bleeding, liver & kidney failure & even death. Removal of metal ions from wastewater in an effective manner has become an important issue. Efficient methods for the removal of metals have resulted in the development of new separation techniques. Precipitation, ion-exchange, flocculation, adsorption, electro-chemical processes, electro dialysis, nano-filtration and reverse osmosis are commonly applied for the treatment of wastewater. However, these methods are either inefficient or expensive when heavy metals exist in low concentrations Parthenium (Parthenium hysterophorus L.) also known as white top or carrot weed, an annual herbaceous weed a native of North-east Mexico, has now widely spread in India, China, Australia, Pacific Islands, etc.

II. MATERIALS AND METHODS

2.1. Preparation of sulphuric acid treated Parthenium carbon:

Fully grown plants of Parthenium stems were collected in and around 34oimbatore (India), washed cut into small pieces and air dried. The dried Parthenium was used for carbon preparation by mixing one part of Parthenium and 1.5parts of concentrated sulphuric acid and keeping it at120°C for 24h. The carbonized material was then washed with distilled water several times to remove the free acid and soaked in 1% sodiumbicarbonate solution overnight to remove any residual acid. This material was then washed with distilled water and dried at 105° C in a hot air oven for 24 h. The material was placed in airtight plastic containers for further use.

2.2. Preparation of copper solution

The solution of Cu(II) was prepared by diluting a 100 ppm stock metal ion solution obtained by dissolving 0.393 g of hydrated copper sulphate ($CuSO_4.7H_2O$) in 1L distilled water. The range of concentration of prepared Cu (II) solution was 1–100 mg/L. The range of pH selected was 2–10. The pH of each solution was adjusted to the required value with 1M HCl & 1M NaOH before mixing the adsorbent with the solution.

2.3. Adsorption Process

Standard solution was prepared at different concentrations 10-50mg/L. 1g of adsorbent was added in a 100ml conical flask and agitated at 150 rpm for predetermined time intervals at room temperature (30±2°c) in a mechanical shaker at the end of agitation time, the adsorbate and adsorbent were separated using centrifugation and 500rpm and estimated using spectrophotometer.

2.4. pH solution preparation:

Standard solution was prepared at different pH 3-7. 1 g of adsorbent was added in 100 mL conical flasks and was agitated at 150 rpm for predetermined time intervals at room temperature (30±2°c) in a mechanical shaker at the end of agitation time, adsorbate and adsorbent were separated using centrifugation at 5000 rpm and estimated using spectrophotometer at 420 nm.

III. RESULTS AND DISCUSSION

3.1. Effect of contact time on adsorption

The agitation time was considered to be one of the most important factors affecting the adsorption efficiency. The amount of the adsorbed metal ion contact time increases with increase in time fig: 1, after 150 minutes it becomes constant and attained equilibrium.

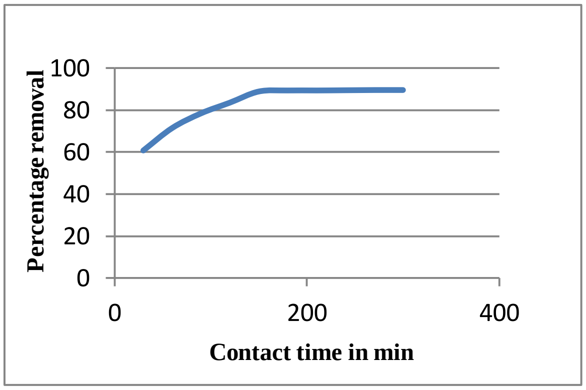

Figure 1: Effect of contact time on Cu (II) removal

3.2. Effect of Adsorbent dose

The adsorption of Cu (II) ions were studied by varying the adsorbent quantity (2.0-1g/10.0g/100ml) of the adsorbent. The adsorption efficiency increased with an increasing adsorbent dosage fig: 2. This is due to an increase in the surface area of the adsorbent which in turn increases the availability of binding sites. Maximum metal ion removal was achieved within 100-150 min after which the Cu (II) ion concentration in the test solution was almost constant.

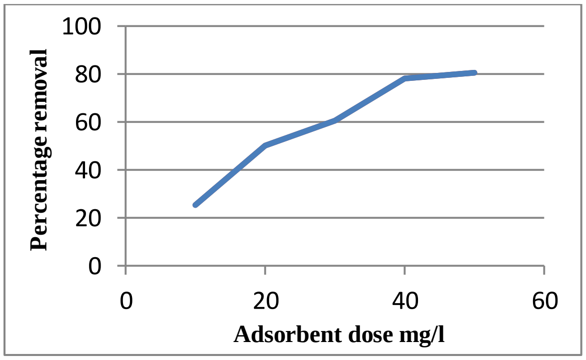

Fig 2: Effect of Adsorbent dose on Cu (II) removal

Effect of pH

The pH of the metal solution played an important role in the adsorption of Cu (II). With an increase in pH from 2 to 10, percentage sorption and uptake also increased. At lower pH values, the surface charge on the adsorbent is positive and adsorption was not favorable and also the H+ ions complete strongly with metal ions for active sites in adsorbent [11]. Increase in pH result in the electro static repulsion between the cations and surface sites, there by the competing effect of the H+ ions decreases and the positively charged Cu(II) ions get adsorbed on the free binding sites, resulting an increase in the total metal uptake, as shown in figure-3.

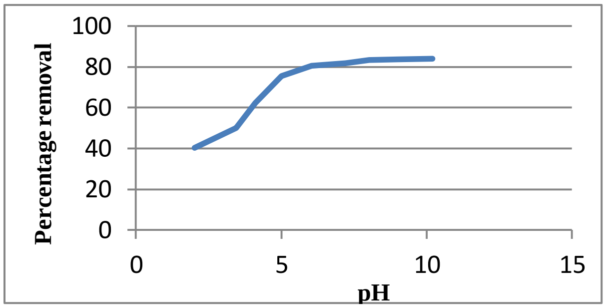

Fig 3: Effect of pH on Cu (II) removal

Adsorption Isotherm:

The Langmuir and Freundlich equation were employed to study the adsorption isotherms of metal ion. When adsorbent and adsorbate come in contact with each other, a dynamic equilibrium is established between adsorbate concentrations in both the phases. Both Langmuir and Freundlich models were used to describe the data derived from the adsorption of Cu (II) by sulphuric acid treated *Parthenium hystereophorous*. The Langmuir model is based on the hypothesis that uptake occurs on a homogenous surface by monolayer sorption without interaction between adsorbed molecules, and is expressed as

$q_e = q_{max}\, bC_e/(1+bC_e)$

Where q_{max} represents the maximum adsorption capacity and b is a constant related to affinity and energy of binding sites. Langmuir Isotherm shows better fit model with higher correlation coefficient (R^2 = 0.998) shown in Fig. 4.

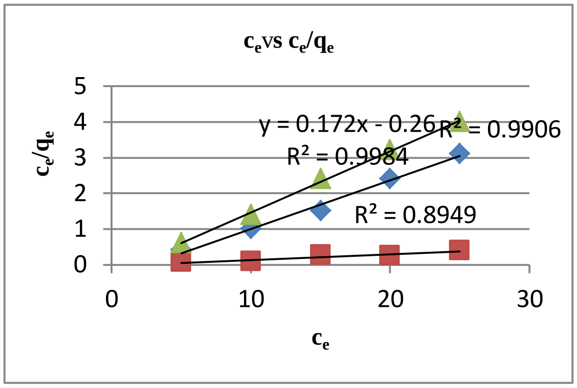

Fig 4. Langmuir Fit for Adsorption of Cu (II) at 50 mg/L R^2 = 0.998, 40 mg/L R^2 = 0.990, 30 mg/L R^2 = 0.894

The Freundlich model proposes a multilayer sorption with a heterogeneous energetic distribution of active sites and with interaction between adsorbed molecules. It is expressed mathematically as

$q_e = K_f C_e^{\,1/n}$.

Where K_f and n are the Freundlich coefficients. K_f provides an indication of the adsorption capacity and n is related to the intensity of adsorption.fig:5

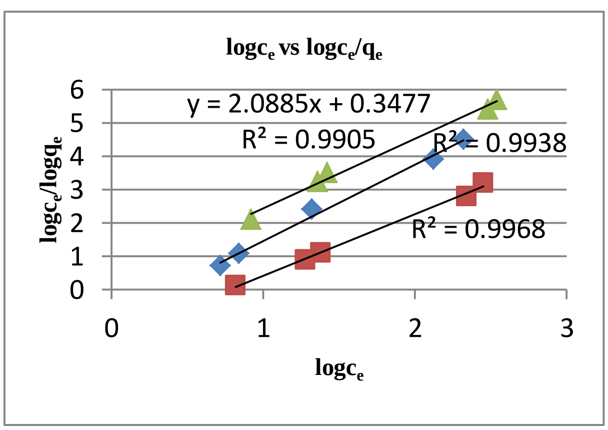

Fig 5. Freundlich Fit for Adsorption of Cu (II) at 50 mg/L R^2 = 0.990, 40 mg/L R^2 = 0.993, 30 mg/L R^2 = 0.996

Conclusion:

From the present result it is concluded that *Parthenium hystereophorous* is a promising low cost adsorbent for Cu (II) removal. This adsorbent is locally available and Pre-treated before using for adsorption. The adsorption was dependent on adsorbent time, adsorbent concentration and on pH. The removal increased with time and adsorbent dose. This study also shows that the equilibrium data fits both Langmuir and Freundlich isotherm. Therefore use of *Parthenium hystereophorous* is a cost effective and can be used at household level to mitigate the metal ions problem

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