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Adsorption Study Of Chromium(VI) By Dried Biomass Of Tea-Leaves

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Abstract:

Chromium contamination has increased in the last few years in industrial effluents. Environmental Protection Act has set an enforceable Criteria Maximum Concentration (CMC) level of total chromium in freshwater as 16 μg/L. The aim of this study was to investigate the Cr (VI) adsorption on used and dried tea leaves (*Camellia sinensis*). The parameters used to study the adsorption behaviour of chromium on tea leaves were pH of the reaction mixture, initial chromium concentration, dried biomass of tea leaves and agitation speed. The batch kinetic studies showed that adsorption have increased with increase in dried biomass and decrease in pH. Increase in the agitation speed caused a slight increase in the removal efficiency. Response Surface Methodology was used as a tool of varying multiple experimental parameters simultaneously to get the output. Maximum removal efficiency (99.9%) was obtained after 24 hours at pH 6, initial chromium concentration of 16.94mg/l, agitation of 14.79 rpm and dried biomass of 1.41g. Successful adsorption by tea leaves have been further confirmed by Scanning Electron Microscope, which showed the appearance of smoother surface after adsorption.

***Keywords*— *Camellia sinensis*; wastewater; chromium; response surface methodology; Scanning electron microscope**

I. INTRODUCTION

Chromium is one of the most widely used industrial metals. Due to its wide applications, contamination of chromium has increased in the last years in industrial effluents [1]. US Environmental Protection Act has set an enforceable Criteria Maximum Concentration (CMC) level of total chromium in freshwater as 16 μg/L [2]. Chromium exists in several oxidation states, but the most stable and common forms are Cr (0), the trivalent Cr (III), and the hexavalent Cr (VI). Cr (VI) is considered the most toxic forms of chromium. It has been reported to cause severe eye irritations, skin ulcers, liver disorder, renal failure, intravascular haemolysis cardiovascular effects leading to death and reproductive and development effects [3,4]. Cr (III) is less toxic as it is relatively insoluble in water, presents lower mobility, and is mainly bound to organic matter in soil and aquatic environments. Chemical methods of Chromium removal are quite effective in removing it from industrial effluent but are expensive and often cause disposal problem of toxic sludge generated. Biodegradation by microorganisms are cost effective but thick biofilm may cause diffusion barrier for the chromium. Physical methods such as adsorption offers significant advantages like cost-effective, availability, simple design, ease of operations and efficiency in comparison with other methods [5] .

The objectives of this study were to investigate the potential of dried mass of used tea leaves (*Camellia sinensis*) as an adsorbent to remove chromium from aqueous solution. The parameters used

to study the adsorption behaviour of chromium on tea leaves were pH of the reaction mixture, initial chromium concentration, dried biomass of tea leaves and agitation speed. Response Surface Methodology (RSM) is used as a tool of varying multiple experimental parameters simultaneously to get the removal efficiency [6].

II. MATERIALS & METHODS

Preparation of Adsorbent:

Used tea leaves obtained from a nearby stall were boiled, dried and ground to fine powders which were used as adsorbent for the present study.

Batch adsorption studies:

The batch adsorption studies were carried out by varying the experimental conditions namely agitation speed (0,50 and 100 rpm) dried biomass (1 and 2 gm)and pH (5,7 and 9). The removal of chromium was measured by 1,5-Diphenylcarbazide absorption method using a UV-Visible spectrophotometer.

Optimization of process parameters for removal of chromium using Response Surface Methodology (RSM) by "Design-Expert Version 10" software:

The process parameters, like initial concentration of Chromium, pH, dried biomass and agitation speed were taken as input variables in Response Surface Methodology. The output i.e. the response was chosen to be the Chromium removal efficiency (%), which was found out experimentally. This response was studied and analysed by the software.

SEM Analysis:

The SEM analysis of the dried tea leaves biomass (adsorbent) were carried out before and after adsorption of chromium(VI).

III RESULTS & DISCUSSION

Chromium (VI) was removed from the solution by the dried leaves. Best removal efficiency (98%) was obtained at pH 5 with an initial chromium concentration of 12.5 mg/L by 2 g of dried tea leaves biomass. There is slightly better removal in 50 rpm and 100 rpm than when no agitation is applied.

The optimized value of the parameters for chromium removal obtained after running the set of 30 experiments designed by RSM is given in Table 1:

Table 1: Optimized value of the parameters for chromium removal

Parameters	Optimized Value
pH	6
Initial Chromium Concentration(mg/L)	16.94
Agitation(rpm)	14.79
Weight of dried biomass(g)	1.41

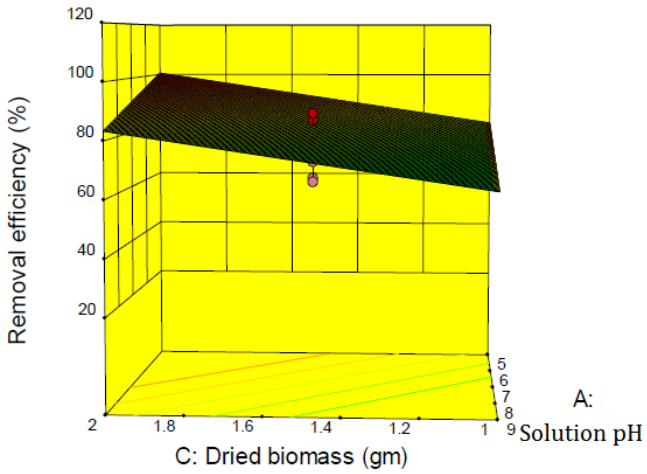

Figure 1: Response surface 3D plot indicating the effect of interaction between dried biomass and Solution pH with removal efficiency

Since the p-value of the model having pH and dried biomass as the input parameters is less than 0.05, it can be concluded that there is a statistically significant association between the removal efficiency and the input variables.

SEM image reveals that the adsorbent before adsorption has very irregular or uneven rough surfaces. After adsorption the surfaces of the adsorbent became much smoother.

IV .CONCLUSION

It can therefore be concluded that dried mass of tea leaves (*Camellia sinensis*) is an effective alternative biomass for the removal of chromium (VI) from effluent coming from various industries. The material has a high adsorption capacity, available naturally and abundantly at a low cost.

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