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Research Article

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Desorption Studies of Cr (III) on Non-Living Biomass of Water Hyacinth and Chrome recovery

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ABSTRACT

The ability of desorption of Cr (III) from roots of water hyacinth, Eichhornia crassipes has been studied at varying pH and concentrations and in the presence of tannery effluent water in order to stimulate real time conditions. The chrome tanning has been employed in Tamil Nadu for almost 75 years and the chrome waste has been directed into river waters for long. Recently, chrome recovery method has been employed and chrome salt is recovered from it. But the chrome which has been released in the water before remains absorbed by the water hyacinth and has been remaining in it for decades. The chromium has been found to leap on from one generation of the plant to another. The desorption of chromium, after the intake in water hyacinth roots were measured with varying pH and sorbent concentration and kinetic studies were conducted. A remedial measure to remove the chromium traces in the water hyacinth roots after absorption was also tested and chrome recovery method was employed.

Keywords: *Chromium (III), Chrome recovery, Desorption, Kinetic studies, Tannery effluent water, Water hyacinth roots.*

INTRODUCTION

Chromium occurs in aqueous systems in both the trivalent Cr (III) and the hexavalent Cr (VI) forms and is widely used in a large number of industries, including metal finishing, inks, dyes, pigments, glass, ceramics and glue. It is also employed in chromium tannery [1, 6], textile dyeing, and wood preservation. Chromium compounds are also used to inhibit corrosion in boiling waters[1]. Consequently, untreated effluents from industrial inputs mainly tanneries could contain a wide range of concentrations of Cr (III) and Cr (VI) elements [1]. The toxicity of chromium has been documented, and depends on its oxidation state. Cr (VI) is approximately 100 times more toxic than Cr (III) because Cr (VI) is carcinogenic and mutagenic and is also a strong oxidant [2]. However, both are undesirable in aqueous environments.

Various treatment processes for the removal or reduction of Cr are available; the most commonly used include reduction and precipitation, ion exchange and adsorption. Activated carbon is costly both to use and to regenerate. The use of roots for filtration known as rhizofiltration, to remove heavy metals has been studied before [3]. Water hyacinth (*Eichhornia crassipes*) is a fast growing perennial aquatic plant[5]. It is widely found in all parts of India and is capable of tolerating heavy drought[4]. The roots of water hyacinth have the ability to absorb and store chromium[5, 8, 9, 11]. The plant also has the ability to absorb other heavy metals [12]. The desorption studies on the roots of water hyacinth has not been performed before using tannery water as a substrate. Recently, the recent investigation into chrome recovery method in tanneries was found to be effective[1] and in this paper we report on the use of the non-living biomass of water hyacinth roots, as a sorbent for absorption and desorption of chromium and an effective method in the recovery of chromium from it.

MATERIAL AND METHODS

Materials

Water hyacinth roots were collected from Bhavani Dam, near Erode. The roots were cleaned with tap water and then with distilled water to remove foreign materials, unhealthy parts of the roots were discarded and the roots were finally rinsed with sterilised distilled water. The dry roots were then rinsed with 1M solution of H_2SO_4 for relief from volatile impurities in it. The acid treated roots were washed with distilled water until the pH of the rinse was near neutral. They were dried at 80ºC in a hot air oven. The roots were collected and any physical impurities were removed by hand.

Methods and Studies

The roots were initially analysed for chromium by subjecting the roots to protein digestion and estimating the chromium by atomic absorption. The total chromium content present was recorded and the next phase was directed towards the adjustment of pH. The roots were sorted into different batches with 2 grams each of roots. The batches were supplied with tannery water and the pH was adjusted to 2, 4,7,10 and 12. The pH was achieved by addition of 0.1 M of HCl or NaOH respectively. The constant was kept and the pH was measured to be 8.3. The batches were subjected to orbital shaker at 125 rpm and at an ambient temperature of 37ºC for a time period of one hour. The roots are removed and the extract obtained was subjected to atomic absorption and the concentrations of chromium were found.

The effect of different concentrations of roots were also studied by taking 2, 4,6,8 grams of the roots in batches and the tannery water was added to each. The pH was set 7 and the batches were again subjected to orbital shaker at 125 rpm for a period of 1 hour at 37 degree Celsius. The extract was taken and they were analysed for chromium by atomic absorption spectroscopy at SITRA, Coimbatore. The varying concentrations of the chromium were recorded, and the results were carried out and analysed.

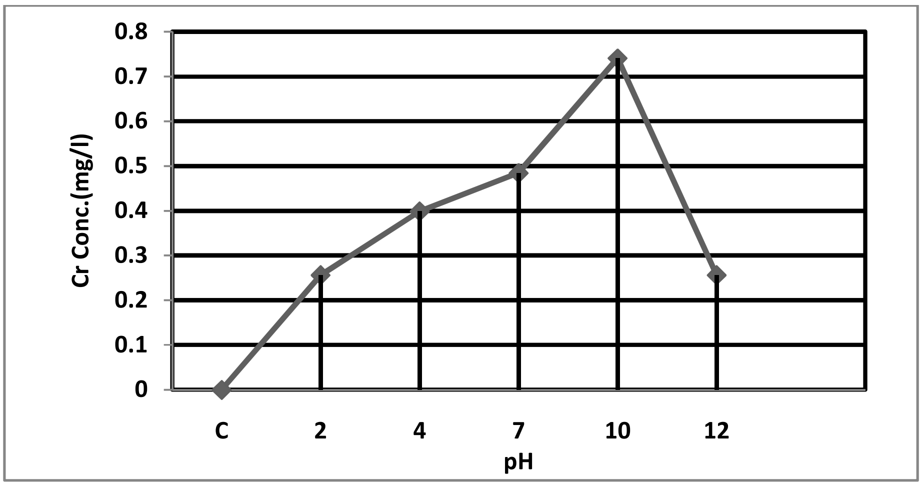
RESULTS AND DISCUSSION

The roots were analysed for chromium and the chromium was found to be 11.91mg per litre of water and per 2 grams of roots. So, the total chromium was found to be 11.90 mg per 2 grams of the root. The roots were kept for orbital shaking at 120 rpm in distilled water and no chromium was observed in it at different time intervals. The experiment was then conducted in the presence of tannery water obtained from a tannery located nearby Bhavani Sagar dam, Erode.

Effect of pH

The effect of pH on the desorption of Cr (III) by the water hyacinth roots is shown .The experiment was done to 2, 4, 7, 10 and 12 as Cr (III). The concentration of roots was fixed at 2 grams and the rotation was set at 125 rpm. The temperature was fixed at 37ºC. The roots were then gathered together and filtered. The filtered water was then subjected to atomic absorption spectrum. Tab1 and Fig 1 shows the graphical analysis of the effect of pH on desorption.

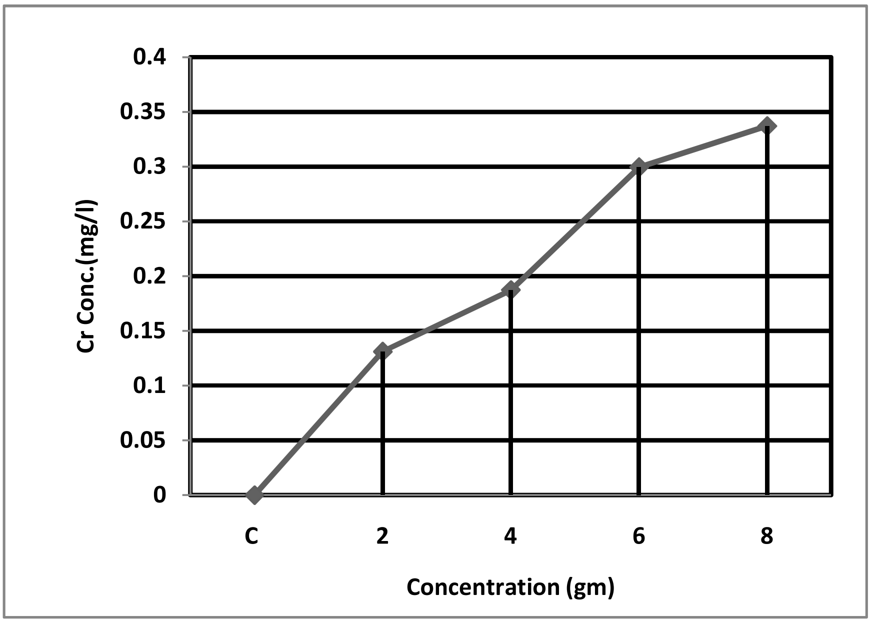
Fig.1 The figure shows the increase of concentration of Cr (III) in the tannery water with respect to the pH increase. There seems to exist a linear increase in concentration until pH 10 then a steep fall at 12



Effect of Concentration of Sorbent roots

The study on the variation of the Cr (III) with respect to the concentration of the sorbent roots was done. The orbital shaker was set to 125 rpm and the temperature was also kept constant at 37 degree Celsius. The filtrate was obtained using filter paper and the filtrate was subjected to atomic absorption spectroscopy again. The following results were tabulated in Tab 2 and the Fig 2 shows the linearity in the desorption of chromium explaining the direct proportionality of sorbent roots and chromium.

Fig 2. The increase in chromium concentration with respect to the increase in the concentration of the hyacinth roots added in grams. The graph increases linearly showing chromium adsorption linearly



FTIR Studies

The FTIR studies were conducted with the sample without the desorbed chromium (Fig 3) and another sample containing desorbed chromium (Fig 4). The two samples were analysed and the extra functional groups were also identified at peak maximum of 2360cm^{-1} and 1650 cm^{-1}

Fig3. The FTIR study of the sample containing no desorbed chromium

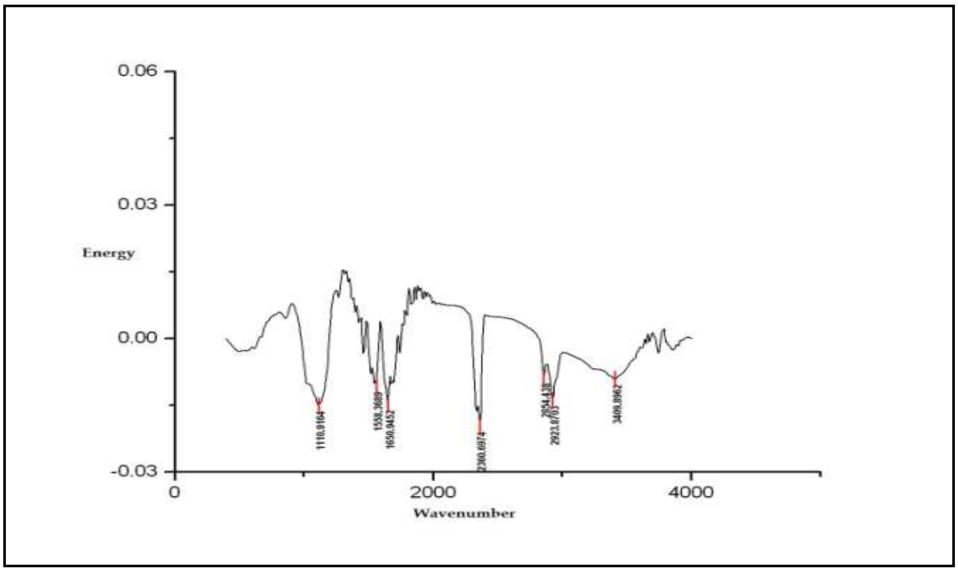
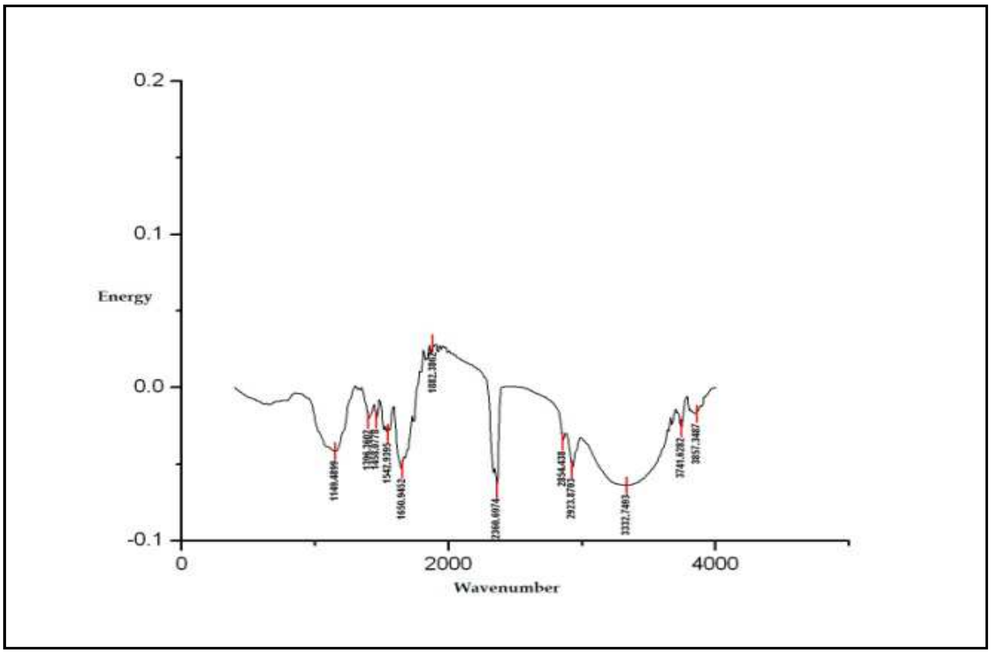


Fig4. The FTIR study of the sample containing desorbed chromium and other compounds



Chrome Recovery

The chromium content present in the filtrate can be recovered by the action of various chemicals. The method is already employed in the tannery industries. The filtrate was then subjected to treatment with Magnesium Oxide (MgO). The precipitate was then hardened using 50% Sulphuric acid (H_2SO_4) which results in the formation of Chromium Sulphate(Cr $(SO_4)_2$). The resulting mixture is green in colour and the mixture can be reused in the tannery industry.

CONCLUSION

The non-living biomass of water hyacinth roots, an easily available bio-material, has been shown to have the ability to remove Cr (III) from tannery waste and desorption of the same is also seen. The desorbed water can be recovered by chrome recovery method. The tannery water contains some compounds that cause the leaching in the roots of water hyacinth. Further studies into the determination of the components causing desorption has to be studied. It can be stored easily and there are no associated problems of maintaining living plants. The re-absorption of chromium can reduce the toxicity level in the water sources and can provide a safe drinking water to many and avoid health related problems.

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