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Research article

Bioremoval of Chromium (Cr^{+3}) using leaves of *Myrtus communis*

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ABSTRACT

The present study showed that leaves of *Myrtus communis* have many compounds which can serve as hunting net to heavy metals. The potential to remove Cr^{+3} from aqueous solutions through bio-sorption using leaves of *Myrtus communis* as agriculture waste was investigated in batch experiments at (200 mg/l). Wilson-Box as mathematical program was used in order to examine several factors influencing metal adsorption such as pH (4-8), contact time (5 – 240 min) and bio-mass (0.1-10 g). The Best rate of Bioremoval of Chromium (99.1%) of 400 mg/l of Chromium (Cr^{+3}) was found at the following conditions: pH, 7.1; contact time, 190.4 min; bio-mass, 2.2g. While, the lowest rate of bioremoval of Cr^{+3} (45%) was observed at pH, 6; contact time, 122.5 min and bio-mass, 0.1g. At 200 mg/l of Cr^{+3}, the best Bioremoval was similar to the results of 400mg/l but the lowest bioremoval rate was found at pH, 4.8; contact time, 54.6 min and bio-mass, 2.2g. From these results it can be concluded that the leaves of *M. communis* have good ability to remove Cr^{+3} from water because its active compounds, which serves as entrapment positions to heavy metals. Finally, it can be hypothesis that heavy metals just like all pollutants can be easy removed by using green chemistry that gives a simple, safe and inexpensive solution to solve the problem of pollution with heavy metals.

Keywords: **Bioremova**, **Chromium, *Myrtus communis,* pH.**

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INTRODUCTION

One of the most ancient systems of wastewater management was constructed in the Mesopotamian civilization (3500 to 2500 BC) some homes were connected to a storm water drain system to carry away wastes. However, treatment of waste water is a relatively modern practice it was not until the 19th century; especially industrial waste water treatment had its beginnings later during the industrial revolution [1]. However, the source of water pollution was classified into two main categories, which are natural and artificial

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sources. The artificial sources may be the most effective and common sources, which includes various industrial activities, such as; mining, sewage treatment plants, transporting, agricultural applications and others relating to the civilization and development [2]. the release of heavy metals into the environment have been increased significantly as a result of various industrial activities and technological applications, that may result in deposition different pollutants that find their ways to the water bodies which is considered a serious threat to both human and environment [3].

Recently, it seems clearly that biotechnology may be an effective alternative technique for the removal and recovery of metals from contaminated water, applying biotechnology in controlling and removing metal pollution has been received much attention and consequently becomes a hot topic in the field of metal pollution control due to its potential application [4]. Chromium containing effluents are released by following activities: metal plating, anodizing, ink manufacture, dyes, pigments, glass, ceramics, glues, tanning, wood preserving, textiles and corrosion inhibitors in cooling water. Both Cr (III) and Cr (VI) can be present in these effluents [5]. The present study, *M. communis* was used to remove the heavy metal Cr^{3+} from pullulated water experimentally in laboratory at different conditions.

MATERIALS AND METHODS

In this study, one species of plant wastes adsorbents was used, myrtus leaves were selected for their availability to remove pollutants from swage water. Leaves of myrtus were collected (it must be young, fresh and green as the young leaves contain the highest rate of active compounds more than old leaves) and washed carefully, then dried in oven at 35 ^{o}C to avoid loss or burn the active compounds. After that the leaves were crushed and grained to be like powder. The powder was sieved using special sieve with pore size, 1.18 mm.

Chromium standard solution

An adsorbent standard solution of 1000 mg/l of chromium was prepared by dissolving 5.1 g of $CrCl_3.6H_2O$ in 1000 ml of de-ionized distilled water.

Experimental design and optimization of parameters

The adsorbent solution, pH and contact time were chosen individually according to the condition of experiments. In this study, three factors were studied; pH, contact time, weight of bio-mass together by using mathematic program called Wilson box: [pH (4-8), contact time (5 - 240 min) and weight of bio-mass (0.1 – 10 g)]. To prepare concentration of 200 ppm from the stock solution ($C_1V_1=C_2V_2$). The adsorption was carried out in 250 ml flask by mixing together unknown amount of plant waste (according to Wilson –Box low) with constant volume of aqueous solution (100 ml) of $Cr^{+}3$. The contents were shaken at 150 rpm for different periods of time using electric shaker and then the powder of *Myrtus* leave was removed by filtration using a filter paper. The filtrate solution was analyzed via metal content by atomic absorption spectrometer. Removal rate calculated according to the following equation [6].

$$\textit{Efficiency of Removal}(Er)\ \% = \frac{C_o - C_f}{C_o} \times 100$$

RESULTS AND DISCUSSION

The present study showed that leaves of *M communis* have good ability to remove $Cr^{+}3$. leaves of different tree very versatile natured chemical species as these contain a variety of organic and inorganic compounds. Cellulose, 17 hemicellulose, pectins and lignin present in the cell wall are the most important sorption sites [7]. The important feature of these compounds is that they contain hydroxyl, carboxylic, carbonyl, amino and nitro groups which are important sites for metal sorption [7]. Pineapple leaves, for instance, which are used in the study of Weng *et* al. [**8**] for removal of methylene blue, contained majorly cellulose (70-80%), lignin (5-12%), and hemicelluloses. The significance of the parameters is determined by the values of F and p [**9**,10].

In current study **ANOVA test was used** to know whether there is a significant difference among the results of cases. According to Wilson-Box program (table 1 and 2) strong significant difference was observed among the studied groups (F value =4.438, P value=0.006) **table 1** and **table 2**.

Table 1. Working Range of the Coded and Corresponding Real Variables.

Coded level	Biomass conc.(mg)	Contact time (min.)	pH
-1.732	0.1	5	4
-1	2.2	54.6	4.8
0	5.05	122.5	6
+1	7.9	190.4	7.1
+1.732	10	240	8

It can be shown that highest removal rate of the plant was 97.6% by *M. communis* at pH, 7.1 followed by 91.2% at pH, 8, while the lowest removal rate (62.8%) was at pH, 4.8 (**Fig. 1**).

The variation of solution pH is one of the most important factors in the biosorption of metal ions [11]. This factor is capable of influencing not only the binding site dissociation state, but also the solution chemistry of the target metal in terms of hydrolysis, complexation by organic and / or inorganic ligands and redox potentials [12]. Most researches conducted on heavy metal biosorption indicate that the decrease in ion biosorption at acid pH may be due to the increase in competition with protons on active sites [13]. This means that the

Table 2. Sequence of Experiments According to Box - Wilson Design.

Exp. No.	Coded variable			Real variable			Data	
	X_1	X_2	X3	Biomass conc(mg)	Contact time (min.)	pH	Con.of cr after treatment	Rate of (%)
1	-1	-1	-1	2.2	54.6	4.8	120	40
2	+1	-1	-1	7.9	54.6	4.8	37	81.5
3	-1	+1	-1	2.2	190.4	4.8	60	70
4	-1	-1	+1	2.2	54.6	7.1	2.3	98.85
5	+1	+1	-1	7.9	190.4	4.8	80	60
6	+1	-1	+1	7.9	54.6	7.1	3.7	98.15
7	-1	+1	+1	2.2	190.4	7.1	1.8	99.1
8	+1	+1	+1	7.9	190.4	7.1	11.2	94.4
9	-1.732	0	0	0.1	122.5	6	48.4	75.8
10	+1.732	0	0	10	122.5	6	16.6	91.7
11	0	-1.732	0	5.05	5	6	12.4	93.8
12	0	+1.732	0	5.05	240	6	18	91
13	0	0	-1.732	5.05	122.5	4	47	76.5
14	0	0	+1.732	5.05	122.5	8	17.6	91.2
15	0	0	0	5.05	122.5	6	16.4	91.8
16	0	0	0	5.05	122.5	6	16.4	91.8
17	0	0	0	5.05	122.5	6	16.4	91.8
18	0	0	0	5.05	122.5	6	16.4	91.8
19	0	0	0	5.05	122.5	6	16.4	91.8
20	0	0	0	5.05	122.5	6	16.4	91.8

highest H^+ concentration, the biosorbent surface becomes more positively charged and the attraction between biomass and metal cations is reduced [14]. As the pH value increases, more negatively charged surf-ace becomes available to facilitate greater metal removal [15].

At alkaline pH, however, other effects may arise that also alter the process, such as the predominant presence of hydrated species of heavy metals, changes in surface charge or the precipitation of the appropriate salts [16].

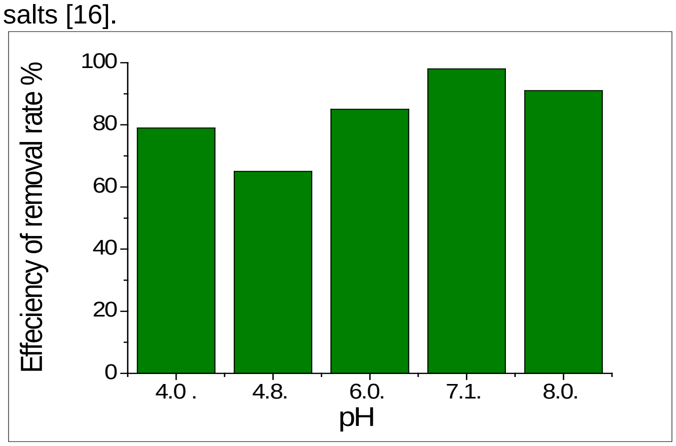

Fig 1. Effect of pH on removal rate by *M.communis*

Optimum pH for chromium and zinc adsorption was laid between 5 and 6 in case of using plant wastes [17]. Furthermore Ahluwalia and Goyal [**18**] reported that the pH values ranged from 5 to 6 for the best adsorption of Pb, Zn, Cd, Cr, Cu and Ni ions from aqueous solutions by using plant derived biomass for removal of heavy metals from waste water. Additionally, if the pH value becomes more than 6.5, this will lead to precipitation of metals in solution during adsorption process this case will be given wrong data with unacceptable study. Many heavy metals are amphoteric; therefore, their solubility reaches a minimum at a specific pH (different for each metal). Therefore, the solubility of metals is known to be lowered at higher pH values [19].

From the results of current study, its clear that best removal rates at the studied concentration was 93.8% at 5 min, while it have the lowest removal rate 79.6% at 54.6 min (**fig 2**). Contact time is one of the important parameters for the successful adsorption application. Generally, in given contact time. There are three primary rate steps in the adsorption of materials from solution by plant wastes. First, the transport of the adsorption through a surface layer to the exterior of the adsorbent (film diffusion); second is diffusion of the adsorption within the pores of the adsorbent (pore diffusion); the third is adsorption of the solute on the interior surfaces bounding pore and capillary spaces. For most operating conditions, transport of adsorption through the 'surface layer' or boundary layer is rate-limiting, if sufficient turbulence is provided; transport of the adsorption within the porous adsorbents may control the rate of uptake. Adsorption of Chromium and zinc onto the palm tree wastes was studied by previous investigators [20], the absorption of copper and zinc increased with a contact time from 10-40 min. The recent study proved strongly the ability of *Ceratophyllum demersum* to eradicate the cadmium in ecosystem [21].

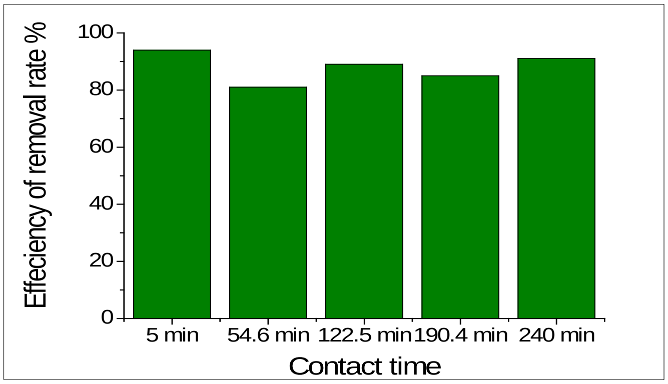

Fig 2. Effect of contact time on removal rate of Cr^{3+} by *M. communis*.

It can be noticed, that the best removal rate (91%) was at 10 g, but the lowest removal rate (75%) was at 0.1g (**fig. 3**). The decrease in sorption capacity may be due to the fact that some sorption sites may remain unsaturated during the sorption process whereas the number of sites available for sorption increases by increasing the sorbent dose [22]. However, this may be attributed to reduction of total area of biosorbent, or may be due to aggregation during biosorption and modification of the biomass surface depending on the experimental conditions such as pH, ionic strength, temperature [23], or due to the blockage of binding sites with excess biomass. From the current results it can be concluded that leave of *M. communis* have a good ability to remove chromium especially at a suitable conditions (pH 7.1, contact time 5 min, bio-mass 10 g).

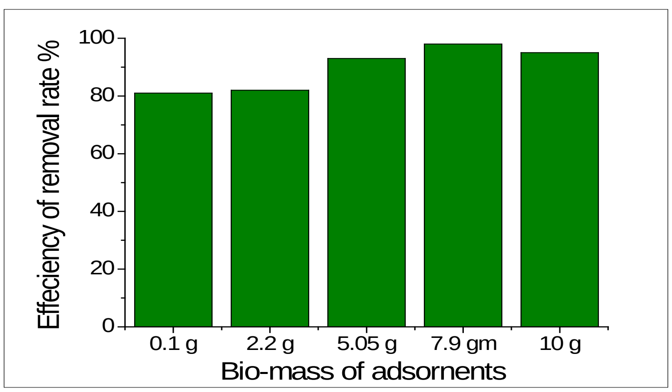

Fig 3. Effect of biomass on removal rate of Cr^{3+} by *M. communis*

Conflict of interest

The authors declare that they have no conflict of interests.

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