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Study on the Assessment of Adsorption Potential of Dry Biomass of *Canna indica* with Reference to Heavy Metal Ions from Aqueous Solutions

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Abstract

Present paper is an attempt to evaluate the adsorption of heavy metals like Cadmium (Cd), chromium (Cr), zinc (Zn), and lead (Pb) by the dry biomass of terrestrial plants *Canna indica* commonly called Saka siri. Very less literature is available for the study on the absorption/adsorption of heavy metals by this plant. The present experimental study was conducted to assess the adsorption capacity of dry biomass of *Canna indica* to compare and identify their potential to improve the water quality by removing the impurities. The paper critically evaluates the water-purifying capacity of dry-biomass of this plant basically knows for its ornamental identity. Manuscript will be helpful in showing the water purifying capacity of dry biomass of *C. indica* and also will evaluate the best results of adsorption shown by varying quantity of the adsorbent.

Keywords: Dry biomass; *Canna indica;* Heavy metals; Adsorbent quantity; Adsorption; Isotherm

Introduction

The rapid technological advancement, industrialization, urbanization and population growth has resulted in the deterioration of water, air and land quality, making it unfit for human consumption, water is an essential component of life, but is getting polluted day by day and thus unsafe to consume. There are number of toxic elements known to exist in the environment, which directly or indirectly make their way into water bodies. Sewage, industrial chemicals, heavy metals from industrial processes, and household waste are examples of materials commonly discharged into water bodies. Natural sources of water are depleting fast and are polluted due to industrialization and urbanization in haphazard manner. The Potential toxic metal elements such as cadmium, chromium, lead, Copper, Zinc etc. are identified to cause health hazards in animals [1,2] these heavy metals are reported to be toxic and found associated with the occurrence of several health effects.

The lakes and reservoirs are under great environmental stresses, which are now gradually getting filled up by excessive sewage input, silting and growth of organic matter [3]. On the other hand heavy effluents discharge from the industries lead to intrusion of heavy metals in the water bodies which leads to further toxicity to man and environment. Waste water generated from residential and industrial day today activities must be treated before is released into surface water bodies or to environment. So that it does not cause further pollution of water sources. Due to the extreme consequences, environmental contamination with heavy metals is a topic of significant concern. Treatment processes for metals contaminated waste streams can be treated with so many methods but still a cost effective alternative technologies or sorbets for treatment of contaminated waste streams are needed, so in the present study an effort is made by utilizing dead or non-living biomass [4] of *Canna indica* plant available in large quantity as adsorbent for the removal of selected heavy metals from aqueous solution, the study is presently carried out at laboratory scale. The success of which can be further replicated for the field study i.e. for the treatment of the waste water.

Materials and Methods

The present study was mainly concentrated upon adsorption of four heavy metals viz. chromium, cadmium, lead and zinc by dry biomass of *C. indica* for which the experiments are conducted. The plants are collected from sahapura lake drainage basin. The plants are washed with Milli-Q water to eliminate the remains of lake sediments and particulate matter, and then the plants are cut into pieces and sun dried. After being completely dried/dehydrated they are grinded into powder. The powder was grounded to pass through 2 mm sieve. The heavy metal samples of 10, 50 and 100 mg/l concentration, for the analysis were prepared by standard method [5]. In 100 ml of each of the heavy metal samples i.e. chromium, cadmium, lead and zinc, varied quantity i.e. 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 gm respectively of the *C. indica* powder was added and then put into shaker at 65 rpm and at temperature of 28°C, for time period of 30 min. The samples after attaining complete reaction period were filtered with whatmann no. 40 filter paper. All the experiments were set in duplicate, and for all the parameters a control set was also studied where there was no powder (dry biomass) added. All the parameters were analyzed by the method as mentioned in APHA.

Results

The results of the study indicate the effect of variation of the quantity of adsorbent (dry biomass powdered of *C. indica*) on the adsorption of selected heavy metals. Figure 1a-d, represents adsorption of Cd, Cr, Pb, and Zn ion on dry biomass of *C. indica* at various adsorbent concentration i.e. from 0.5 to 4.0 gm. Results after treating 10 ppm of standard solution of cadmium at different biomass conc. are very encouraging. Adsorption percent of 'Cd' solution was found in the range of 36 to 96.5% (Figure 1a-d), it shows that the dry biomass adsorbed

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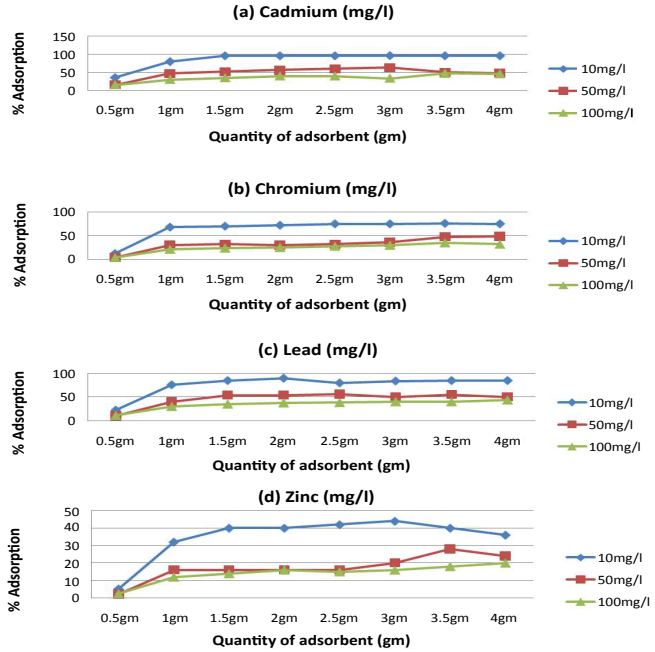

Figure 1(a-d): Percent adsorption of heavy metals by dry biomass of *C. indica*.

almost whole of the Cd metal ion. Here the adsorption concentration was found directly proportional to quantity of adsorbent. Cadmium is considered very much toxic [6,7] metal ion.

Dry biomass of *C. indica* efficiently adsorbed Chromium from 10, 50, 100 mg/l concentration of aqueous solution using about 2-2.5 gm of adsorbent. The adsorption percent increased with increasing quantity of adsorbent. The average percentage adsorption of chromium was found 76.0% for 10 mg/l solution. The result shows that at initial concentration the adsorption rate was high and by further increasing the quantity from 2.5 gm. The adsorption was almost stationary. Cr is very much toxic and carcinogenic for living beings.

The lead metal showed reduction in its concentration after treating with the dry biomass, the concentration of sample is decreased from 10 ppm to 1.0 ppm by treating the adsorbent of upto 4 gm. It shows that there is the adsorption of about 90% on an average for 10 ppm solution. With the increasing adsorbent quantity the original concentration in the solution decreased with slow rate and remained stationary after 4 gm. It showed adsorption of 56% for 50 ppm solution and even less for 100 ppm solution. Lead is very much toxic and carcinogenic for living beings.

Results obtained by treating 10 mg/l of zinc soln. with varied adsorbent quantity showed marked decrease in its concentration (Figure 1a-d) with only 2 gm of adsorbent and then there was reduction in adsorption percent after utilizing 3 gm of adsorbent. The % adsorption of Zn metal ion of 10 mg/l concentration calculated for adsorbent concentration of 1.0 gm, 2.0 gm, 3.0 gm and 4.0 gm were 32%, 40%, 44% and 36% respectively. Zinc is not very much toxic, the permissible limit is 30.0 ppb for aquatic life and 5.0 mg.L^{-1} for drinking water as per WHO [8].

Discussion

Increase in percent adsorption of Cd, Cr, Zn and Pb with increase in concentration of adsorbent is supported by considerable increase in reaction rate. Probably at high sorbent dosage the available ions are inadequate to cover all the available sites on the sorbent. Thus, the time of contact required to reach saturation varied with the biomass quantity. The figure shows that within a short time a large fraction of the total amount of heavy metal ion was removed but the uptake capacity of heavy metal ion per unit amount of sorbent (mg/g) decreases with increase in biomass concentration [9,10]. It is observed that there is a sharp increase in percentage removal of heavy metals with adsorbent quantity for studied heavy metal ions upto 1-2 gm of adsorbent quantity but after that there is gradual percentage removal with increasing quantity, it is due to the greater availability of the exchangeable sites or surface area [11] and as the sites are occupied the adsorption slowly decreases.

Results for Cd. Cr, Zn and Pb ions removal indicate that when quantity of adsorbent is increased from 0.5 to 2.5 gm initially lesser time is required to attain equivalence concentration, while the same equivalence concentration is attained with more adsorbent at higher metal ion concentration. This can be interpreted as more removal of Cd. Cr, Zn and Pb contents with less amount of adsorbent, when longer contact period is permitted. In other words, increase in contact period and quantity of adsorbent affects economics of the adsorption process and enhances the removal Cd. Cr, Zn and Pb contributing components of the waste water.

The regression analysis and experimental observations shows that the experimental data fitted well in both the isotherms. However, the values of correlation coefficient 'R^2, were marginally better for Langmuir isotherm than the values of 'R^2, for Freundlich isotherm [12] (Table 1).

Two types of observations were collected after treating the aqueous solution with the dry- biomass of *C. indica*.

1. Reduction in concentration of studied heavy metals due to adsorption on the dry biomass of *C. indica* as adsorbent.
2. Increase in the rate of adsorption with increasing adsorbent quantity.

Conclusions

Observations obtained from the above mentioned batch study concluded that dry biomass of whole plant of *C. indica* can be used for reducing heavy metals impurities in the present context but it can be further considered even for waste water treatment of effluents generated from industrial activities with technological up gradation. The control samples merely showed any visible difference in the concentration to that of original concentration which signifies that the dry biomass of the plant has good potential for removal of selected heavy metals. It is well evaluated that the dry mass of the plant showed the required

Metal	Temperature °C	Langmuir Isotherm			Freundlich Isotherm		
		Q°(mg/g)	b×10³ (dm³/mg)	R^2	1/n	K	R^2
Cadmium	30	31.25	71.51	0.979	0.632	0.421	0.982
	60	16.39	7.37	0.987	0.511	0.013	0.953
Chromium	30	71.43	1930.50	0.963	0.742	1.073	0.931
	60	76.92	160.93	0.944	0.479	0.343	0.926
Lead	30	111.11	487.33	0.99	0.694	0.680	0.989
	60	166.67	400.64	0.996	0.843	0.176	0.999
Zinc	30	322.58	333.80	0.999	0.881	0.117	0.999
	60	1000.0	556.17	0.999	1.017	0.300	0.998

Table 1: Freundlich & Langmuir isotherm parameters for Cd, Cr, Pb, and Zn.

good results in case of heavy metals as it has shown great reduction from its original concentration for all the studied heavy metals. It was also noticed that many of the studied heavy metals viz. Cadmium, Chromium, Zinc and Lead showed reduction in their concentration with increasing adsorbent quantity but after 4 gm they showed stability in reduction percentage. This concludes that the dry biomass powder of *C. indica* can be effectively utilized for reducing heavy metals and it gives the results in short span of time with less amount of adsorbent (dry biomass of *C. indica*) and so upgrading the same can prove to be a powerful tool for waste water treatment.

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