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Phytoremediation of Chromium from Seawater Using Five Different Products from Coconut Husk

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Heavy metals released in coastal environments are of increasing concern. The anthropogenic discharge of chromium in the Indian environment is enormous due to indiscriminate use of chromate in leather industries (Khasim and Nanda Kumar 1989). Chromium (VI) is soluble and highly toxic and has got adverse impact on the aquatic species (Cutter 1991). It accumulates in fish tissues and at high concentrations cause reduction in brackishwater fish production (Krishnani et al. 2003). It is therefore essential to remove chromium from seawater before its use for coastal aquaculture. Many methods viz. sulphide precipitation, ion exchange using macroporous resins (Jianlong et al. 2000), electromigration (Li et al. 1997) and adsorption by activated carbon (Quki and Neufeld 1997) had been suggested for chromium removal. These methods suffered from the need for high capital investment and high operational and regeneration cost and can not be recommended for chromium removal from coastal water. Therefore, there is a need for the development of cost effective, high efficiency ecofriendly method, which can remove hexavalent chromium from coastal waters economically.

Agriculture is an economic foundation for many countries. With improved technology, agricultural production increase every year, but also more wastes are generated. Utilizing wastes for phytoremediation has attractive environmental benefits. Recently, the removal of Cr (VI) from aqueous solution was studied by natural, low cost materials such as gum moss peat (Sharma and Forster 1993), acacia arabica bark (Singh et al. 1994), tea leaves carbon (Singh et al. 2001), saw dust (Raji and Anirudhan 1998), modified plant barks (Gloaguen and Morvan 1997), bagasse (Ayub et al. 2001) and rice hulls (Low et al. 1997). Coconut husk is a fibrous cellulosic material. Use of chemically treated coconut husk carbon for the reomoval of As (III) also has been reported (Manju et al. 1998). In the present paper, five different types of products prepared from coconut husk have been used for the removal of chromium from seawater.

MATERIALS AND METHODS

Standard solution of chromium were prepared by dissolving suitable amount of potassium dichromate in distilled water. Five different types of products were prepared from coconut husk :

i. Raw coconut husk fiber (CRF)

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ii. Dried coconut husk fiber (CDF)- Raw material was thoroughly washed with water and then dried in sunlight.

iii. Dried coconut husk powder (COP): Material dried in sunlight (CDH) was dried in oven at 100°C for 12 hours and then powdered.

iv. Charred coconut husk powder (CCP): - Dried material (CDH) was charred at 250 °C in the muffle furnace and then powdered.

v. Coconut husk charred with sulphuric acid (CSP): - Dried material (CDH) was charred with concentrated sulphuric acid. After complete charring, charred material was thoroughly washed with water to remove sulphuric acid and dried at 100°C and then powdered.

One litre of sea water (salinity 30±1ppt) was taken in glass jars. A solution of chromium metal ion was added in the jars in order to get known concentration of metal. The resulting solution was treated with five different products from coconut husk @ 3, 6 and 10 g/L. Further, water samples were analyzed for measurement of chromium concentration at daily intervals for a period of 4 days. At the end of the experiment, water samples were collected from all the treatments and other water quality parameters such as pH, salinity, ammonia, nitrite and phosphate were analysed by standard methods (Strickland and Parson, 1972; APHA, 1989). The analysis of hexavalent chromium in solution was carried out spectrophotometrically by developing a purple violet colour with 1,5 diphenyl carbazide in acidic medium (APHA, 1989). UV-VIS spectrophotometer (HITACHI U - 2000) was used for analysis.

Statistical analysis of Results: The data was statistically analyzed using 5 (Duration) x 5 (Materials) factorial completely randomized design with two replications for each dose. Duncan's multiple range test was applied to identify significant differences between main effects and interaction effects. M-STATC statistical software was employed to perform statistical analysis.

RESULTS AND DISCUSSION

Effect of five different products from coconut husk @ 3 g/L on 8.25 ppm chromium is presented in Fig.1(a). This shows that raw coconut husk fiber (CRF), dried coconut husk fiber (CDF), oven dried coconut husk powder (COP), charred coconut husk powder (CCP), and coconut husk charred with sulphuric acid (CSP) decreased chromium from 8.25 mg/L to 6.972 (15.49%), 6.674 (19.10%), 5.496 (33.38%), 5.204 (36.92%) and 3.718 (54.93%) within 24 hours respectively. There was further decline and after 48 hours, chromium levels were 6.572 (20.34%), 6.236 (24.41%), 4.164 (49.53%), 5.15 (7%) and 1.928 (76.63%) and after 96 hours, chromium levels were 5.514 (33.16%), 5.664 (31.35%), 2.556 (69.02%), 4.168 (49.48%) and 0.14 (98.30%) respectively. From Fig.1(a), it is evident that chromium removal was most effective with coconut husk charred with sulphuric acid (CSP) followed by oven dried coconut husk powder (COP).

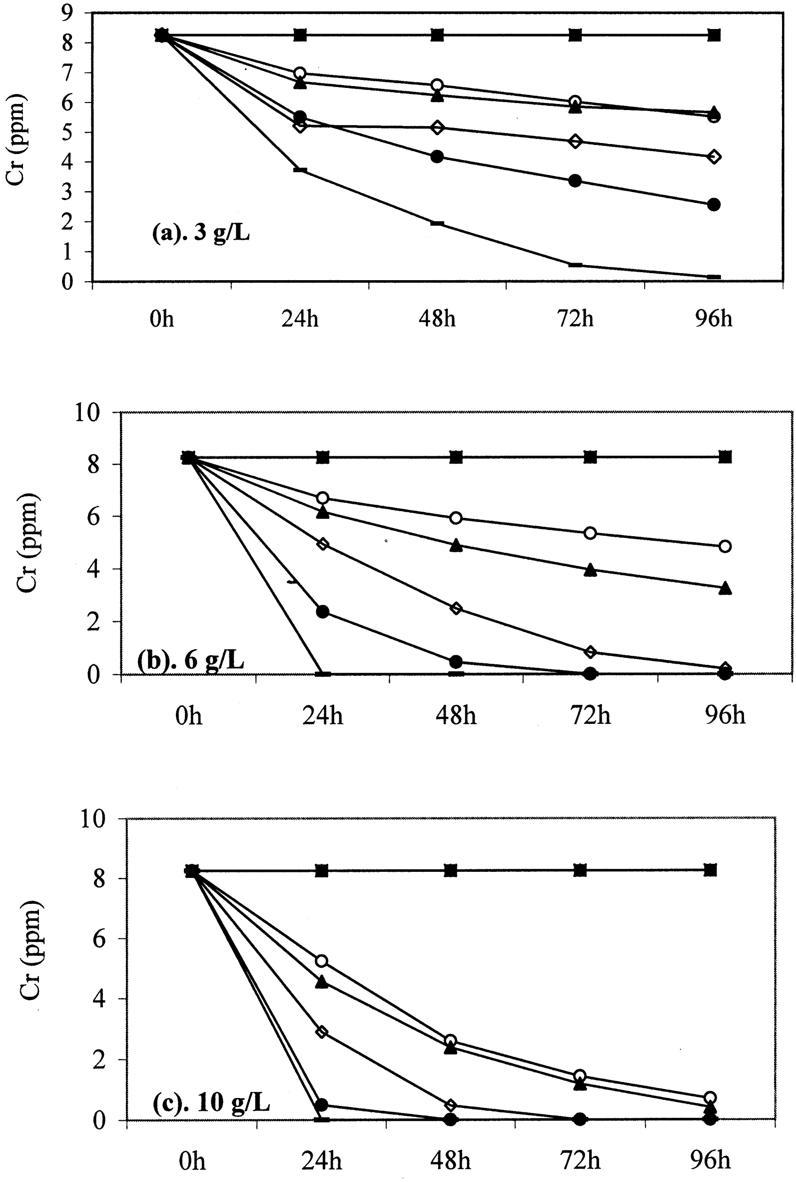


Figure 1. Effect of five different products from coconut husk @ 3, 6 and 10 g/L on chromium removal from seawater.

—■— Control —○— CRF —▲— CDF —●— COP —◇— CCP —▬— CSP

Table 1. Comparison of efficacies of the products from coconut husk for the removal of chromium from seawater

(a). Effect of materials

Materials	3 g/L	6 g/L	10 g/L
CRF	7.125^{B}	6.255^{B}	3.640^{A}
CDF	7.402^{A}	6.840^{A}	3.356^{B}
COP	5.962^{C}	3.595^{D}	1.749^{D}
CCP	5.747^{D}	4.868^{C}	2.324^{C}
CSP	1.625^{E}	1.625^{E}	1.650^{E}

(b). Interaction effect of materials and duration

Materials	Hours	Initial Concentration 8.250^{A} ppm		
		3 g/L	6 g/L	10 g/L
CRF	24	6.972^{B}	6.686^{B}	5.228^{B}
	48	6.572^{D}	5.908^{D}	2.590^{E}
	72	6.012^{F}	5.328^{E}	1.432^{G}
	96	5.514^{I}	4.814^{G}	0.698^{I}
CDF	24	6.674^{C}	6.158^{C}	4.556^{C}
	48	6.236^{E}	4.880^{F}	2.380^{F}
	72	5.853^{G}	3.948^{H}	1.186^{H}
	96	5.664^{H}	3.240^{I}	0.409^{K}
COP	24	5.496^{I}	2.350^{K}	0.494^{J}
	48	4.164^{L}	0.450^{M}	0.0001^{L}
	72	3.359^{N}	0.0001^{O}	0.0001^{L}
	96	2.556^{O}	0.0001^{O}	0.0001^{L}
CCP	24	5.204^{J}	4.928^{F}	2.892^{D}
	48	5.150^{J}	2.482^{J}	0.478^{J}
	72	4.684^{K}	0.813^{L}	0.0001^{L}
	96	4.168^{L}	0.194^{N}	0.0001^{L}
CSP	24	3.718^{M}	0.0001^{O}	0.0001^{L}
	48	1.928^{P}	0.0001^{O}	0.0001^{L}
	72	0.538^{Q}	0.0001^{O}	0.0001^{L}
	96	0.140^{R}	0.0001^{O}	0.0001^{L}

Means in the vertical row with different superscripts are significantly different ($p \leq 0.05$)

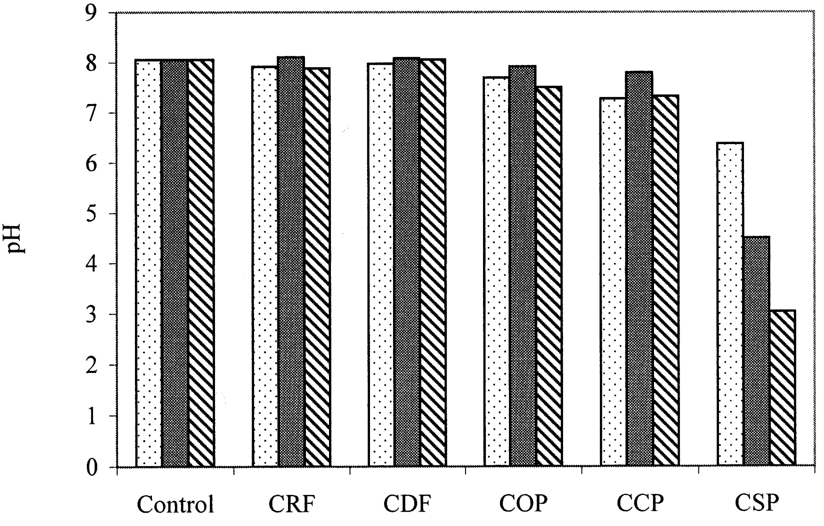
Effect of five different products from coconut husk @ 6 g/L on 8.25 ppm chromium is presented in Fig.1(b). This shows that chromium removal was effective with coconut husk charred with sulphuric acid (CSP) followed by dried coconut husk powder (COP) and they decreased chromium from 8.25 mg/L to nil (100%) and 2.35 (71.52%) within 24 hours. In the case of COP, 100% chromium removal was achieved within 72 hours. Charred coconut husk powder (CCP), dried coconut husk fiber (CDF) and raw coconut husk fiber (CRF) decreased chromium from 8.25 mg/L to 4.928 (40.27%), 6.158 (25.36%) and 6.686 (18.96%) within 24 hours respectively. There was further decline and after 72 hours, chromium levels were 0.813 (90.15%), 3.948 (52.15%) and 5.328 (35.42%) and after 96 hours, levels were 0.194 (97.65%), 3.24 (60.73%) and 4.814 (41.65%).

Effect of five different products from coconut husk @ 10 g/L on 8.25 ppm chromium is presented in Fig.1(c). This shows that raw coconut husk fiber (CRF), dried coconut husk fiber (CDF), dried coconut husk powder (COP), charred coconut husk powder (CCP) and coconut husk charred with sulphuric acid (CSP) decreased chromium from 8.25 mg/L to 5.228 (36.63%), 4.556 (44.78%), 0.494 (94.01%), 2.892 (64.95%) and nil (100%) within 24 hours respectively. In the cases of COP and CCP, 100% removal was achieved within 48 and 72 hours respectively. In the cases of CRF and CDF, after 72 hours, chromium levels were 1.432 (82.64%) and 1.186 (85.62%) and after 96 hours, levels were 0.698 (91.54%) and 0.409 (95.04%) respectively.

Statistical analysis for the comparison of efficacies of five different types of coconut husk with respect to 8.250 ppm chromium concentration and their interaction with hours is given in the Table-1. This shows that efficacies of all five coconut husk materials @ 3, 6 and 10 g/L were significantly different ($p \leq 0.05$). From these analyses, it is evident that chromium removal was highest for CSP followed by COP. The interaction effect between duration and materials for chromium removal showed that efficacy of all the materials @ 3g/L was significantly different. In the case of CSP @ 6 and 10 g/L, there was no significant effect of duration on chromium removal and maximum removal was achieved within 24 hours, whereas, in the case of COP @ 10 g/L, chromium removal within 24 hours was significantly different from 48 to 96 hours and maximum removal was achieved within 48 hours. Amount of chromium removal by CCP @ 10g/l after 48 and 72 hours can be achieved using COP @ 10 g/L within 24 and 48 hours respectively.

Effect of coconut husk materials on physio-chemical parameters of coastal water is presented in Fig.2. At the end of the experiment, other water quality parameters such as salinity, ammonia and nitrite did not show much changes with the treatments with CRF, CDF, COP, CCP and CSP and they ranged from 29 - 31 ppt, 0.034 – 0.329 and 0.001 – 0.028 mg/l respectively. There was not much change in pH with the treatments with CRF, CDF, COP and CCP, whereas, CSP @ 3, 6, 10 g/L decreased pH from 8.05 to 6.38, 4.5 and 3.04 respectively. There was not much change in phosphates with the treatment with CDF, COP, CCP and CSP, whereas CRF @ 3, 6 and 10 g/L increased phosphates from 0.041 ppm to 0.184, 0.761 and 1.717 ppm respectively.

The aim of the present study was to evaluate the efficacy of five different products prepared from agricultural waste material-coconut husk for the removal of chromium (VI) from seawater. In general, the efficiency of a material is evaluated on the basis of



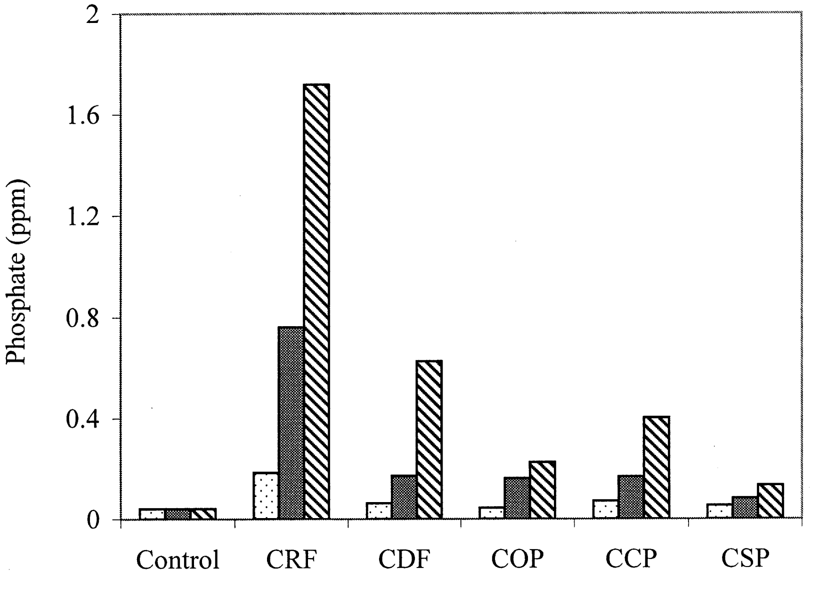


Figure 2. Effect of five different products from coconut husk on pH and phosphates in seawater

3 g/L 6 g/L 10 g/L

percentage of removal, quantity of material used, time taken for removal and effect on other water quality parameters. In view of this, it can be concluded from the present study that oven dried coconut husk powder (COP) @ 6 g/L is the most effective without any adverse effect on the water quality. Successful studies on these materials could be beneficial to the agricultural countries, which generates considerable amount of this agricultural waste, for the removal of chromium from aquatic environment.

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