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Biosorption of Some Heavy Metal Ions (Pb^{2+}, Cd^{2+}, Ni^{2+}) From Aqueous Solution by Malicorium

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In this study, removal of some heavy metal ions such as Pb^{2+}, Cd^{2+}, Ni^{2+} from aqueous solution has been investigated by using malicorium as natural adsorbent. The research is a bench scale experimental type and analyses have performed by using different amounts of adsorbent in solutions with 5 different concentrations of each metal ions. Besides, the effect of various amounts, size of malicorium used and pH in biosorption efficiency experiments has been investigated. Results from this work have indicated that (a) the removal efficiency is highest for lead and is minimum for nickel. About 98 % Pb^{2+} were achieved by using 2.5 g absorbent having concentration of 100 mg/L Pb^{2+}. For Cd^{2+} and Ni^{2+}, the efficiency were 83 and 43 %, respectively in the same condition, (b) optimal efficiency obtained in 30-100 mesh size particles for all three ions, (c) maximum biosorption occurred at pH = 12 for Ni^{2+} and Cd^{2+} but for Pb^{2+} it happens at acidic pH.

Key Words: Malicorium, Heavy metal ions, Adsorption, Aqueous solution.

INTRODUCTION

The problems of the ecosystem are increasing with developing technology. Heavy metals pollution is one of the main problems toxic metal ions compounds coming to the earth's surface not only reach the earth's waters, the earth's waters may contain various toxic metal ions are often discharged by a number of industrial processes. This can lead in turn to the contamination of freshwater and marine environment heavy metals are major pollutants in marine, ground, industrial and even treated wastewaters[1,2]. Industrial waste constitutes the major source of various kinds of metal pollution in natural waters. The important toxic metals *i.e.*, Cd, Zn, Ni and Pb finds its way to the water bodies through wastewaters[3]. Many physico-chemical methods have been proposed for their removal from industrial effluents[4-7]. Absorption is an effective purification and separation technique used in industry especially in water and wastewater treatments[8]. Cost is an important parameter for

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comparing the sorbent materials[9]. By products of soybean, cottonseed hulls, algae, coconut copra, rice straw and sugarcane bagasse were evaluated as metal ions adsorbent in aqueous solutions[10-15]. Therefore, studies on the removal of heavy metal pollution and the effect of various parameters such as particle size, initial concentration of metal ions and amount of biosorbent are important[13]. It is reported that pH is an important parameter affecting the biosorption process[16,17]. In this study, the efficiency of malicorium has been determined in the process of heavy metal ions removing from single metal ion solutions. Cadmium is non-essential and toxic element to plants and animals. Lead is a hazardous waste and is highly toxic to humans, plants and animals and nickel is one of important toxic metal ions.

In this study, malicorium has been used for adsorption experiments and some important parameters that should be considered in removal of heavy metal ions from industrial wastewaters were investigated.

EXPERIMENTAL

The malicorium washed at the first step and then rinsed with distilled water, drying in 100 ºC for 16 h, ground and screened different meshs. For preservation, it was kept in plastic stopper bottle and to minimize contact with humidity all these bottles were preserved in a desiccators before the time of use. Individual solutions of Pb^{2+}, Cd^{2+} and Ni^{2+} with 5 different concentrations of 5, 10, 20, 30 and 100 mg/L where prepared synthetically and in order to determine the efficiency of malicorium in metal ions adsorption, the experiments were performed using 5 different amounts of adsorbent: 0.5, 1.0, 1.5 , 2.0 and 2.5 g in solution. The procedure for first experiment was as follows: to 5 flasks each containing 0.5 g adsorbent, 50 mL of solutions with known concentration (5, 10, 20, 30, 100 ppm) of lead were added after 1 h contact time the contents of flasks were filtered through Whitmann No. 42 filter paper to prevent the probable interference of turbidity. The same procedure was repeated for Cd^{2+} and Ni^{2+}. The effect of pH on efficiency of Pb^{2+}, Cd^{2+} and Ni^{2+} biosorption was studied in a single component system. Initial concentration of heavy metal ions was 30 ppm, amount of biosorbent was 2.5 g and initial pH of solutions was varied from acidic to basic pH.

In another experiment effect of biosorbent size on efficiency of Pb^{2+}, Cd^{2+} and Ni^{2+} biosorption was investigated. Initial concentration of heavy metal ions was 100 ppm amount of biosorbent was 2.5 g and the size of biosorbent was varied. The concentration of each filtered solutions was then determained by using the flame atomic adsorption spectrophotometery (FAAS Shimadzu AA-670 spectrometer).

RESULTS AND DISCUSSION

Results of this study indicate that the maximum biosorption efficiency is 98 % for Pb^{2+}, 83 % for Cd^{2+} and 43 % for Ni^{2+}. The residual concentration of lead, cadmium and nickel in solution after 1 h contact time show in Tables 1-3.

TABLE-1
CONCENTRATION OF RESIDUAL LEAD AFTER ADSORPTION BY MALICORIUM

Initial concentration (ppm)	Quantity of malicorium (g)	Concentration after adsorption	Efficiency
5	0.5	1.01	80
	1.0	0.82	84
	1.5	0.54	90
	2.0	0.41	92
	2.5	0.42	92
10	0.5	0.91	82
	1.0	1.65	84
	1.5	0.80	92
	2.0	0.61	94
	2.5	0.53	95
20	0.5	3.60	82
	1.0	2.12	90
	1.5	1.07	95
	2.0	0.85	96
	2.5	0.61	97
30	0.5	3.07	90
	1.0	2.10	93
	1.5	1.53	95
	2.0	1.21	96
	2.5	0.62	98
100	0.5	6.27	94
	1.0	3.13	97
	1.5	2.12	98
	2.0	2.03	98
	2.5	2.01	98

TABLE-2
CONCENTRATION OF RESIDUAL CADMIUM AFTER ADSORPTION BY MALICORIUM

Initial concentration (ppm)	Quantity of malicorium (g)	Concentration after adsorption	Efficiency
5	0.5	2.45	51
	1.0	2.35	53
	1.5	2.35	53
	2.0	2.29	56
	2.5	2.05	59
10	0.5	3.62	64
	1.0	3.65	64
	1.5	3.53	65
	2.0	3.55	65
	2.5	3.20	68

20	0.5	6.41	68
	1.0	6.01	70
	1.5	5.83	71
	2.0	5.80	71
	2.5	6.11	70
30	0.5	7.52	75
	1.0	6.05	80
	1.5	6.62	78
	2.0	6.90	77
	2.5	6.32	79
100	0.5	16.01	84
	1.0	15.11	85
	1.5	16.08	84
	2.0	17.02	83
	2.5	17.11	83

TABLE-3
CONCENTRATION OF RESIDUAL NICKEL AFTER ADSORPTION BY MALICORIUM

Initial concentration (ppm)	Quantity of malicorium (g)	Concentration after adsorption	Efficiency
5	0.5	4.21	16
	1.0	4.10	18
	1.5	4.35	13
	2.0	4.65	7
	2.5	4.56	10
10	0.5	8.34	17
	1.0	8.50	15
	1.5	8.74	13
	2.0	8.51	15
	2.5	8.42	16
20	0.5	16.8	16
	1.0	16.2	19
	1.5	17.8	11
	2.0	16.8	16
	2.5	17.1	15
30	0.5	23.7	21
	1.0	22.5	25
	1.5	24.0	20
	2.0	23.4	22
	2.5	25.2	16
100	0.5	58.4	42
	1.0	60.3	40
	1.5	63.7	37
	2.0	65.3	35
	2.5	65.1	35

Figs. 1 and 3 represent that increases in adsorption of Pb^{2+} and Cd^{2+} by increasing the amount of adsorbent seem to be and effect of increase in adsorption sites. But the result about Ni^{2+} was different (Fig. 5). The effect of concentration of cadmium, nickel and lead ions indicate that the uptake of cadmium, nickel and lead depend on initial concentration, increasing with increase in concentration from 5 to 100 ppm (Figs. 2, 4 and 6) and Fig. 2 represent the adsorption efficiency for various concentration of lead as it is obvious malicorium is a wonderful adsorbent for removal of lead from wastewater. The influence of biosorbent size on cadmium, nickel and lead biosorption can be evaluated from Fig. 7. The experimental result indicate that the biosorbent size influence the efficiency of cadmium, nickel and lead biosorption, then the influence of biosorbent size on metals uptake seems to be a function of both the type of biomass and the metal ions.

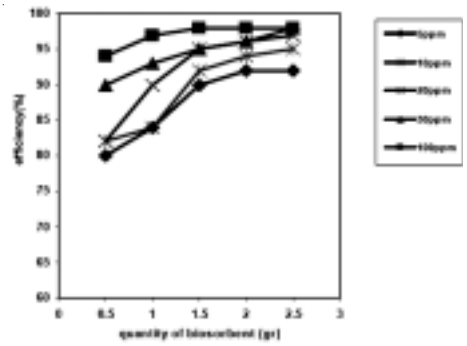

Fig. 1. Effect of quantity of biosorbent on the adsorption (%) of lead by malicorium

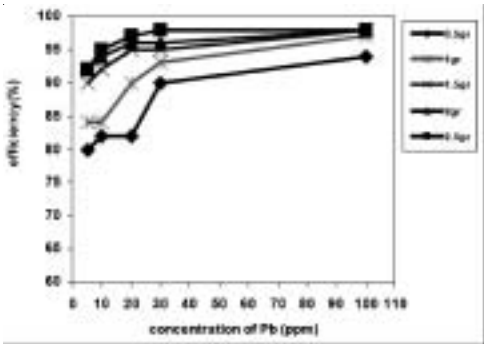

Fig. 2. Effect of initial concentration on the adsorption (%) of lead by malicorium

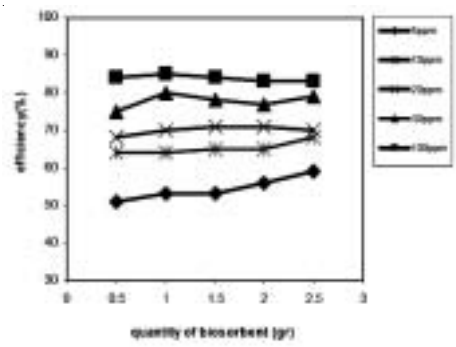

Fig. 3. Effect of quantity of biosorbent on the adsorption (%) of cadmium by malicorium

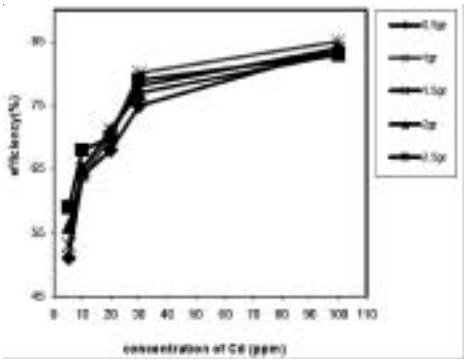

Fig. 4. Effect of initial concentration on the adsorption (%) of cadmium by malicorium

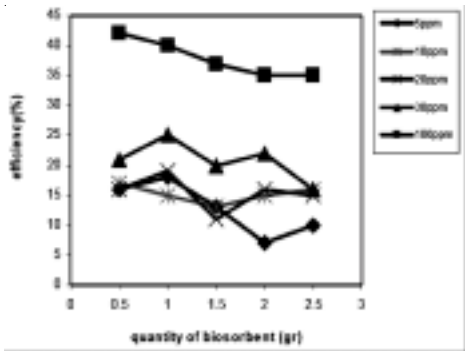

Fig. 5. Effect of quantity of biosorbent on the adsorption (%) of nickel by malicorium

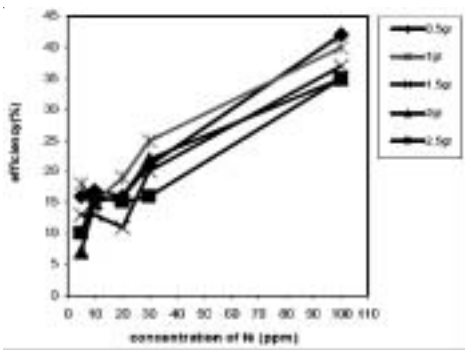

Fig. 6. Effect of initial concentration on the adsorption (%) of nickel by malicorium

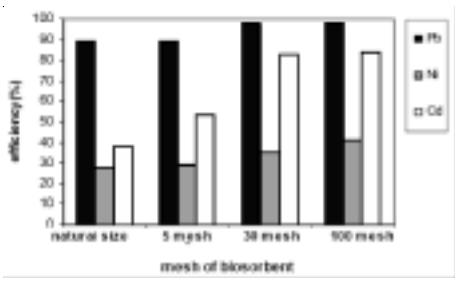

Fig. 7. Effect of biosorbent size on adsorption (%) of lead, nickel and cadmium by malicorium

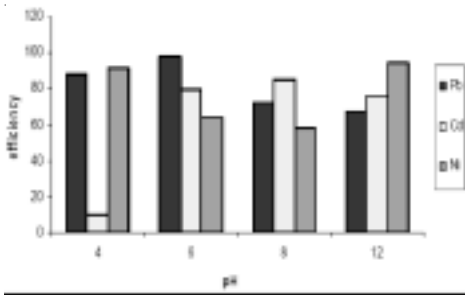

Fig. 8. Effect of pH on adsorption (%) of lead, nickel and cadmium by malicorium

The effect of pH on Pb^{2+}, Cd^{2+} and Ni^{2+} biosorption was observed in the different pH range. Results of this study indicate that maximum biosorption occurred at pH = 12 for Ni^{2+} and Cd^{2+} but for Pb^{2+}, it happens at acidic pH (Fig. 8).

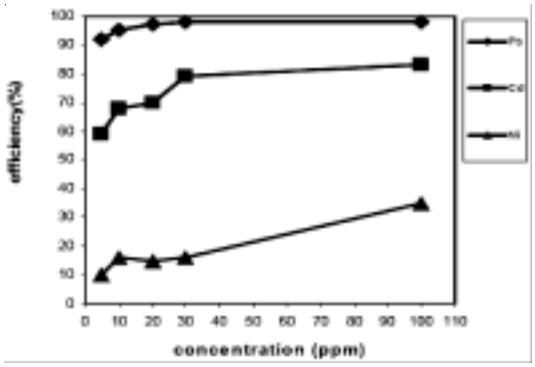

Fig. 9. Adsorption (%) of lead, nickel and cadmium by 2.5 g malicorium

By comparing the results of the study presented in Fig. 9, it is also concluded that the adsorption efficiency is dependent to the type of metal too, adsorption of Pb^{2+} is more than Cd^{2+} and Ni^{2+} in the same condition.

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