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Removal of Ni^{2+} and Cd^{2+} from Aqueous Solution Using Iranian Natural Bentonite

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Bentonites consist clay minerals of the smectite group have a wide range of industrial uses. A particular feature of this group of minerals is the substitution of Si^{4+} and Al^{3+} in the crystal structure by lower valency cations. The structure, chemical composition, exchangeable ion type and small crystal size of smectite are responsible for several unique properties. In this study by using chemical analysis analysis methods *e.g.*; XRD, XRF, SEM, the kind of Reshm natural bentonite mine have been determined as montmorillonite and clinoptilolite. Then the ability of bentonite to reomove heavy metal ions from wastewater and its factors affecting it have been examined. The batch sorption experiments of Ni^{2+} and Cd^{2+} were conducted on Na-bentonite under various conditions. Adsorption behaviour of bentonite was strongly depending on pH, initial concentration, time and temperature. The removal rate of bentonite decreases with an increase in the initial metal ion concentration. pH for removal of Ni^{2+} is 4 and for Cd^{2+} is 5.

Key Words: Bentonite, Adsorption, Wastewater, Batch exprimetall, Ni^{2+}, Cd^{2+}.

INTRODUCTION

Heavy metals, lead to imbalances in living creatures and especially humans and create the wide spectrum of complications and symptoms. Of the most important complications of this disorder is cancer creating and effects on the nervous system, skin, hematopoietic system, cardiovascular system and damage on kidney. So far, lead, mercury and cadmium reasoned many unpleasant incidents[1,2]. The adsorption capacity of montmorillonite for heavy metal ions has been concerned[3]. This group can be activated carbon, resins, zeolite and bentonite. Clay used as adsorbent of pollutants is growing dramatically. It also features more attractive than other absorbents[4]. Abollino *et al.*[5] reported that clays are widely used as barriers in landfills to prevent contamination of subsoil and groundwater by leachates containing heavy metals. Nickel is one of the toxic metals discharged as a pollutant into the environment during industrial operations particularly in galvanized pipe manufacturing, hydrogenation of vegetable oils, electroplating etc. Its presence in drinking water has shown to be linked with some chronic diseases[6]. The average concentrations of Cd(II) in soils lie between 0.06[7].The main object of the present work was to study the adsorption and retention mechanisms of Ni^{2+} and Cd^{2+} on natural bentonites as an adsorbent collected from Reshm mine of Damghan in Iran. The ability of bentonite to adsorb metal ions in solution was shown as a function of some experimental parameters.

EXPERIMENTAL

Investigated samples of scientific principles was provided in the Northern Damghan Reshm area. Its mineralogical composition and chemical components are listed in Tables 1 and 2.

TABLE-1
MINERALS PRESENT IN BENTONITE

Major mineral present	
Montmorilonite	Gypsum
Clinoptilolite	Feldspar
Illite	Quartz
Cristoballite	–

TABLE-2
MAJOR COMPONENTS OF BENTONITE

SiO_2	77/67	CaO	35/0
SO_3	07/0	Cl	61/0
MgO	93/1	K_2O	90/0
Y_2O_3	01/0	Fe_2O_3	43/1
SrO	03/0	Na_2O	75/2
ZrO_2	03/0	Al_2O_3	90/11
TiO_2	18/0	L.O.I.	05/12

Based on XRD analysis the dominant bentonite minerals are montmorillonite and clinoptilolite. According to XRF analysis in change the CaO value ./35, K_2O ./90 and Na_2O 2/75. SEM for Reshm's bentonites is in Fig. 1.

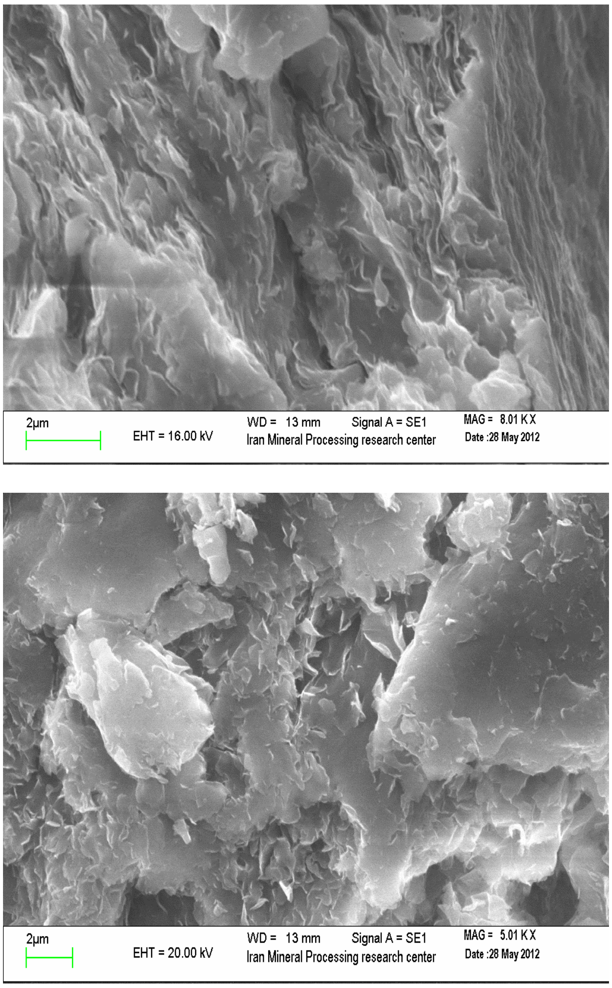

Fig. 1. Scanning electrone microscopic for Reshm bentonites

All the other reagents used were of analytical grade and were obtained from Merck. The $Cd(NO_3)_2$ and $Ni(SO_4)_2$ were used to prepare metal ion solutions. The solutions (1000 g/L) were prepared by dissolving appropriate amounts of metal salts in doubly distilled water. pH adjustments of these solutions were made by 1 M HNO_3 solutions.

Adsorption on the samples was determined in batch sorption experiments in the single species system. Adsorption experiments were carried out by shaking a certain particle size of the bentonite with 100 mL of metal ions solution at a certain concentration in covered poly-ethylene containers. The pH of the solution was kept constant by the addition of HNO_3 solutions. The suspension was stirred on the magnetic stirrer at controlled temperature and stirring rate. The sorption rate (P %) were calculated as:

$$P\ (\%) = 100\ (C_0–C_e)\ C_0$$

where C_0 and C_e are the concentration of metal ion in the initial and equilibrium concentration of metal ion in solution (mg/L) and amount of metal ion adsorbed by the bentonite adsorbents (Q) were calculated:

$$Q = \frac{(C_0 - C_e)}{m} V$$

V is the volume of metal ion solution used (mL) and m is the weight of the adsorbent used (g).

RESULTS AND DISCUSSION

Effect of contact time: A fixed particles size of the adsorbents reagent (through 200 mesh) was added to 100 mL of Ni and Cd ions solution which adjusted pH to 5 at concentration 0.005 mol/L, with liquid-to-solid ratio of 100 mL/g at 27 ºC. At different time an interval of 2-120 min, the adsorption rate of Ni^{2+} and Cd^{2+} on the bentonite adsorbents has been shown in Fig. 2.

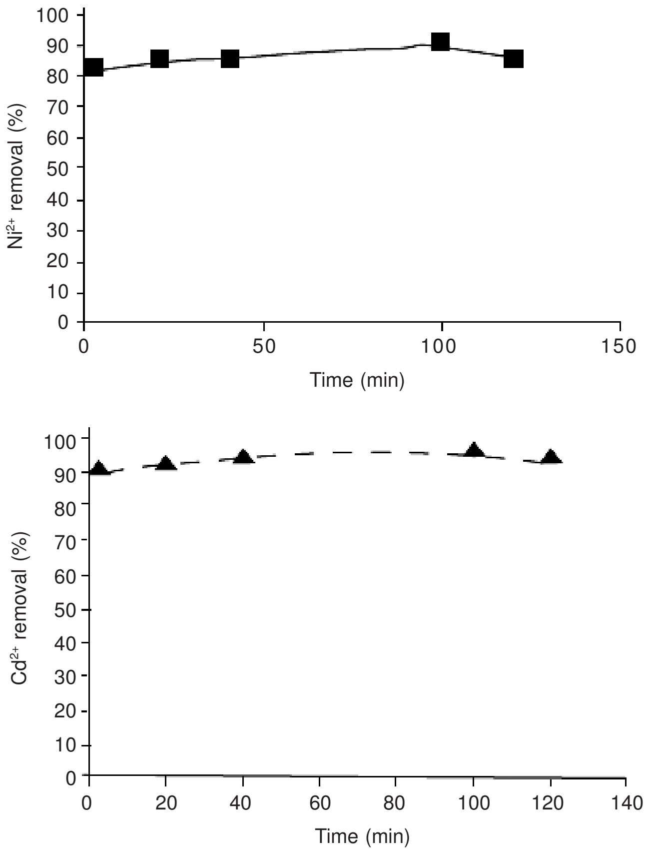

Fig. 2. Effect of contact time on the adsorption of Ni^{2+} and Cd^{2+} ions onto bentonite

Effect of temperature: In order to evaluate the effect of temperature on adsorp-tion characteristics of the bentonites, the experiment was studied at a constant initial concentration of 5×10^{-3} mol/L, bentonite particles size through 200 mesh, liquid-to-solid ratio of 100 mL/g and pH 5 at stirring speed of 1200 rpm, adsorption time 2 h. The results of the studies on the influence of temperature on cation adsorption are presented in Fig. 3.

Effect of initial concentration: The effect of initial concentration was investigated under the following conditions: the bentonite particles size (through 200 mesh), liquid-to-solid ratio (100 mL/g), pH (5), temperature (27 ºC), stirring speed (1200 rpm), adsorption time (2 h) (Fig. 4).

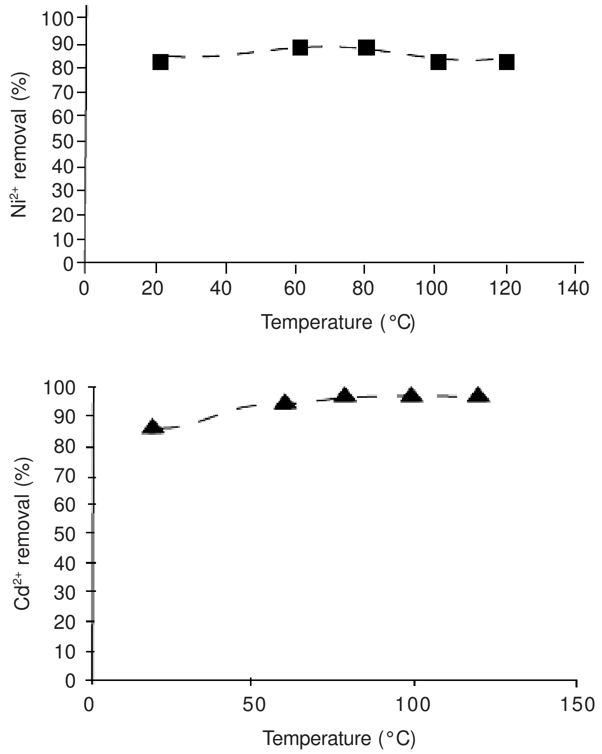

Fig. 3. Effect of solution temperature on the adsorption of Ni^{2+} and Cd^{2+} ions onto bentonite

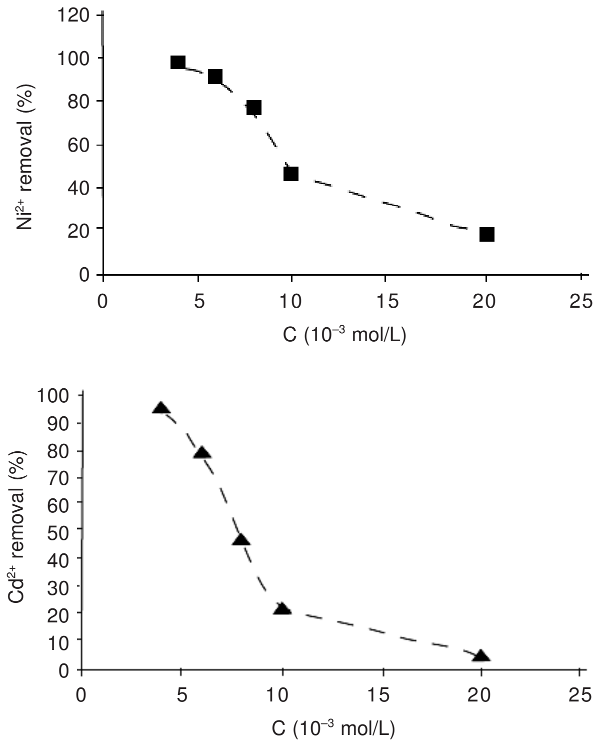

Fig. 4. Relationship between initial metal ion concentration and $Ni^{2+}$and Cd^{2+} adsorption

Effect of pH: To determine the pH necessary for adsorption, liquid- to-solid ratio is 100 mL/g of solution containing 0.005 mol/L metals ions and particles size through 200 mesh were stirred at 1200 rpm at varying time intervals (2-120 min) at 27 ºC. Fig. 5 indicates that the adsorption capacity was dependent on pH.

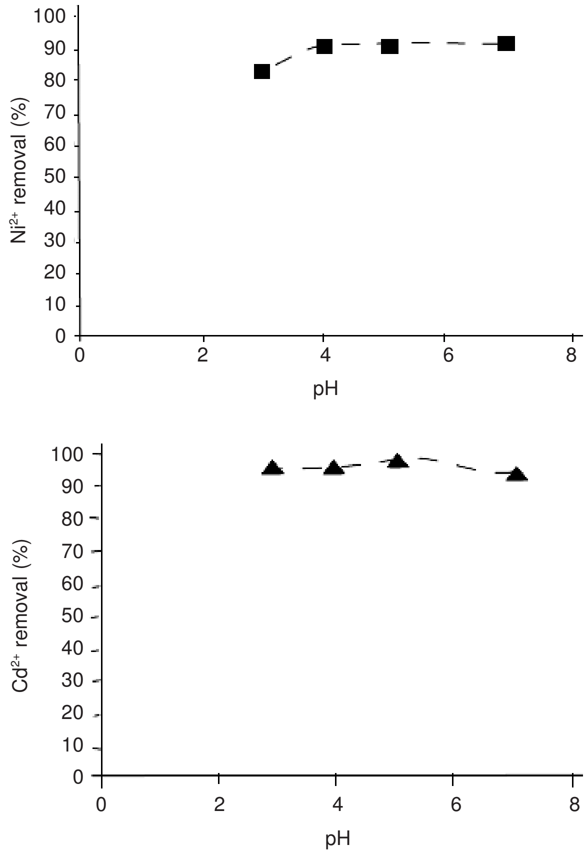

Fig. 5. Effect of pH on the adsorption of Ni^{2+} and Cd^{2+} ions onto bentonite

Conclusion

Local bentonite was tested as adsorbent material for the removal of Cr^{6+} and Pb^{2+} ions from waste solutions. The results indicate that the removal by bentonite is good. Compared to the published data in the same field, it is found to be in agreement with most of them. The adsorption experiments were conducted under different conditions. The extent of Cr^{6+} and Pb^{2+}adsorption increased with increase in pH, temperature, contact time and initial concentration.

REFERENCES

1. J. Schubert, E.J. Riley and S.A. Tyler, *J. Toxicol. Environ. Health*, **4**, 763 (1978).
2. A.I. Zoubolis and K.A Matis, *Crit. Rev. Environ. Sci. Technol.*, **27**, 195 (1997).
3. G.X. Zhao, X.L. Wu, X.L. Tan and X.K. Wang, *The Open Colloid Sci. J.*, **4**, 19 (2011).
4. K. Bhattacharyya and S. Gupta, *Adv. Colloid Interf. Sci.*, **140**, 114 (2008).
5. O. Abollino, M. Aceto, M. Malandrino, C. Sarzanini and E. Mentasti, *Water Res.*, **37**, 1619 (2003).
6. F. Brown and W. Sunderman, Progress in Nickel Toxicology, CRC Press: USA (1991).
7. E. Gerard, G. Echevaria, T. Sterckeman and J.L. Morel, *J. Environ. Qual.*, **29**, 1117 (2000).