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MEANS OF REMEDIATION TO THE POLLUTED WATERS BY NICKEL ELEMENT

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Abstract

The clay minerals like (zeolite, montmorillonite and bentonite) are suitable material for heavy metal removal from the industrial wastewater. High specific surface areas, high cation exchange capacities, and low cost, are the reasons for their choice. Adsorption mechanism of Ni ion on natural zeolites, bentonite and montmorillonite studied in a batch adsorption system. Adsorption methods can efficiently use to treat heavy metal ions polluted wastewater the effect of rates of addition of clay minerals initial concentration of metal ions in the adsorption process estimated. In this, study clay minerals used to reduce the hazardous of nickel on aqueous solutions.

The used minerals were zeolite, bentonite and montmorillonite. Each mineral applied at the rates of 1, 3 and 5% (W/V) of wastewater. The concentrations used of nickel were 100, 150 and 200ppm. The clay significantly, with increasing of the ratio resulted in increasing Ni adsorption. The average amount removal efficiency was 110.96, 130.19 and 142.77 by 1, 3, and 5% of zeolite respectively, 102.20, 119.59 and131.28 by montmorillonite and 84.51, 99.79 and110.95 by bentonite. This indicates that the highest amount of nickel absorption was by adding zeolite. In addition, the highest amount adsorbed of Nickel obtained with 5% of soil minerals in all cases.

Keywords: Montmorillonite, bentonite, zeolite, Nickel, Heavy metals.

Introduction

Industrial activities lead to the disposal of heavy metals contaminated with water that would cause serious environmental degradation and human health problems and vulnerable animals (Lakherwal, 2014) and pointed out that adsorption becomes an attractive alternative technique in treatment heavy metals wastewater contaminated due to its documented cost effectiveness. In this respect, Atkovska *et al*. (2018) indicated that zeolite is widely used as a conventional absorbent material in removing ions of various heavy metals, such as Ni^{2+} from wastewater. Furthermore Shaheen *et al*. (2012) showed that Ni^{2+} and the other heavy metals tend to accumulate in organisms, causing numerous diseases and trouble.

In addition, confirm that the use of natural zeolites as potential sorbents for the removal of the heavy metals, including Ni from industrial wastewater. Wafaa (2017) declared that clay minerals are important as inorganic components. Their sorption capabilities come from their high surface area and exchange capacities. Negative charging on the clay metal structure gives the clay the ability to attract metal ions such as (Ni).

On the other hand, in using the organic materials to decrease the hazard of heavy metals, Mu'azu *et al*. (2018) stressed on the addition of montmorillonite resulted in increasing the capacity for Ni^{2+} adsorption. This indicates that the ratio of montmorillonite in the mud adsorbents is vulnerable to the effect of removing different metal ions from the water in a different way. With respect to use the natural materials in remediation harmful effect of heavy elements zeolite. Ahali (2017) demonstrated that zeolites have a framework silicate with a three-dimensional cage structure. Its structure carries negative charges, which balanced by absorbing interchangeable cations. Due to the high deposits of zeolite in nature and its strong ability to absorb water, it recently drew attention to its use in industrial wastewater treatment.

Zeolite is very promising to remove metal ions from the aqueous solution, and thus may encourage the use of zeolite in environmental applications, Abd El-Azim (2018). On the other hand, Bandura *et al*. (2015) explained in zeolites are micro porous crystalline alumino-silicates containing easily large amounts of extra framework cations. Consequently, it has valuable exchange properties and it applied in treating water and wastewater to remove heavy metal cations. Natural zeolite is widely used for these applications. To the mechanism of the role of zeolite for adsorption heavy elements, (Zhou and Haynes, 2010) investigated the mechanism of adsorption by zeolite, functional group of the adsorbent and the sorbet forms a direct coordinate-covalent bond with surface functional groups on the variable charge surface. In this point (Kulprathipanja, 2010) added that the structure of the zeolite frame includes cavities occupied by large ions and water molecules that are able to move, allowing exchange of ions.

This article aims to investigate parameters that affect removal rates, such as clay minerals, initial solution and the difference between clay minerals. In addition, the maximum absorption capacity of clay minerals, which used to remove metal ions studied through equilibrium reactions, has been determined.

Materials and Methods

To investigate sorption characteristics of nickel onto three clay minerals (montmorillonite, bentonite and zeolite) at rates 1, 3 and 5% from aqueous solutions, have done by using batch experiments technique.

In three replicates, these clay minerals were weighed into 50 ml centrifuge tubes containing 25 ml of prepared solutions of Ni^{+2} (100, 150 and 200 mgl^{-1}). The suspensions shaken mechanically for 24 hr. After equilibration, the suspension was centrifuge at 3000-5000 rpm for 10-20 min. Equilibrium concentration of heavy metal (Ce) was determined in 1 ml of supernatant using Atomic Absorption Spectroscopy (AAS).

The differences between Ci "initial concentration of heavy metal" and Ce assumed to adsorb. On adsorption materials. The concentration of HMs adsorbed on clay minerals, Cs (mmol l^{-1}) expressed by equation: Cs = Ci - Ce. Sorption isotherms curves were obtained by plotting (Cs = conc. of heavy metal adsorbed on clay mineral in mg kg^{-1} clay) versus Ce = mg per liter).

Heavy Metals: The stock solutions of metal ions, having concentrations of 1000 mg l^{-1} were prepared from nickel nitrate Ni $(NO_3)_2$in1 mM HNO_3 acid. Nickel concentration determined by atomic absorption (Perkin Elmer-AAnalyst 400) as described by (Cottenie *et al.*, 1982).

Clay Minerals Three types of clay minerals namely bentonite, montmorillonite and zeolite (clinoptilolite) from ALIX zeolite Company used in batch experiments.

The data in (Tables 1, 2 and 3) represent some physic-chemical properties of these clay materials.

Table 1 : Selected chemical analyses of zeolite mineral used in the study

CEC Cmolc Kg-^{1}	Surface area (m^2 g^{-1})	pH 1:2.5	K_2O	Na_2O	Elements oxides (%)			
					SiO_2	Al_2O_3	Fe_2O_3	CaO
220	89.82	6.8	3.27	0.78	62.220	11.096	4.033	3.583

Table 2 : Particle size distribution and some chemical properties of bentonite

Particle size distribution (%)					pH 1:2.5	EC dS/m	$CaCO_3$ g Kg^{-1}	CEC cmolc Kg^{-1}
C.sand	F.sand	Silt	Clay	Text.class				
1.1	3.8	5.3	89.8	Clay	8.3	4.10	27.3	53.2

Table 3 : Selected chemical analyses of montmorillonite mineral used in the study

Color	Purity (%)	pH 1:2.5	Maximum moisture (%)	CEC cmolc Kg^{-1}	Chemical structure
Off white	> 98	6.8	89.82	116	Natural montmorillonite MMT M+y (Al2-y Mgy) (Si4) O10$(OH)_2$nH_2O

Results and Discussion

Retention of Nickel by clay minerals concerning the influence of various clay minerals on nickel retention data in (Table 4) and (Fig. 1) indicate that decreasing amount of nickel element desorbed more pronounced in zeolite mineral compared to bentonite and montmorillonite respectively. The results proved that the mean values of retained nickel by zeolite were 76.61, 132.28 and 171.38 ppm with increasing the concentration of nickel from 100, 150 to 200 ppm, respectively.

Otherwise, data in (Table 4) Show that the rate increased of applied zeolite from 1 to 5% led to increase the amount of nickel adsorption. At 100 ppm Ni and rate, 5% of zeolite the amount of retained Ni increased from 90.22 ppm these amounts reached to 138.51 and 187.59 ppm at 150 and 200 ppm Ni, respectively. It is clearly show the highest retained amount of nickel was 187.59 ppm with 5% of zeolite and the least retained amount was 60.44 ppm at 1% of zeolite.

Table 4 : Amount of nickel removed from aqueous solutions by clay minerals.

Clay minerals	Rate	Ni (100) ppm	Ni (150) ppm	Ni (200) ppm	Mean
Zeolite	1%	60.44	121.37	151.07	110.96
	3%	77.83	137.27	175.48	130.19
	5%	90.22	138.51	187.59	138.77
Mean		76.61	132.38	171.38	
Montmorillonite	1%	52.65	111.56	142.40	102.20
	3%	71.20	125.87	161.70	119.59
	5%	82.30	128.82	173.71	128.28
Mean		68.72	122.08	159.27	
Bentonite	1%	46.51	92.47	114.56	84.51
	3%	61.14	101.47	136.77	99.79
	5%	68.88	105.27	142.70	105.62
Mean		58.84	99.74	131.34	

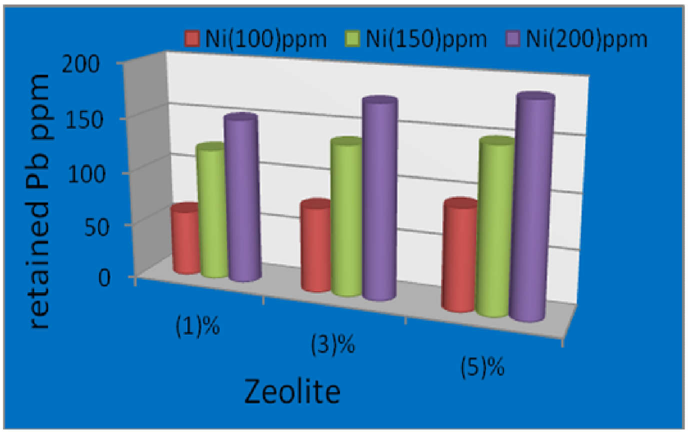

Fig. 1 : Nickel removal by zeolite from aqueous solutions containing different nickel concentrations at different rates of zeolite.

Removal of nickel by zeolite from aqueous solutions containing different nickel concentrations at different rates of zeolite. This results agreement with (Abd El-Azim and Fekry, 2018) showed that natural zeolite holds great potential for remove cationic heavy metal species of industrial wastewater and confirms the potential use of zeolite to remove heavy metals from industrial wastewater via adsorption.

On the other hand, in the case of montmorillonite, the mean values of retained nickel by montmorillonite As shown in the table 4and illustrated by Fig. 2 were 68.72, 122.08 and 159.27 ppm as the rate of applied Ni increased from 100, 150 to 200ppm, respectively.

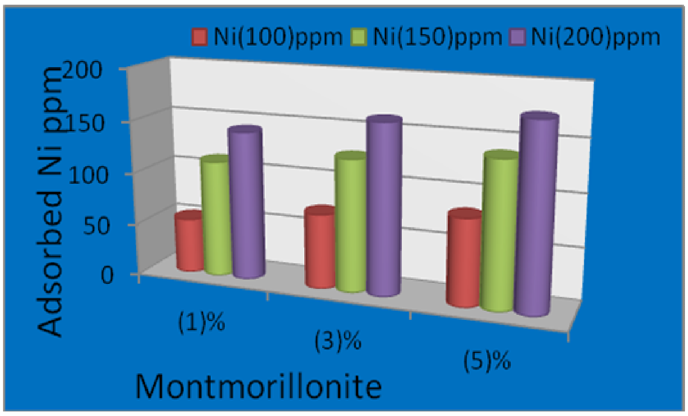

Fig. 2 : Nickel removal by montmorillonite from aqueous solutions containing different nickel concentrations at different rates of montmorillonite.

The values in Table 4 which illustrated by (Fig. 2) Indicate that the highest amount of nickel absorption was 173.71ppm at 5% of montmorillonite and the least amount retained was 52.65 ppm at 1% of montmorillonite. These results are in agreement with Wahba *et al.* (2016) who recorded that zeolite, as a therapeutic substance, was more effective in absorbing heavy metals than bentonite. This was due to the specific structure of zeolite; Cation exchange ability is high and large surface area. The release of elements as result of adding both zeolite and bentonite followed the order Cd^{2+}> Cu^{2+}> Ni^{2+}. Otherwise, data in (Table 4) show that an increase rate of applied montmorillonite from 1 to 5% led to increase the amount of nickel retention.

At 100 ppm Ni and rate of montmorillonite 1 %,the amount of retained Ni increased by about 52.65% these amounts reached to 71.20 and 82.30% with 3, 5% montmorillonite respectively. With respect to add the amount of montmorillonite Mu'azu *et al.* (2018) showed that, the addition of montmorillonite resulted in increasing the capacity for Ni^{+2} adsorption.

Concerning the retention of Nickel by bentonite, data showed in (Table 4) reveals that the mean values of retained nickel by bentonite increased from 58.84, 99.74 to 131.34 ppm with increasing the concentration of nickel from 100, 150 to 200 ppm, respectively. Moreover, the quantity of retained nickel increased with increasing the rate of applied bentonite from 1 to 5%.

At 200ppm, Ni the quantity of nickel adsorption increased from 114.56, 136.77 to 142.70ppm respectively. These results agree with (Saad and Fares, 2014) reported that adsorption of single metal such as nickel on bentonite clay it is clear that, increasing the metal concentration resulted in increasing the amount adsorbed on clay.

The mechanism of adsorbed Ni on bentonite (Bhattacharyya and Gupta, 2008) investigated that bentonite is a 2:1 mineral with an eighth surface alumina paper sandwiched between two tetrahedral silica paper, forming a layered structure. Such arrangement gives a net unconstructive charge due to the broken bond surround the ends of the silica-alumina units that balanced by the exchangeable cations Water molecules in the interlayer region. This charge and structural properties of bentonite clay make it a highly effective absorbent for removing heavy metals.

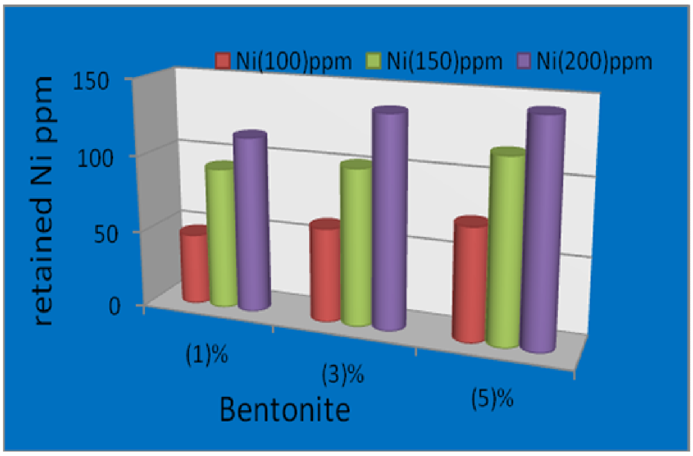

Fig. 3 : Nickel removal by bentonite from aqueous solutions containing different nickel concentrations at different rates of bentonite.

Figure (3) illustrated the amount of adsorbed nickel at different ratio of bentonite with different concentration of nickel. The highest amount of retained nickel was 142.70 ppm with 5% of bentonite at concentration 200 ppm of nickel while the lowest amount of retained nickel was 46.51 ppm with 1% of bentonite at concentration 100ppm of nickel. These results are in agreement with Hamidpoura *et al.* (2010) reported that the highest absorbance return obtained for lead compared to cadmium. The quantities of cadmium and lead absorbed from the bentonite were more than zeolite, indicating that zeolite and sorbents are more effective for treating water and wastewater. Mitchell (1993) descripted the adsorption mechanism by bentonite, due to the high surface area and cation exchange potential; bentonite is a 2: 1 metal with one octahedral sheet and two silica sheets, which form a layer. Classes held together by Vander Wals forces. Because of these weak forces and some charging deficiencies in the structure, water can easily penetrate between layers and cations balance the deficiencies.

On the other hand, (Fig. 4) illustrates the concentration of nickel element adsorbed from water as affected by three rates of zeolite, bentonite and montmorillonite (1, 3 and 5 percentage). Wherever increased the rate of clay minerals increased the amount adsorbed of nickel.

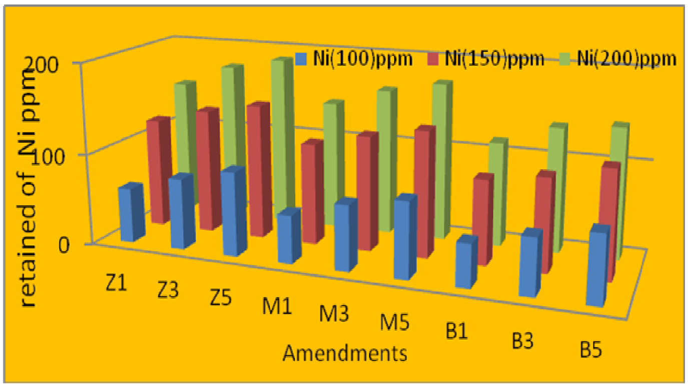

Fig. 4 : Nickel removal from aqueous solutions containing different nickel concentrations at different rates of zeolite, montmorillonite and bentonite.

Regarding the effect of zeolite, add montmorillonite and bentonite on the retention of Ni^{+2} added to water, the retention by zeolite is obviously higher than montmorillonite and bentonite, respectively. Similar results have already been reported Katerina *et al.* (2018) shown that bentonite and zeolite are widely used as conventional absorbents in removing Ni^{+2} from wastewater. The results demonstrated that the highest rate of nickel retention was 177.59 ppm zeolite followed montmorillonite and bentonite 173.71, 142.70 ppm respectively.

The other researcher reported that Bentonite and zeolite are widely used as a traditional absorbent in removing Ni^{2+} from wastewater (Katerina *et al.*, 2018). Summarize the previous results as follow; the role of zeolite as a therapeutic substance, it was more effective in absorbing heavy metals than montmorillonite and bentonite, respectively. This relates to the specific structure of zeolite with a high cation exchange capacity and a large area.

Conclusions

In this present study, the following conclusions Natural materials such as clay minerals can used to remove the harmful effect of heavy metals such as nickel. It is due to great surface area, ionic diameter, Cation exchange ability is high and type of bond between clay mineral and the element such as Vander-walls bonding whereas it connect the hydrogen lead with a hydroxyl group of zeolite, bentonite and montmorillonite surfaces.

Moreover, the variation in adsorption capacity of each of them was the zeolite gave the highest adsorption results of nickel followed by montmorillonite and then bentonite. Therefore, we recommend the possibility of using natural materials such as clay minerals to remove the harmful effect of heavy metals. The use of natural raw materials obtain high economic and good health.

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