CHARACTERISTICS OF THE ADSORPTION OF HEAVY METAL IONS Pb2+, Cd2+, AND Ni2+ FROM INDUSTRIAL WASTEWATER

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ABSTRACT

The aim of the study is to research of the adsorption properties of heavy metal ions Pb2+, Cd2+ and Ni2+ from industrial wastewater. For the adsorption of heavy metal ions, natural clinoptilolite was used, which belongs to the Ai-Dag deposit of the Tovuz-Kazakh region of Azerbaijan. Isotherms and kinetic curves of adsorption of heavy metal ions Pb2+, Cd2+ and Ni2+ were determined. The dependence of the adsorption of heavy metal ions on the pH value is also shown. It was revealed that the separation process proceeds more intensively at pH values of 5-6. It has been established that the maximum adsorption capacity of the clinoptilolite adsorbent for the adsorption of Pb2+, Cd2+, and Ni2+ ions is 7.5, 6.7, and 5.9 mmol/g, respectively.

Keywords: waste water, heavy metals, adsorption, kinetics, isotherm.

INTRODUCTION

The purpose of this research work is to study the adsorption properties of heavy metal ions Pb2+, Cd2+ and Ni2+ from industrial wastewater. Heavy metals and their compounds have a toxic effect on humans, flora and fauna. These toxic effects are not eliminated without restrictions. They exist only in certain chemical compounds and in a certain concentration. Some heavy metal compounds (such as Au and Pt) are used for therapeutic purposes, such as in autoimmune diseases and as cytostatic in some types of cancer, and some heavy metals are required by the human body in small amounts. [1,2]. It is known that in recent times, due to their high toxicity, special attention has been paid to not pollute the environment with heavy metals. Common methods used to remove heavy metal ions from various industrial wastewater include: chemical precipitation, membrane separation, ion exchange, evaporation and electrolysis, etc. includes. These methods are often expensive or inefficient, especially when the amount of heavy metal ions in solution is low.

DATA AND METODOLOGY

In the treatment of wastewater from heavy metals, the adsorption method is used, which occupies a special place among the traditional methods used. However, the advantages of this method are offset by the increased cost of adsorbents such as activated carbon and synthetic ion exchangers. Inexpensive and widely available adsorbents, as well as natural adsorbents such as natural zeolites, have forced us to focus on them. Natural clinoptilolite, one of the natural zeolites, is widely

distributed in many countries of the world, and there are rich deposits of natural clinoptilolite in Azerbaijan.
For example, the Ai-Dag deposit in the Tovuz-Kazakh region of Azerbaijan. Molecules play a key role in the adsorption process, since the formation of covalent bonds is significantly different. The outer portions of the surface complexes are usually at least one water molecule. Natural clinoptilolite was used to adsorb heavy metal ions Pb2+, Cd2+, and Ni2+ [3, 4].
The adsorption properties of clinoptilolite and its characteristics are shown in Table.
As described above, isotherms and adsorption kinetics were determined in cycle experiments with stirring and temperature control. Heavy metal ions and clinoptilolite zeolite were used in equilibrium experiments. The weight load is calculated as follows:

aeq = (Co-Ceq) V/m (1)

here:
aeq - weight load,
Co is the initial concentration of metal ions in the solution,
the concentration
Ceq is obtained after adsorption equilibrium is established,
V is the volume of the adsorbate, and
m is the mass of the adsorbent (clinoptilolite).

Table 1.

Indications	Clinoptilolite
Volume scattering density, g/cm3	0.65-0.7
Clinoptilolite content: no more than, %.	76-80
Porosity, %.	29.4-50
Intergranular porosity: not less than, %	40
Water resistance: not less than, %	95
Vibration loss: no more, %	1
Temperature resistance: 0C	650
Mechanical resistance of pellets to crushing: - not less than	8 кг pellets
Volumetric capacity for NH4, mg-eq/g - not less than	0.70 - 2.5
Standard fractions: (yield of the target fraction is not less than 85%)	3-5 mm
Moisture capacity in static conditions at relative air humidity (1.0%) not less than:	60 mq/sm^3
Appearance:	irregular granules
Color:	light gray, yellow gray

For the metal ion, the following concentrations were used: 0.1; 1.0; 10.0; 100 and 1000 mg/l. Sorption isotherms were obtained in samples of natural zeolite (clinoptilolite) solutions of heavy metal ions at pH 1-7. It was found that the separation process is more intense at pH values of 5-6.
In the dry state, the clinoptilolite adsorbent was used for comparative studies with the removal of toxic metal ions, such as Pb2+, Cd2+, and Ni2+, from aqueous solutions. The effect of the initial solution pH, contact time, parent metal, ion concentration, and temperature on the adsorption capacity of the adsorbent was studied. Desorption of the clinoptilolite adsorbent from metal ions was achieved using 0.1 M HCl in about 20 minutes [5-7].
It is important to determine sorption isotherms in order to determine the time to reach equilibrium under adsorption conditions. Samples are taken periodically and in a state of equilibrium. Heavy metal ions were quantitatively determined using an AAA method.
On Figure 1 shows the kinetic curves for the adsorption of heavy metal ions Pb2+, Cd2+, and Ni2+. As can be seen from Figure 1, the equilibrium concentration of adsorption of heavy metal ions Pb2+, Cd2+ and Ni2+ occurs after 45 min.

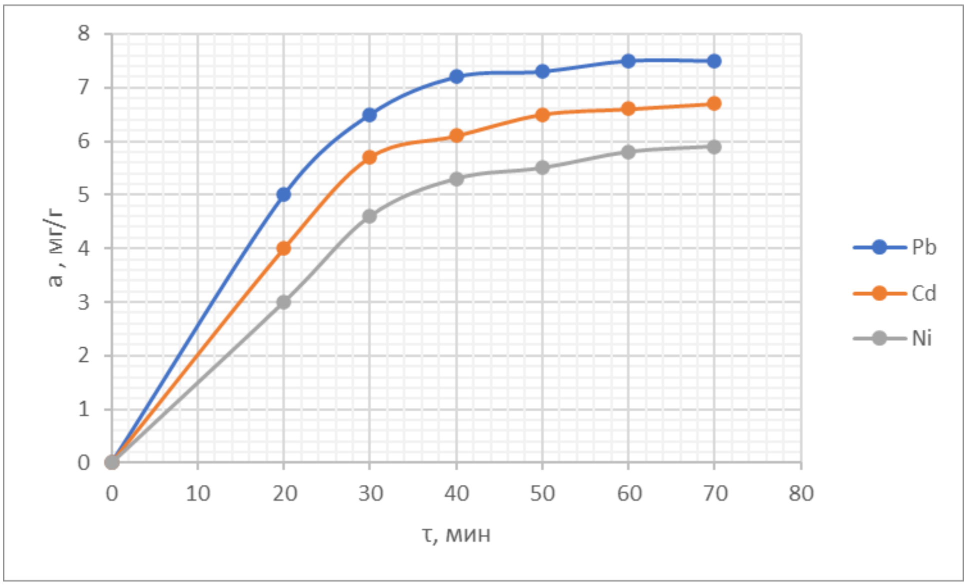

Fig. 1. Kinetic curves for the adsorption of heavy metal ions Pb2+, Cd2+, and Ni2+.

Fig. 2 shows the adsorption isotherms of heavy metal ions Pb2+, Cd2+, and Ni2+; it shows that adsorption equilibrium occurs at a concentration of 0.1 mg/l. The isotherm curves are non-linear and correspond to Langmuir-type isotherms.

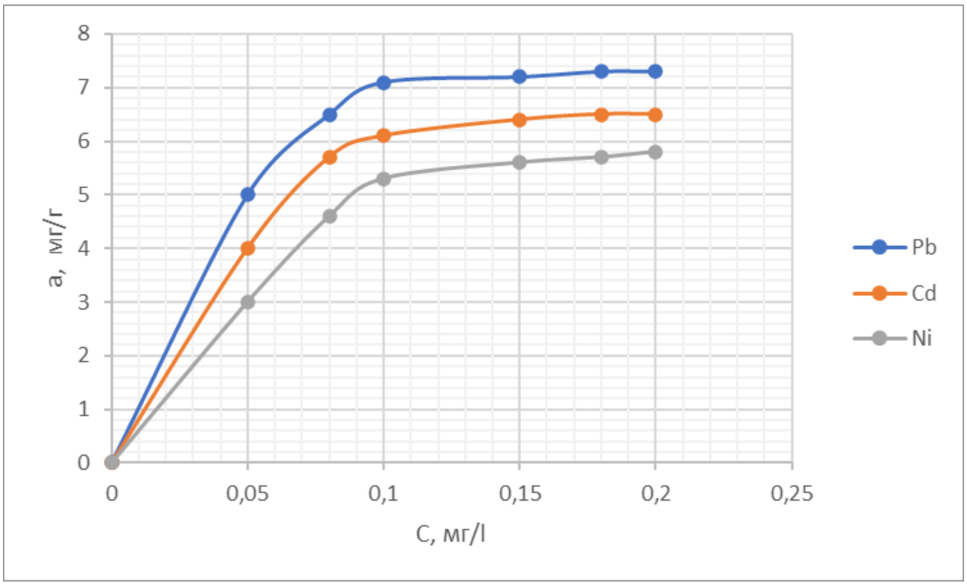

Fig. 2. Adsorption isotherms of heavy metal ions Pb2+, Cd2+, and Ni2+.

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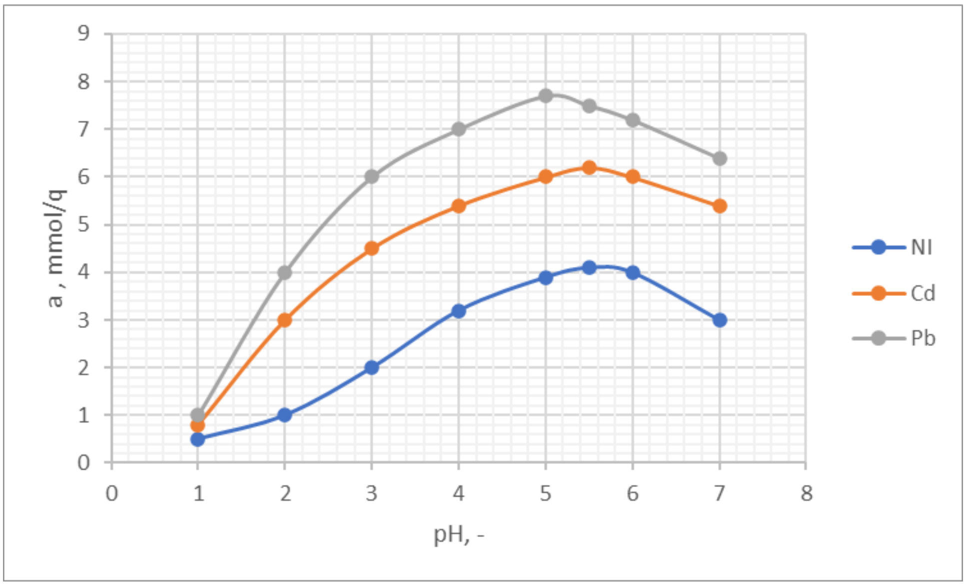

Fig. 3. Adsorption of heavy metal ions Pb2+, Cd2+, and Ni2+ as a function of pH.

From fig. 3 we can see that the maximum adsorption value is achieved at 5-5.5 pH.

The mathematical internal kinetics of diffusion is expressed by the following equation [5]:

$$F = 1 - \frac{6}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{n^2} \exp\left(- \frac{n^2 \pi^2 \overline{D}}{r_0^2} \right) \tau \quad (2)$$

It is taken into account here that:

F is the rate of completion of the process,

n is an arbitrary integer,

ro is the radius of the ion exchanger core,

D is the diffusion coefficient,
τ is time.
The hydration surface area of the adsorbed ion is also important.

Because chemisorption requires interaction between the adsorbent and adsorbate, it can occur as long as the free binding sites on the surface of the adsorbent do not repel. Therefore, chemical adsorption is limited to monomolecular adsorption.

RESULTS

Our results are as follows: physical sorption can also occur in multicomponent molecular layers. At equilibrium, the rate of adsorption is the same. The degree of desorption, adsorption rate, liquid pressure is proportional to the number of metal molecules per unit volume and the concentration of molecules for adsorption. The adsorption isotherms of lead, nickel, and cadmium are non-linear. These curves correspond to Langmuir isotherms. The maximum adsorption capacity of the clinoptilolite adsorbent for the adsorption of Pb2+, Ni2+, and Cd2+ ions was 7.5, 6.7, and 5.9 mmol/g, respectively.

DISCUSSION

It is known that in recent times, due to their high toxicity, special attention has been paid to not pollute the environment with heavy metals. Common methods used to remove heavy metal ions from various industrial wastewater include: chemical precipitation, membrane separation, ion exchange, evaporation and electrolysis. These methods are often expensive or inefficient, especially when the amount of heavy metal ions in solution is low.

CONCLUSIONS

Physical sorption can also occur in multicomponent molecular layers.
The degree of desorption, adsorption rate, liquid pressure is proportional to the number of metal molecules per unit volume and the concentration of molecules for adsorption.
The adsorption isotherms of lead, nickel, and cadmium are non-linear.
The maximum adsorption capacity of the clinoptilolite adsorbent for the adsorption of Pb2+, Ni2+, and Cd2+ ions was 7.5, 6.7, and 5.9 mmol/g, respectively.

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