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Chamotte clay sorbent for the extraction of lead and cadmium ions from aqueous solutions

Abstract: Nowadays the problem of wastewater pollution by heavy metal (HM) ions is extremely urgent. HM are harmful for health and environment, they are not biodegradable and can accumulate in plants and body. Clay minerals are known for their high adsorption capacity towards heavy metal ions. There are many research studies on appliance of different types of clays for wastewater treatment. Chamotte clay is a white heat-treated kaolin clay with stone properties, resistant to aggressive media, which contains highly dispersed hydroaluminosilicates. The clay does not require additional purification after secondary use. It is used in industry in large quantities, though wastes of clay are needed to be utilized. In current work chamotte clay wastes are offered to be used as a sorbent for lead (II) and cadmium (II) ions extraction. The choice of the ions is based on the high toxicity and abundance of these metals in wastewaters. Polyvinylpyrrolidone (PVP) was used as a modifier to increase adsorption capacity of the clay. The extraction degree of ions by initial chamotte clay reaches $(97 \pm 7.2) \%$ and $(67 \pm 6.0) \%$ for Pb^{2+} and Cd^{2+} respectively. The modification with PVP increases the extraction degree of Cd^{2+} to $(86.0 \pm 6.4) \%$. The initial and modified clay was characterized by scanning electron microscopy, energy dispersive spectroscopy and Fourier transform infrared spectroscopy methods. The adsorption process was carried out under static conditions at $\text{pH} = 6$ and $T = 298 \text{ K}$, initial concentration of the metal ions was 10 mg/l . The optimal mass for the sorption of lead and cadmium ions was also determined during the study and is equal to 1 g per 100 cm^3 of solution. The use of chamotte clay as the basis for the development of sorbents helps reducing the cost of cleaning water bodies, and also allows solving the problem of wastes disposal.

Key words: adsorption, chamotte clay, polyvinylpyrrolidone, heavy metal ions, wastewater treatment

Introduction

Large industrial production is characterized by the formation of effluents containing heavy metal ions (HM). Heavy metals are natural components of the earth's crust. They cannot be degraded or destroyed [1-3]. However, due to large emissions as a result of industrialization and urbanization, HMs pose a great threat. Unlike organic pollutants that are capable of biodegradation, heavy metals do not decompose into harmless end products and have global consequences for both the human body and the environment [4]. According to studies [5, 6], some TM ions are nutrients for the physiological functions of humans in small doses, but in large quantities they have a negative effect on health.

Many methods are known to reduce the concentration of pollutants or to completely purify water from heavy metal ions (HM), but many of them are

expensive. One of the most effective and low-cost methods for the neutralization of HM ions is sorption [7]. The sorption method makes it possible to purify water from HM ions with high efficiency, approximating the concentration of contaminants to maximum acceptable concentration (MAC) and general sanitary standards.

There is a shortage of clean drinking water existing in some regions of Kazakhstan [8]. One of these regions is the village of Alatau Batyr. The local population is forced to drink low-quality water containing TM ions. During the experiment, a number of water samples were taken and their composition was studied. As it turned out, the water in the region needs to be treated as TM ions in high concentrations, which do not meet sanitary standards, were found in the samples.

In recent years, the use of industrial waste as secondary products has been of great interest [9].