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Adsorption of Pb(II) and Cd(II) from aqueous solutions on Kyzylsok natural clay modified by polyvinylpyrrolidone

Abstract. Present work considers the production of a cheap and effective sorbent based on natural clay originated from the Kyzylsok deposit (Almaty region, Kazakhstan) to purify wastewater from heavy metal ions (Cd^{2+} , Pb^{2+}). It was found that the starting clay sample is applicable for the extraction of Cd^{2+} ions (the degree of extraction is $(97.40 \pm 1.99)\%$), while for the extraction of Pb^{2+} ions the initial clay must be modified by impregnation with 0.1 % polyvinylpyrrolidone (PVP) aqueous solution. The degree of extraction of Pb^{2+} ions with modified clay increased from $(70.01 \pm 1.77)\%$ to $(98.03 \pm 1.13)\%$. The desorption of metal ions which was also investigated in the work did not exceed 2% confirming the usability of untreated and modified clay as sorbents for a long time. It was found that the sorption process is described by the monomolecular Langmuir isotherm model and the kinetic model of the pseudo-second-order.

Key words: natural clay, polyvinylpyrrolidone, modification, sorption, desorption, cadmium (II) ions, lead (II) ions.

Introduction

Water is an essential resource for maintaining human life (food, blood circulation, respiration, reproduction, etc.). More than two-thirds of the earth's surface is covered with water, but only a small part of it is suitable for drinking, cooking or irrigation [1]. Serious problems arise from the uneven regional distribution of water resources, due to the increase in its use due to the growing population and rising living standards, which contribute to water pollution. This leads to a reduction in the available water supply [2].

Industrial wastewater and agricultural waste are major environmental pollutants. Most industries dump waste water containing toxic substances into rivers without high-quality treatment [3]. Environmental pollution, especially with heavy metals and minerals in wastewater, is the most serious problem in Kazakhstan. Heavy metals are one of the main pollutants in marine, land, industrial and even treated wastewater [4].

The main sources of heavy metal emissions are industrial wastewater from mining, metal processing, tanneries, pharmaceuticals, pesticides, organic chemicals, rubber and plastics, timber and

wood products [5]. Heavy metals are transported by wastewater and pollute water sources downstream of the industrial site [6]. Most of the heavy metal ions discharged into wastewater are toxic and carcinogenic and pose a serious threat to human health [7].

The release of a large amount of hazardous materials into the natural environment leads to many environmental problems and, due to their biodegradability and persistence, can accumulate in the elements of the environment, and, thus, can pose a significant hazard to all living things [8].

The accumulation of such elements in the human body can lead to irreparable consequences. For example, acute exposure to lead can cause headaches, loss of appetite, abdominal pain, fatigue, insomnia, hallucinations, dizziness, renal dysfunction, hypertension and arthritis, while chronic exposure can lead to birth defects, mental retardation, autism, psychosis, allergies, paralysis, weight loss, dyslexia, hyperactivity, muscle weakness, kidney damage, brain damage, coma, and even death [9]. In addition, exposure to lead can disrupt the functioning of intracellular "secondary messengers" and alter the functioning of the central nervous system [10].

In turn, exposure to cadmium can cause damage to bones and lungs, impaired function and kidney