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SELECTION AND EVALUATION OF PROMISING BENTONITE DEPOSITS FOR THE PRODUCTION OF SORPTION MATERIALS USED IN INDUSTRIAL WASTEWATER TREATMENT

Husenov Abdurasul Uktamovich

Independent Researcher, Jizzakh Polytechnic Institute, Jizzakh, Uzbekistan
E-mail: abdurasulhusenov4@mail.ru
ORCID ID: 0009-0004-4255-6266

Xadjibayev Diyor Asadullayevich

Doctor of Philosophy (PhD) in Technical Sciences, Jizzakh Polytechnic Institute, Jizzakh, Uzbekistan
E-mail: diyorxadjibayev@gmail.com
ORCID ID: 0009-0007-1273-6153

Sabirov Baxtiyor Toxtayevich

Doctor of Technical Sciences, Professor, Jizzakh Polytechnic Institute, Jizzakh, Uzbekistan
E-mail: bentosb@rambler.ru
ORCID ID: 0009-0007-1273-6153

Abstract. *This paper investigates the selection and evaluation of promising bentonite deposits for the production of sorption materials intended for industrial wastewater treatment. The mineralogical composition and physicochemical properties of bentonite raw materials were analyzed, and their influence on adsorption performance was assessed. The results demonstrate that locally available bentonite deposits possess high sorption potential and can be effectively used for manufacturing sorbents capable of removing heavy metals and other pollutants from industrial wastewater, thereby improving environmental safety and resource efficiency.*

Keywords: *bentonite, bentonite deposit, sorbent, adsorption, industrial wastewater, water treatment, mineral raw materials, physicochemical properties, environmental safety.*

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ВЫБОР И ОЦЕНКА ПЕРСПЕКТИВНЫХ МЕСТОРОЖДЕНИЙ БЕНТОНИТОВОГО СЫРЬЯ ДЛЯ ПОЛУЧЕНИЯ СОРБЦИОННЫХ МАТЕРИАЛОВ, ПРЕДНАЗНАЧЕННЫХ ДЛЯ ОЧИСТКИ ПРОМЫШЛЕННЫХ СТОЧНЫХ ВОД

Хусенов Абдурасул Уктамович

Независимый исследователь Джизакского политехнического института, Джизак, Узбекистан

Хаджибаев Диёр Асадуллаевич

Доктор философии по техническим наукам (PhD), Джизакский политехнический институт, Джизак, Узбекистан

Сабиров Бахтиёр Тохтаевич

Доктор технических наук, профессор, Джизакский политехнический институт, Джизак, Узбекистан

Аннотация. *В статье рассмотрены вопросы выбора и оценки перспективных месторождений бентонитового сырья для получения сорбционных материалов, предназначенных для очистки промышленных сточных вод. Проведён анализ минералогических и физико-химических свойств бентонитов и дана оценка их влияния на сорбционные характеристики материалов. Результаты исследования показали, что местное бентонитовое сырьё обладает высокими адсорбционными свойствами и может эффективно использоваться при удалении тяжёлых металлов и других загрязняющих веществ из промышленных сточных вод.*

Ключевые слова: *бентонит, месторождение бентонита, сорбент, адсорбция, промышленные сточные воды, очистка воды, минеральное сырьё, физико-химические свойства, экологическая безопасность.*

SANOAT OQOVA SUVLARINI TOZALASH UCHUN BENTONIT ASOSIDAGI SORBSION MATERIALLARNI OLISHDA ISTIQBOLLI XOM ASHYO KONLARINI TANLASH VA BAHOLASH

Husenov Abdurasul O‘ktamovich
Jizzax politexnika institutining mustaqil tadqiqotchisi, Jizzax, O‘zbekiston

Xadjibayev Diyor Asadullayevich
Texnika fanlari bo‘yicha falsafa doktori (PhD), Jizzax politexnika instituti, Jizzax, O‘zbekiston

Sabirov Baxtiyor To‘xtayevich
Texnika fanlari doktori, professor, Jizzax politexnika instituti, Jizzax, O‘zbekiston

Annotatsiya. *Maqolada sanoat oqova suvlarini samarali tozalash uchun bentonit asosidagi sorbsion materiallar ishlab chiqarishda foydalanilishi mumkin bo‘lgan istiqbolli bentonit konlari tanlash va baholash masalalari o‘rganilgan. Bentonit xom ashyosining mineralogik va fizik-kimyoviy xossalari tahlil qilinib, ularning adsorbsion samaradorlikka ta’siri baholangan. Tadqiqot natijalariga ko‘ra, mahalliy bentonit konlaridan olinadigan xom ashyo yuqori sorbsion xususiyatlarga ega bo‘lib, sanoat oqova suvlarini og‘ir metallar va boshqa ifloslantiruvchi komponentlardan tozalash uchun samarali sorbentlar ishlab chiqarishda istiqbolli manba ekanligi asoslangan.*

Kalit so‘zlar: *bentonit, bentonit koni, sorbent, adsorbsiya, sanoat oqova suvlari, suvni tozalash, mineral xom ashyo, fizik-kimyoviy xossalar, ekologik xavfsizlik.*

Introduction. Although the use of synthetic adsorbents in industrial wastewater treatment is effective, their use in this field is relatively expensive due to their high cost, complexity, and selectivity of regeneration processes. Therefore, it is important to search for effective natural materials and opportunities for their use for wastewater treatment.

Bentonites, also known as "bentonite clays," are a type of clay consisting mainly of smektite group minerals that disperse in water to a colloidal state [1]. Bentonites are representatives of a class of highly dispersed aluminosilicate polymineral minerals, which possess crystal size at a level of less than 1 μn and, accordingly, a large specific surface area and exchange capacity. Bentonite clays were formed during the later stages of geological history, approximately 140 million years ago. According to geological data, all identified large deposits of bentonite clays were formed by the underwater decomposition of volcanic ash and tuffs, which is confirmed by the location of bentonites in zones of high volcanic activity within the Earth's crust. According to geologists' estimates, in the deposits of bentonite clays considered economically and industrially suitable for extraction, there are deposits of bentonite clays ranging from several thousand to several million tons, and the length of their sections can reach several kilometers [1].

As is known [2], bentonite clays (bentonites) are fine-dispersed clays, the main components of which are clay minerals of the smectite group - montmorillonite (Al_2O_3-$4SiO_2H_2O$) and beidellite (Al_2O_3-$3SiO_2nH_2O$). Minerals of the smectite group exhibit high binding capacity, exchange capacity, adsorption, and catalytic activity. The composition

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of bentonite clays is accompanied by mixed-layered minerals, hydrosludes, palygorskite, illite, zeolites, quartz, kaolinite, galloisite, etc., in the form of impurities. Bentonite clays of various deposits and their individual areas differ in their external (visual) characteristics, chemical-mineralogical composition, as well as physicochemical properties, the color of which varies weakly from white to light green, light blue, cream, and has a yellowish-pink tint.

The structure of the bentonite framework based on the rock-forming mineral montmorillonite, the formula of which can be represented as $Al_2O_3 \times 4SiO_2 \times nH_2O$, also plays a significant role [3]. It is precisely this general structure that predetermines the physical and technical properties of bentonite clay.

In the sources [4, 5] presents the results of a systematic study of the sorption properties of natural materials in the extraction of petroleum products of various natures. To improve the quality of oil water purification, the authors developed combined multilayer sorbents that allow for the production of oil mixtures of a wide dispersion with a purification level of 92-98%.

Natural minerals such as bentonite (montmorillonite), kaolinite, biotite, vermiculite glauconite are considered effective and promising in softening industrial effluents and removing heavy metals [6-10]. This is due to the fact that natural minerals are called promising because they are relatively inexpensive and in sufficient quantities, and their performance properties are high enough.

The adsorption properties of natural minerals are explained by their chemical, mineralogical composition, as well as the structure of the crystals and the dispersion of the particles [11-23]. The main chemical components in them are SiO_2 (30-70%), Al_2O_3 (10-40%) and H_2O (5-10%), with a specific surface area of up to $500 m^2/g$.

In the work of the authors [12-23] the adsorption of heavy metals in tourmaline consisting of alumosilicates was studied. Tourmaline is a complex alumosilicate with selective adsorption properties.

Methods and materials. Bentonite clay samples from the Nurata, Azkamar, and Navbakhor deposits were selected for the study. X-ray analysis of the chemical and mineralogical composition of the samples was conducted, and their fractional composition was determined.

Results and discussion. The main problem in the treatment of wastewater contaminated with various organic substances, especially at basalt fiber production plants, is the cost of sorbents used for purification, the cost of ion exchangers, and the fact that they are mainly imported. Taking this into account, we conducted research on the use of natural bentonite clay for the purification of wastewater from organic pollutants.

To study the physicochemical properties of bentonite clays from various deposits in our republic, samples of bentonite clays were imported from the Nurata, Azkamar, and Navbakhor deposits, and their physicochemical properties, including chemical and mineralogical composition, were studied and compared. The reserves of these deposits are sufficient and have the potential for industrial development.

Table 1

Chemical composition of bentonite samples from various deposits

№	Mineralogical composition of the sample	Mineral content in bentonite, %		
		Bentonite of the Nurata deposit	Bentonite of the Azkamar deposit	Bentonite of the Navbakhor deposit
1	SiO_2	55,15	56,23	45,73
2	TiO_2	0,62	0,61	0,36
3	AI_2O3	14,17	13,56	7,24
4	Fe_2O_3	9,03	2,50	3,30
5	MgO	2,22	3,76	3,42
6	CaO	0,30	0,69	15,1
7	Na_2O	2,20	4,98	0,93
8	K_2O	1,54	2,20	0,92
9	P_2O_5	0,11	0,92	0,66
10	SO_3	0,10	0,49	0,49
11	FeO	-	-	-
12	Others	13,76	14,06	21,85

The chemical composition of bentonite clay samples obtained from various selected deposits was determined by X-ray fluorescence; the analysis results are presented in Table 1. From the above data, it can be concluded that the chemical composition of natural bentonite clays in the sampled deposits is close to each other, and the bentonite of the Nurata deposit is more promising than other deposits; the amount of aluminum oxide in this sample, which plays an important role in the sorption process, is relatively high, and the composition of the main elements differs slightly from that of other deposits.

The phase composition of the bentonite clay of the Azkamar deposit according to the X-ray

diffraction pattern (Fig. 1) is primarily represented by montmorillonite d=0.44; 0.32; 0.256; 0.246; 0.167; 0.149 nm. X-rays also show d=1.26; 1.05 nm, as well as quartz lines d=0.427; 0.335; 0.199 and 0.182, indicating the sandiness of the bentonite clay. On the X-ray diffraction patterns of Azkamar bentonite, the lines of the high-alumina form of montmorillonite corresponding to baidelite are also observed at d=0.725 and 0.169 nm.

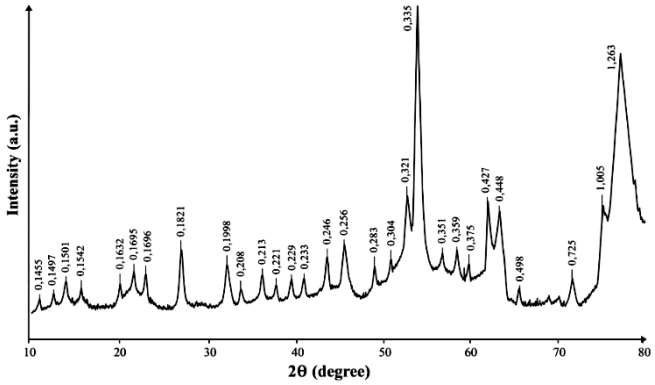

Fig.1. X-ray of a sample of white bentonite from the Azkamar deposit.

X-ray phase studies of bentonite samples from the Nurata and Navbakhor deposits (Fig. 1). 2-3) also indicates the presence of characteristic lines corresponding to montmorillonite at d=1.52; 0.714; 0.448; 0.412; 0.249 nm, etc. In the samples of their Bolgali manifestations, the lines corresponding to the illite are d=0.384; 0.308; 0.288 nm and others. X-ray diffraction patterns of bentonite samples from the Navbakhor deposit: d=0.304, excluding lines corresponding to montmorillonite; 0.227 and 0.151 nm, which indicates their proximity to Palygorskite clays.

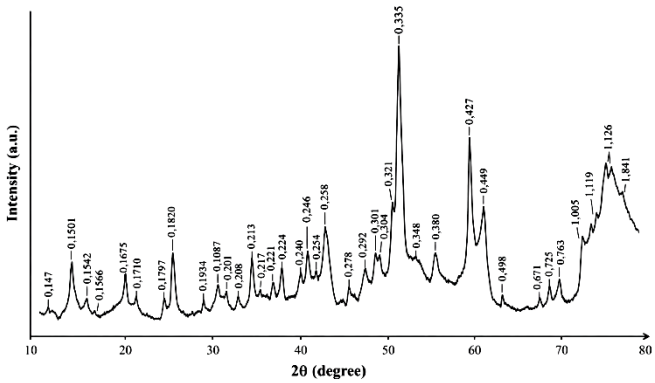

Fig.2. X-ray of a bentonite sample from the Nurata deposit.

The results of the study of the physicochemical properties of various natural bentonite clays in our republic showed that, despite the adsorption activity of these natural minerals, they are unsuitable for natural water treatment due to spontaneous peptization and decomposition in an aqueous medium. Furthermore, natural bentonite clay contains up to 40% of ballast mineral additives that do not participate in the sorption process and reduce the overall efficiency of the sorption material.

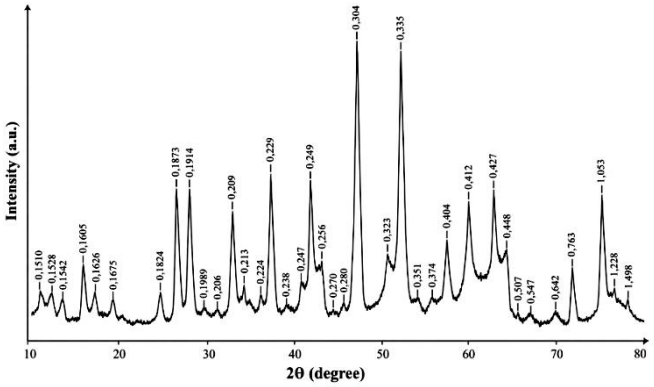

Fig.3. X-ray diffraction pattern of a Paligorskite sample from the Navbahor deposit.

Therefore, to bring the application of sorption materials based on bentonite clay to an industrial scale, it is first necessary to process and modify them. To do this, it is first necessary to dry and classify the natural bentonite clay. For this purpose, we selected Nurata bentonite clay, which is most suitable for further research and contains potassium ions easily exchangeable during sorption and calcium ions easily exchangeable during modification.

To prepare a natural sorbent based on bentonite clay, 1 kg of bentonite from the Nurata deposit was weighed, crushed, and dried in a drying unit at a constant weight for 1 hour at a temperature of 150°C with periodic stirring. After drying, the weight of the weighed bentonite was 0.85 kg, and the average moisture content of the samples was 15%. Based on the results of our experiments to determine the mineralogical composition of bentonite, it was established that the maximum content of bentonite is found in fractions with a diameter of less than 0.002 mm. Therefore, to separate the dried bentonite samples from organic additives, pebbles, and other impurities, they were passed through a sieve with a hole diameter of 0.002

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mm. The granulometric and mineralogical composition of our classified sample was determined to be particles with a diameter of less than 0.002 mm, cleaned of fine sand and organic impurities, and containing at least 60% bentonite.

The determination of the granulometric composition of bulk materials consists of determining the material fractions of various dispersions and their sums [14]. Bentonite samples were divided into fractions in sieves consisting of cells of various diameters, and their fractions were calculated. The results of the analysis of the fractional composition of samples from the Nurata, Azkamar, and Navbakhor deposits are presented in Table 2.

Table 2

Fractional composition of bentonite clay samples obtained and enriched from various deposits

Sieve cell diameter, mm	Bentonite residue in sieve					
	Bentonite of the Nurata deposit		Bentonite of the Azkamar deposit		Bentonite of the Navbakhor deposit	
	Residual mass, g	Amount of fraction,%	Residual mass, g	Amount of fraction, %	Residual mass, g	Amount of fraction, %
0,063	0,41	0,048	2,95	0,32	0,3	0,041
0,045	0,72	0,085	12,02	1,32	0,22	0,03
0,0315	3,25	0,38	33,30	3,67	1,51	0,20
0,025	30,04	3,53	94,12	10,38	6,81	0,93
0,02	142,28	16,74	193,42	21,32	133,84	18,32
0,002	484,07	56,85	437,13	48,19	399,51	54,68
0,001	132,36	15,57	94,02	10,37	110,02	15,06
0,008	25,27	2,97	19,42	2,14	32,14	4,40
0,005	21,48	2,53	16,43	1,81	37,32	5,11
<0,005	10,12	1,29	4,71	0,52	8,92	1,22

Conclusion. During the conducted research, chemical and mineralogical analyses of bentonite samples from the Nuratina, Azkamar, and Navbakhor deposits were conducted. It has been established that the main part of the bentonite clay is in fractions below 0.002 mm. A suitable deposit was selected to obtain an environmentally friendly adsorbent by processing bentonite clay. It has been established that the main part of the bentonite clay (90-95%) is contained in fractions up to 0.04-0.7 μm. As the optimal raw material, a sample of Nurota bentonite was selected, which contains a relatively high amount of aluminum oxide involved in the sorption process.

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