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PURIFICATION OF UNDERGROUND WATER USING SORBENT BASED ON SILICONY ROCK-FLASK OF WEST KAZAKHSTAN

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ABSTRACT

Currently, the Republic of Kazakhstan maintains an intense environmental situation that is associated with an anthropogenic impact on water supply sources. Technically, providing the required amount of water is a feasible task, but the supplied water must be of a certain quality and comply with drinking water supply standards. In this regard, it is a necessity today to constantly monitor the quality of underground water sources used to purify them from harmful impurities using the most effective and readily available natural sorbents. The paper presents the results of studies of the physical and chemical properties of groundwater from wells No. 48 belonging to LLP "ESCEIPA" and the village of Dzhangala, West Kazakhstan region. A siliceous rock - a flask of Western Kazakhstan was used as an adsorbent for water purification. Acid activation was carried out to increase the sorption capacity of the flask. Permanganate oxidizability, sulfate ions, and dry residue were determined in the studied water samples before and after treatment, the following. The studies were carried out with the original and modified flask. The experimental data obtained showed that the best results were achieved after acid activation of the sorbent. Thus, the content of mineral salts has decreased by 2 times, the permanganate oxidizability for the "ESCEIPA" water sample is below the permissible concentration, and the content of sulfate ions is close to the technical conditions. It has been proved that it is possible to use a flask for groundwater treatment, and acid modification improves the sorption characteristics of the material under study.

Keywords: Siliceous Rock-Flask, Groundwater, Sorbent, Acid Activation, Water Purification, Permanganate Oxidizability, Sulfate Ions, Dry Residue.

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INTRODUCTION

Water quality is one of the most pressing problems, as water is a key natural component for the provision and existence of mankind and ecosystems in general. The deterioration of the environmental situation associated with the intensive production of hydrocarbons and the activities of other subsoil users led to the pollution of water resources. Therefore, there is a need for constant monitoring of the quality of used surface and underground water sources to purify them from harmful impurities using the most effective and readily available natural sorbents. One of the promising methods of water purification is sorption purification. The sorption method is promising, provided that the adsorbent used in the technological process of purification is capable of performing its functions as a water purifier for a long time. At the same time, the efficiency of sorption is due to the absence of secondary contamination, ease of implementation and maintenance, the ability to control the process, and the absence of the need for additional reagents. Also, sorption processes using natural mineral sorbents are being increasingly employed due to the possibility of their use in water purification processes for their low cost and, simultaneously, relatively high sorption capacity[1]. Natural adsorbents are environmentally friendly, affordable, and cheap raw materials. Increasing requirements for

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water quality make it urgent to search for new, more environmentally friendly, and economical methods of water purification. The works of Russian scientists are devoted to the purification of groundwater and wastewater using various sorbents. A method of obtaining a sorbent for the extraction of dichromate anions from an aqueous solution is proposed in study[2]. The method includes mixing a suspension of bentonite in a 20% sodium metasilicate solution for 2 hours, taken from the calculation of the mass ratio of SiO_2 which presents in the sodium metasilicate solution to bentonite, equal to 0.8:1, separating bentonite from the solution, washing it with water, treatment using 10% sulfuric acid solution and subsequent heat treatment at 200°C. The work[3] is dedicated to the technology of sorbents creation based on bentonite clays. During the water treatment process, the granules had their mineralogical composition studied by X-ray phase analysis, the analysis of the specific surface, porosity (pore volume, pore distribution along the radius) was carried out by the method of sorption and capillary condensation of gases, their chemical and mechanical resistance were determined. Physical and chemical properties analysis of the developed sorbents demonstrated that the sorbents meet the requirements of GOST and are efficient to be employed, both as an independent filtering material and as a component in water treatment systems. The author has researched[4] the wastewater treatment impact at the Pishchevik Research and Production Complex with a natural sorbent - flask and microorganisms immobilized on the EM-preparation «Baikal EM1». Calcining of dispersed silica –a flask that changes the adsorption properties of this sorbent was carried out. The efficiency of the initial flask purification and the flask-carrier of microorganisms was compared in the EM-preparation «Baikal EM1». Physical and chemical methods of wastewater treatment (determination of pH, ammonium ions, nitrogen-containing substances, fats) were studied. The work[5-11] has investigated the sorption of sulfate ions on natural sorbents, flasks, and magnesite. Isotherms are plotted and the quantitative characteristics of adsorption are determined. A comparative analysis of the adsorption dependence of sulfate ions on the type of sorbent has been carried out. No less interesting should be noted the work[6], where the process of adsorption of nickel (II) and copper (II) cations from solutions on natural flask material was studied. The sorption properties of the original investment ring and the thermally modified investment ring concerning Ni^{2+} and Cu^{2+} cations are compared. The quantitative characteristics of the adsorption process of the studied cations were obtained depending on the type of flask. It has been shown that the flask has an adsorption capacity concerning nickel (II) and copper (II) cations. Previously, in the study[7-12], together with our Tambov State University colleagues, we analyzed the possibilities of granular filter materials and ceramic filter production which would be based on flasks of deposits in Kazakhstan. The flask chemical compound has been determined. A fundamentally possible technology for obtaining a monodisperse sorbent based on flasks modified with carbon nanomaterials is studied, including the raw materials screening processes, mechanical activation in drum or planetary ball mills, two-stage weight dosing of components, mixing, and high-speed granulation. While analyzing the prospects for ceramic cartridge filter manufacture, it has been noted that the number of plasticities might be increased by mechanical activation or modification of flasks with carbon nanomaterials. Analysis of the literature review showed that the choice of sorbents is determined by a number of the following factors: the efficiency of purification, the removal of harmful substances to the required MPC standards, and the availability and cost of the sorbent, and the ability to regenerate. Thus, obtaining effective sorbents that meet the above requirements and allow, when used, to significantly reduce the anthropogenic load on the environment, is currently expedient and timely. The purpose of this work is the technology of groundwater treatment using a local natural sorbent – flask. The most indicative in this respect is a group of minerals with high adsorption activity such as zeolites, siliceous rocks (diatomites, flasks, tripoli), bentonites, etc.

EXPERIMENTAL

The objects of the research are a natural sorbent - flask and groundwater of well No. 48 of the educational and scientific complex of experimental industrial production of aquaculture (ESCEIPA) and the village of Dzhangala, West Kazakhstan region. Siliceous rock as known as the Taskalinsky deposit flask is a light, hard, microporous rock. By geological data, opokas occur in Paleogene and Cretaceous deposits and are formed in sea basins because of the compaction and cementation of diatomites and tripoli. Their density equals 1.3-1.5 g/cm^3. They may be described as white or gray, greenish light rocks with sparse remnants of

diatoms, radiolarians, and sponge spicules. Figure-1 shows the elemental composition and microstructure of the flask of the Taskalinsky deposit.
According to the results of X-ray phase analysis (XRD) (Fig.-2), it was found that the mineralogical composition of the flask is mainly represented by silicon (SiO_2) d/n=4,23; 3,34; 2,45; 2,28; 2,23; 2,28; 2,12; 1,81; 1,68; 1,62; 1,53 A0. In addition, the composition of the flask contains cristobalite d/n=4.09; 4.05 A 0 and glauconite d / n=4.5; 3.67; 2.58 A0.

RESULTS AND DISCUSSION

To carry out scientific and experimental work under laboratory conditions, a sorbent based on siliceous rock - the flask of the Taskalinskoy field, was preliminarily prepared according to the methodology and technology of Professor Montayev S.A.[8] The analysis of underground[12] and purified water was carried out in an accredited laboratory of the Research Institute of the West Kazakhstan Agrarian Technical University named after Zhangir Khan. The following indicators of water were investigated: permanganate oxidizability, sulfate ions, and dry residue.[9-10] The analysis results are shown in Table-1 and 2.

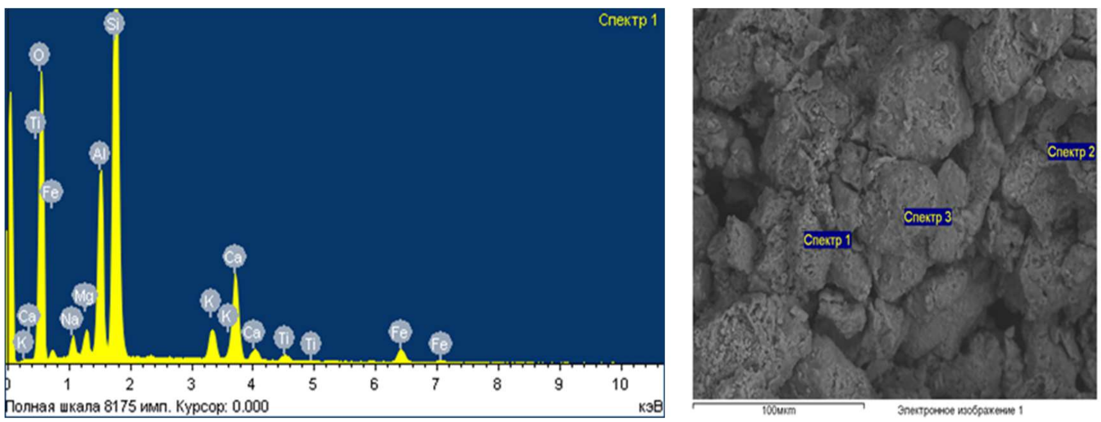

Fig.-1: (a.) Elemental Composition, Microstructure, and (b.) Spectrum of Siliceous Rock – Flasks of Taskalinsk Field

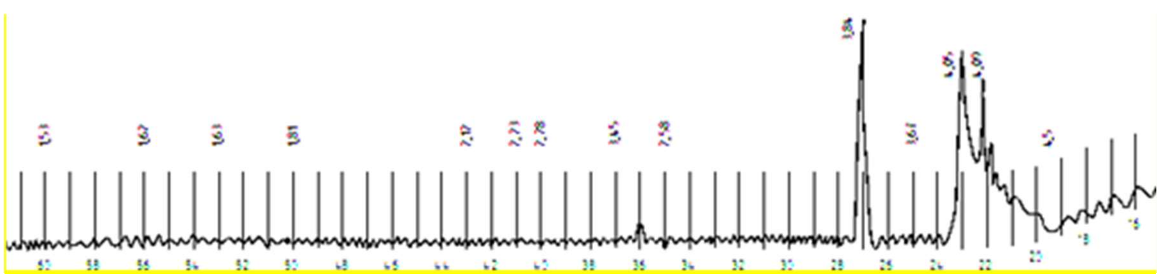

Fig.-2: X-ray Diffraction Pattern of Siliceous Rock - Flasks of the Taskalinsk Field

Table-1: Results of Water Analysis from Well No. 48 «ESCEIPA» LLP

Indicator name	Unit of Measurement	Content	Standard SanRaN 2.1.4.1074–01
Permanganate oxidizability	mg / l	5,44	<5,0
Sulfades		720	<500
Dry residue.		2448	<1000

As the obtained results show, both water samples for the studied indicators exceed the standard indicators SanRaN2.1.4.1074-01. For all three indicators (permanganate oxidizability, sulfates, dry residue), the excess is on average 1.8 and 2 times, which proves the objective need for their purification. Therefore, to achieve this goal, sorption purification of the studied samples of groundwater was carried out.

Cleaning Procedure

A sorbent with a mass of 0.5 g was placed in a flask and 50 ml of analyzed water was poured. The mixture was stirred for 1 h, then after 1 day, the sorbent was filtered. The results of the sorption purification of groundwater from wells No. 48 of «ESCEIPA» LLP and the village of Dzhangala using the original natural sorbent are given in Tables-3 and 4.

Table-2: Results of the Analysis of Groundwater in the Village of Dzhangala

Indicator name	Unit of measurement	Content	Standard SanRaN 2.1.4.1074–01
Permanganate oxidizability	mg / l	9,12	<5,0
Sulfates		955	<500
Dry residue.		1900	<1000

Table-3: Results of Analysis of Water from Well No. 48 LLP « ESCEIPA» with a Natural Sorbent

Indicator name	Unit of measurement	Content	Standard SanRaN 2.1.4.1074–01
Permanganate oxidizability	mg / l	5,3	<5,0
Sulfates		690	<500
Dry residue.		1800	<1000

Table-4: Results of the Analysis of Underground Water in the Village of Dzhangala with a Natural Sorbent

Indicator name	Unit of Measurement	Content	Standard SanRaN 2.1.4.1074–01
Permanganate oxidizability	mg / l	7,9	<5,0
Sulfates		900	<500
Dry residue.		1710	<1000

The results obtained for water purification based on a natural sorbent show that after purification based on a natural sorbent, there is a significant decrease in indicators of permanganate oxidizability, sulfates, and dry residue. However, they still do not meet the regulatory requirements. Therefore, the next stage of scientific and experimental work was to improve the sorption properties of the original natural sorbent. It is known that various activation methods (acidic, alkaline, combined, saline, thermal) are used to purposely change the sorption properties of natural materials in a targeted manner. In our case, to increase the sorption capacity of the studied sorbent, acid treatment was carried out and its sorption properties were investigated about the determined parameters of groundwater. To carry out acid activation, the studied sorbent and a solution of 20% HCl were placed in a beaker with a capacity of 500 ml until the sorbent was completely wetted and left for 2 hours. Then it was washed to acidic salts with distilled water. Next, the test water was added to the activated sorbent in a phase ratio of 1:2. The results of studies of groundwater samples using a modified sorbent are shown in Fig.-3 and 4.

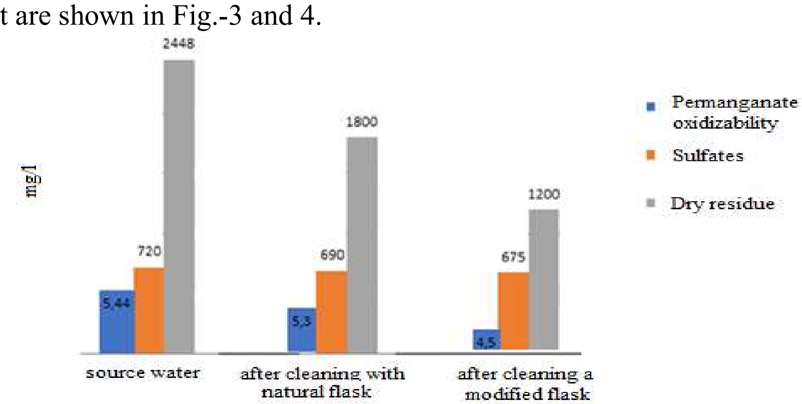

Fig.-3: Results of the Analysis of Underground Water from Well No. 48 of «ESCEIPA» LLP after Purification Using the Original and Modified Sorbent

According to the obtained analysis data, it can be seen that the modified sorbent provides better sorption of mineral salts in comparison with the results of the purification of the unmodified sorbent. The best cleaning performance with the modified sorbent was achieved concerning the dry residue.[13-14] This indicator decreased for well No. 48 from 2448 mg/l to 1320 mg/l and from 1900 mg/l to 1320 mg/l for underground water in the village of Dzhangala, i.e. the degree of purification is at least 50%. For the rest of the indicators, there were also downward changes. Thus, permanganate oxidizability for well No. 48 decreased to 4.5 mg/l, which meets the normative requirements, and for the water sample of the village of Dzhangala, it decreased to 6.8 mg / l and came as close as possible to the technical conditions.
It should be noted that with the help of the modified sorbent, it was possible to significantly reduce the sulfate content from 6.2% to 14.1%. The improvement in the sorption capacity of the modified sorbent is explained by the fact that with acid activation of the initial sorbent, the specific surface area decreases, but at the same time, an increase in the total pore volume and diameter is observed[15]. As a result, many macro- and micropores are formed in the structure of the sorbent, which in turn leads to an increase in the sorption capacity of the material.

Fig.-4: Results of the Analysis of Underground Water in the Village of Dzhangala after Purification Using the Original and Modified Sorbent

CONCLUSION

As a result of the chemical analysis of groundwater in Western Kazakhstan in the sections of well No. 48 of the educational and scientific complex of experimental industrial production of aquaculture (ESCEIPA) and the village of Dzhangala, it was found that they do not meet the regulatory requirements of SanRaN 2.1.4.1074-01 for manganate oxidizability, sulfates and dry content the remainder. For the purification of groundwater in these areas, sorbents were used, developed on the basis of the siliceous rock-opoka of the Taskalinsky deposit of the West Kazakhstan region. The best cleaning performance was achieved when using a modified sorbent by the acid activation method. It was revealed that with acid activation, the specific surface of the material decreases, but the number of micro-and mesopores increases, which leads to an improvement in the sorption capacity. It has been established that the use of a modified sorbent in the purification of groundwater makes it possible to bring the studied indicators as close as possible to the technical conditions. Thus, the modified sorbent based on a siliceous rock - flask can be recommended for use as an independent filtering material for the purification of underground waters from mineral salts, sulfates, and permanganate oxidizability.

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