STUDY OF SORPTION PROPERTIES OF NEW FILTER MATERIALS AS THE BASIS FOR DEVELOPMENT A COMPACT WATER PURIFICATION SYSTEM

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ИЗУЧЕНИЕ СОРБЦИОННЫХ СВОЙСТВ НОВЫХ ФИЛЬТРОВАЛЬНЫХ МАТЕРИАЛОВ, КАК ОСНОВЫ ДЛЯ СОЗДАНИЯ МОБИЛЬНОЙ ВОДООЧИСТНОЙ УСТАНОВКИ

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В работе исследованы сорбционные свойства новых модифицированных сорбентов в отношении ряда химических и микробиологических загрязнителей, в том числе ионов марганца, железа и бактерий E.coli. В качестве носителя использовалась водопроводная вода. Установлена высокая эффективность фильтровального модуля на основе сорбентов, позволяющего элиминировать основные поллютанты до уровней ПДК, даже после 1000 литров фильтрации тестового раствора. Для сравнения, бытовые автономные фильтровальные системы редко имеют ресурс более 200 литров. Полученные результаты создают основу для разработки новой установки, для очистки воды в походных и экстремальных условиях. Основной эффективной составляющей водоочистной системы станет новый разработанный наносорбционный фильтровальный материал на основе природных минералов.

Introduction Lack of clean drinking water is a widespread problem worldwide. Nearly 1 billion people worldwide do not have access to safe drinking water. This problem become more acute at various natural disasters: floods, earthquakes, etc. Therefore, the design of new effective sorbents and mobile water treatment device is an important task [1]. Nowadays, many of available filters can not effectively clean water from both chemical and microbiological contaminants.

Perspective water purification system will operate without electricity consumption and application of mechanical forces for water flow through the filter layer. Effectiveness of water treatment will be achieved through the use of the newest types of filter material, effectively clearing the water from chemical and microbiological contaminants. These sorbents is developed in on the basis of cheap mineral basis, but having good absorption properties. Surface modification greatly enhances the adsorption activity. Perspective water treatment plant on the basis of these sorbents will be able to purify water from heavy metals, pesticides, petroleum products, dyes, bacteria and viruses, etc. The aim of this work is to study the sorption activity of water purification module in relation to heavy metal ions and bacterium Escherichia Coli.

Materials and methods Filtering module, used for experiment, is a cylindrical shell, filled with several layers of different sorption filter materials. Filter module was replaced after passing every 1000 liters of water.

Performance of the filtering module was 8 l/h. Two different sorbents were used simultaneously in this module. First sorption material designed to purify water from a variety of chemical contaminants. Its operating principle is to combine mechanical filtration, chemisorption, ion exchange and involving van der Waals forces and electrokinetic adsorption. The result of all five types of forces, the sorbent provides a very efficient purification of water from various types of pollution, with high initial concentrations. The second filter material is very effective microbiological adsorbent. Its operating principle is based on electrokinetic adsorption. The material is a micro-porous base with surface immobilized nanoparticles of aluminum oxyhydroxide [2, 3]. Determination of sorption capacity was carried out under dynamic conditions by passing the solution through a filter module. Model solution was prepared from the state standard samples manganese Mn^{2+}, iron Fe^{3+} and chromium Cr^{6+} and tap water (allowed to stand for a day, before experiment).

Microbial suspension for testing was prepared on piped drinking water corresponding to GOST 51232. The concentration of the bacterial suspension (Escherichia Coli, strain ATCC 25922) - 10^4 CFU/ml, at water temperature - 23 (±2) ^{0}C. After filtration, inoculation was carried out in Petri dishes. Inoculated cups placed in an incubator for 24 hours at 37 ° C, then, counted the colonies and calculated bacterial titer according to [4].

Results Table 1 shows the sorption characteristics of the filtering module, by passing the test solution containing heavy metal ions with the following concentrations: C (Mn) = 0,5 mg/dm^3, C (Fe) = 3 mg/dm^3, C (Cr) = 0,5 mg/dm^3. The equilibrium concentrations of ions Mn^{2+}, Fe^{3+} and Cr^{6+} was determined by photocolorimetry.

Table 1. The degree of extraction Mn^{2+}, Fe^{3+} and Cr^{6+} from a model solution at different stage of filtration cycle (within -1-1000 l).

Volume (passed through module), liter	Mn^{2+}		Fe^{3+}		Cr^{6+}	
	Final concentration, mg/dm^3	Extraction degree,%	Final concentration, mg/dm^3	Extraction degree,%	Final concentration, mg/dm^3	Extraction degree,%
1	0,0015	99,7	0,0004	99,98	0,0044	99,12
200	0,0049	99,02	0,0007	99,97	0,0072	98,56
400	0,0088	98,24	0,0016	99,94	0,0091	98,18
600	0,0263	94,74	0,0059	98,8	0,0183	96,34
800	0,0515	87,7	0,0461	98,46	0,0341	93,18
1000	0,0827	83,46	0,1716	94,28	0,0426	91,48

As can be seen in Table 1, it was revealed a good sorption capacity of the module for all ions: Mn^{2+}, Fe^{3+} and Cr^{6+}. The final concentrations of all indicators do not exceed the MPC (maximum permissible concentration). It should be noted that extraction degree of iron Fe^{3+} ions was more than 94% even after whole filtration cycle of 1000 l. It is especially important for regions, where drinking water contains a high concentration of iron. It is a very common situation for plenty places, including Tomsk region, northern Siberia and many other. Prolonged a drinking of water with a high content of iron may cause liver disease, significantly increase the risk of heart attacks, and may also provoke allergic reactions.

In the next stage of work the efficiency of module for microbial contamination was determined. Bacteria E. coli is the main criterion for assessing the quality of drinking water and in determining the effectiveness of cleaning and disinfection of wastewater. Table 2 shows the data of water clearing, bacterized Escherichia Coli (strain ATCC 25922) with the initial concentration of microorganisms CFU/l - 4.0 * 10^7. The results are shown in different stages of filtering, taking into account changes of sorption capacity during the passage of a large quantity of test solution.

Table 2. Results of investigation of water samples before and after filtration of test solution containing Escherichia Coli strain.

Initial concentration of E. coli, CFU/l	Volume (passed through module), liter	Final concentration of E. coli, CFU/l
$4{,}0*10^7$	1	0
	200	0
	400	0
	600	0
	800	$2*10^3$
	1000	$4*10^3$

As seen from Table 2, first six hundred liters of filtered water revealed complete cleaning of the test solution. Next two hundred liter of water showed the presence of bacteria Escherichia Coli within the MPC (MPC in RF is not higher than 3 coliforms in 1 mL water). 30% exceed of MPC (Escherichia Coli strain) was detected in tested water only after thousand liter of filtration through module. That reason for necessity of further module modification and more wide microbiological research.

Conclusion In result of the research, comparative sorption characteristics of the filter module were obtained. It was shown a good sorption activity for heavy metal ions, throughout the life of the filter module (1000 liters). The values of the final concentrations for all elements do not exceed the MPC. Filtration of test solution, containing E. coli at initial concentration of 4*107 CFU/l, showed complete removal of microorganisms from test solution within the first 800 liters of filtering. Based on the investigated sorbents, it is possible to create very effective portable water purification system with good activity against a broad spectrum of chemical and microbiological contaminants.

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