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Purification of Drink Water from Iron Ions with Composition Sorbent.

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ABSTRACT

The work deals with formulation of composition sorbent based on montmorillonite clay, modified with pyrolyzates of sunflower seeds peelings, and also covers the question of the sorbent's sorption capacity in connection with iron ions Fe^{3+}.

Keywords: water purification, montmorillonite clay, modification, sunflower seeds peelings, pyrolysis, composition sorbent, iron ions.

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INTRODUCTION

Heavy-metal (in particular iron (III) ions) contamination of natural and drink water is an important ecological problem [1] nowadays, because elevated concentration of iron has a destruct effect on environment, organisms of animals and humans. Iron is a biogenic element necessary for human life and activities, a part of hemoglobin, a carrier of oxygen from lungs to tissues. Lack of iron in a human's organism is usually revealed in iron deficiency anemias. Excess of iron is very harmful for the organism, because in excess of homeostatic concentrations it can be toxic. Accumulation of excess amount of iron leads to abnormality of function of liver, pancreas and cardiovascular system, endocrine dysfunction. Iron often forms a constituent part of natural, underground and surface waters, because it is a part of different rocks formations and soils, with which they come in to contact. Besides, excess amount of iron in water leads to increased spending of washing agents. Content of iron in natural waters of Kursk, Belgorod, Rostov regions (Russian Federation), Kharkiv and Donetsk regions (Ukraine) exceeds maximum allowable one for 5 – 15 times. Therefore the problem of iron on water is one of the most urgent. The process of purification of water from iron ions comes to two main processes: firstly, oxidation of divalent soluble iron to trivalent one, and secondly, purification of water from trivalent iron via filtering through sorption active material [2].

Nowadays there is no all-purpose economically sound method of water purification, but sorption methods demonstrate very good results. Researches of scientists of the Department of general chemistry of Belgorod State National Research University (SRU "BelSU") stated the high performance of purification of water standardized test solution from iron ions (Fe^{+3}) with the help of sorption active materials based on sheet silicates of structure type 2:1 with an intumesce crystal lattice of montmorillonite group [3 – 5]. The problem of contamination of water resources with heavy metal ions, in particular iron ions (Fe^{+3}), is very serious for Russian Federation. The country's water basin contamination is of large scale now. According to some assessments, 75% of surface waters and 50% of all waters of Russian Federation are presently polluted. This caused serious health problems for many inhabitants of Russian cities and villages. Only 8% of waste waters can be returned into utility systems water cycle after purification.

Russian Federation has a lot of fields of montmorillonite clay, and also ecological, technical and economical problem of utilization of sunflower seeds peelings. Investigation of material composition and sorption characteristics, and also development of methods of montmorillonite clay modification allowed to obtain sorption active materials with improved sorption characteristics. Suggested physico-chemical basis of synthesis of composition material (based on montmorillonite clay and activated carbon) will allow to develop industrial technology of manufacturing of effective composition sorbent for water purification.

METHOD

For investigating sorption of iron cations with experimental sorbents and finding quantitative characteristics of sorption process we used the static method. Composition sorbents under development were preliminarily ground in electrically driven mechanical disperser, we used fraction with the size of a grain 10 – 50 µm. Following the dilution method we prepared standardized test solutions with different concentration of Fe^{3+} cations (initial concentration of iron ions in obtained solutions was 1.14 mg/l) out of ferric chloride solution. Batch with weight 1 g was carried off to constant weight via drying at a temperature of 105ºC, then we added standardized test solutions. The ratio sorbate : sorbent was 1 g of sorbent and 50 ml of solution. In the course of the research pH in solutions was not corrected, and no oxidizing agents were added, and so it was 8.82. Iron cations concentration was estimated before and after the sorption process via photometric method with spectrophotometer Specord – 50 according to procedure described in works [6 – 9]. For researching the process of sorption of iron ions Fe^{3+} via experimental sorbents we built sorption curves reflecting kinetics (figure 1), speed (figure 2) and sorption character (figure 3). Curves, similar to figures 1 and 3, are shown in the work [10].

MAIN PART

The article's authors obtained experimental sorbents based on montmorillonite clay (content of sorption active montmorillonite is 45 mass. %) from the field "Nelidovka" of Shebekinsky district of Belgorod region; the sample was named "Nel", and the sample of the specified clay modified with pyrolyzates of sunflower seeds peelings was named "NSHP – 1". One of the most important factors playing a significant role

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for estimating effectiveness of sorbents usage is kinetics of the sorption process. Kinetics of iron ions (Fe^{3+}) concentration changes is shown on figure 1.

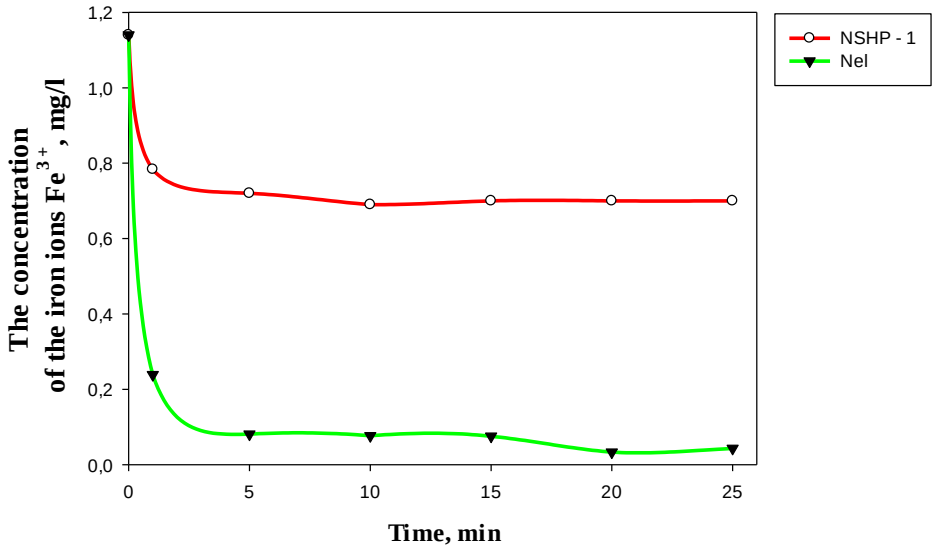

Figure 1: Kinetics of iron ions (Fe^{3+}) concentration changes in standardized test solutions.

In the course of kinetic curves analysis we found that: within the first 5 minutes of the experiment iron ions Fe^{3+} are intensively absorbed from the standardized test solution (iron ions concentration reduces from 1.14 mg/l to 0.75 mg/l in case of the sample NSHP-1 and from 1.14 mg/l to 0.16 mg/l in case of the sample Nel), which is connected with formation of the first adsorbed monolayer on the adsorbent surface. Then sorption equilibrium is achieved. Sorption speed (figure 2) is maximum within the first minutes of the sorption, which is caused by a high speed of adsorbed monolayer filling, then the sorption process becomes slower (difference between speeds of these two stages is substantial and equals to 0.153 mg/l*min (NSHP – 1) and 0.125 mg/l*min (Nel)). In the course of analysis of dependence of sorbed iron ions (Fe^{3+}) weight on sorption duration (figure 3) the same principle was stated, as within the first 5 minutes of the sorption iron ions (Fe^{3+}) are intensively sorbed on the adsorbent surface. Weight of sorbed ions Fe^{3+} increases from 0 mg/g of sorbent to 1.06 mg/g of sorbent NSHP – 1 and from 0 mg/g of sorbent to 0.12 mg/g of sorbent Nel, then adsorption equilibrium is achieved (1.06 mg/g of sorbent NSHP – 1 and 0.13 mg/g of sorbent Nel).

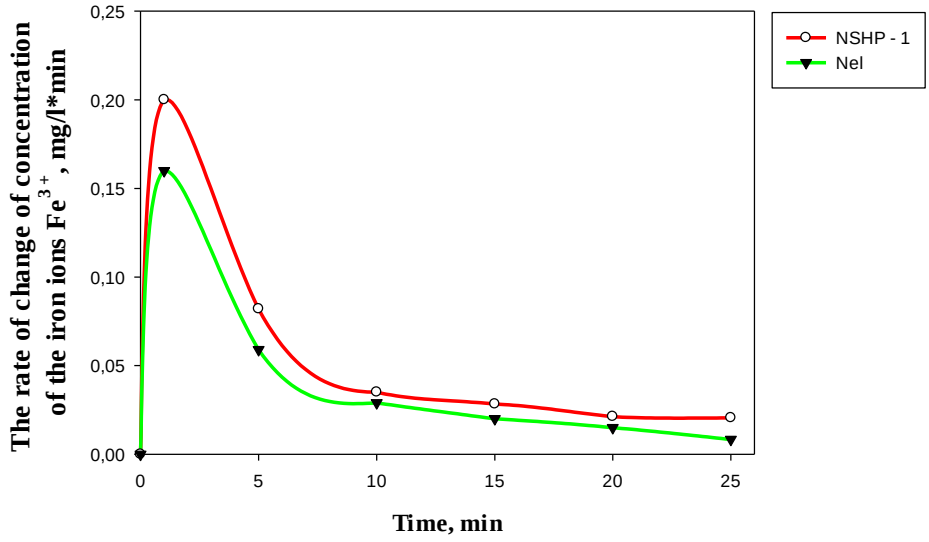

Figure 2: Speed of sorption of iron ions (Fe^{3+}) with experimental sorbents.

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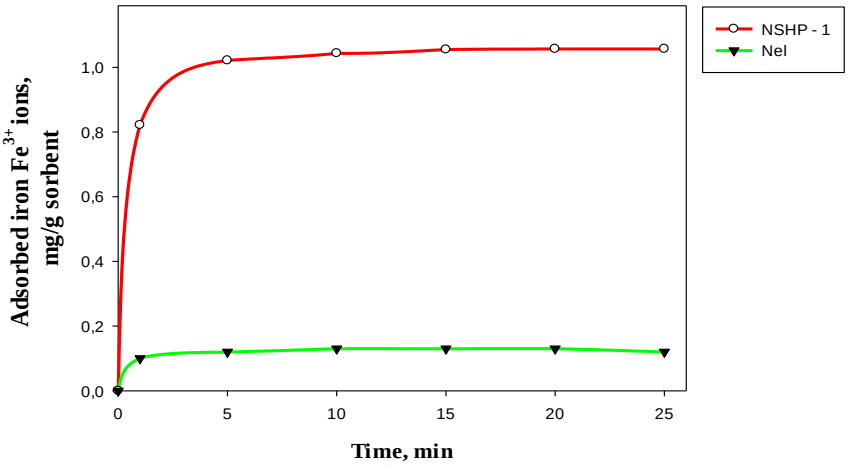

Figure 3: Dependence of sorbed iron ions (Fe^{3+}) weight on type of sorbent and sorption duration.

In the course of analysis of the specified relations of sorption processes (figures 1 – 3) in standardized test solutions it was stated that sorption curves character is comparable for all samples, but one can notice that the suggested modification (NSHP – 1) allows to increase sorption of iron ions Fe^{3+} from standardized test solutions 7 times, as compared to initial montmorillonite clay (Nel). Sorption speed of all investigated samples is maximum within the first minutes of sorbate-sorbent interaction, then sorption process speed slows down (figure 2). Adsorbed iron ions Fe^{3+} weight increased 7 times as compared to initial montmorillonite clay (Nel).

CONCLUSION

We found that sunflower seeds peelings have potential for using them to obtain iron ions Fe^{3+} sorbents from water solutions. We developed a method of modifying montmorillonite clay with pyrolyzates of agro-industry plant by-products, and also defined sorption characteristics of obtained samples in the context of iron ions Fe^{3+}. The suggested modification allowed to increase sorption characteristics of montmorillonite clay (Nel) in the context of iron ions Fe^{3+} 7 times.

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