Study of the dependence of component composition - degree of wastewater purification by adsorbents based on plant raw materials to control the content of priority pollutants in water bodies

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Abstract. In conditions of intensive development of industrial and agricultural production, measures aimed at protecting the hydrosphere from harmful substances are becoming increasingly important every year. Water purification using the sorption method and water treatment is one of the most common technological processes. Almost unlimited reserves of sorbents of natural origin, their low cost, and fairly high adsorption and ion-exchange properties make their use advisable. Sorbents developed on the basis of available secondary plant raw materials show high efficiency and open up the possibility of their practical use in solving environmental problems. New sorbents based on plant raw materials have been developed, their structure and morphology have been studied in order to identify the absorption capacity and effectiveness of use as oil sorbents. Studies of the kinetics and dynamics sorption of oil pollutants confirm the effectiveness of mentioned sorbents and sorption purification technology can be used for environmental monitoring of water bodies.

1 Introduction

Oil and petroleum products (PP) are the main source of technogenic pollution of water bodies, several times exceeding the maximum permissible concentrations. To remove bound finely dispersed oil contaminants from aqueous solutions, their sorption extraction is especially relevant.

Activated carbons, which have a high sorption capacity, are expensive; instead, it is promising to use sorbents based on agricultural waste.

Today, in conditions of intensive development of industrial and agricultural production, measures aimed at protecting the hydrosphere from harmful substances are becoming increasingly important every year. Water purification using the sorption method and water

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treatment is becoming one of the most common technological processes. In recent years, sorbents of natural origin have attracted increasing attention. Almost unlimited reserves of these materials, their low cost, and fairly high adsorption and ion-exchange properties make their use advisable [1].

Sorbents developed on the basis of available secondary plant raw materials show high efficiency and open up the possibility of their practical use in solving environmental problems. The research carried out allows us to propose an original scheme for wastewater treatment with the sequential use of sorption at the post-treatment stage and increase the purification effect to 92% [2].

2 Methods and techniques

Methods for determining petroleum products in water, based on gravimetry, fluorimetry and IR spectroscopy, make it possible to obtain information about the total content of hydrocarbons of petroleum origin in water. Individual hydrocarbons were identified using gas chromatography.

The hydrocarbon composition of a mixture of petroleum products allows one to determine the source of pollution with a specific type of fuel or a mixture of various petroleum products (gasoline and fuel oil, kerosene and lubricating oils, diesel fuel, etc.) [3].

Analysis of the degree of purification of the test water from petroleum products was carried out photometrically on a Jenway 6705 digital spectrophotometer. The test water was quantitatively transferred into a separating funnel, making a volume mark. The container containing the test water is rinsed with hexane (10-20 ml) at an aqueous/organic phase ratio of. equal to 5: 1, hexane is quantitatively transferred into a separating funnel with the test liquid. The liquid is actively mixed in the separating funnel for 30 seconds and left until the layers separate. The lower aqueous layer is drained, the transparent upper oil-containing layer is transferred to a cuvette and the optical density is measured on a Jenway 6705 digital spectrophotometer using a light filter (X = 540 nm). In case of severe contamination, the solution must be diluted and repeated measurements must be taken. The calculation was performed taking into account the dilution factor.

3 Results and discussion

The main indicator of the effectiveness of a sorbent is its sorption capacity, which depends on the specific surface area. The work studied the sorption properties of plant materials: sorption capacity (oil capacity) under static and dynamic conditions, the degree of extraction of oil and oil products from contaminated wastewater (model solutions).

New sorbents based on plant raw materials have been developed, their structure and morphology have been studied in order to identify the absorption capacity and effectiveness of use as oil sorbents. Sawdust absorbs oil and oil products well and quickly, but absorbs moisture even better, so it is necessary to impregnate the sawdust after deep drying with water-repellent compounds, which ensures good quality oil sorbents. The oil-absorbing and water-absorbing capacity of plant sorbents is shown in Figure 1 [4].

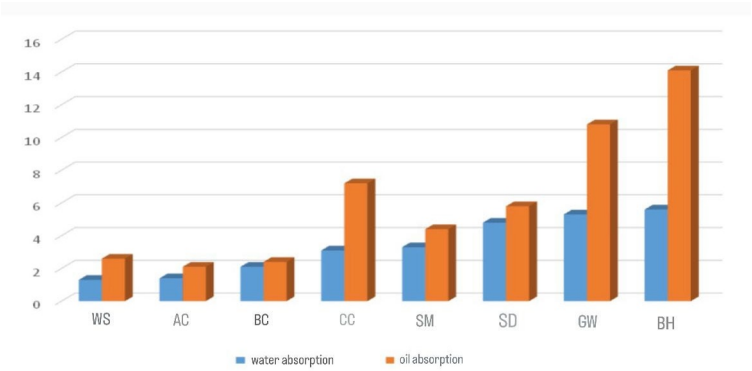


Fig. 1. Diagram comparing water absorption and oil absorption of sorbents from recycled plant materials
(WS – walnut shell; AC– activated carbon; BC – birch charcoal; CC – corn cobs; SM – sunflower millcake; SD – sawdust; GW – grain waste, wheat; BH - buckwheat husk)

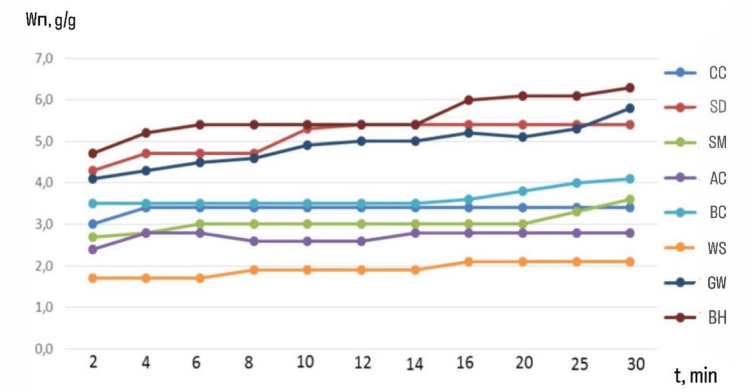


Fig. 2. Dependence of sorption capacity on time

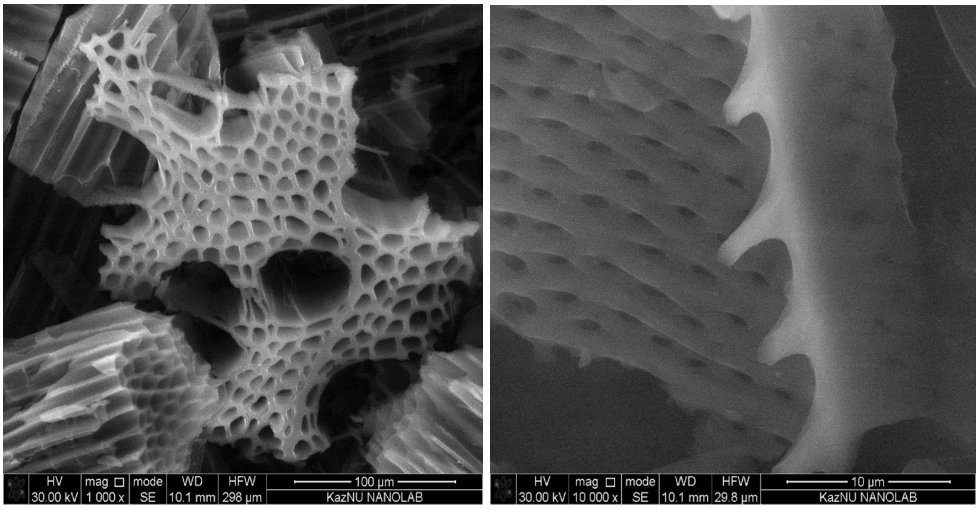
The study of oil absorption of plant sorbents showed that the following sorbents have the greatest oil absorption - corn cobs, grain waste, buckwheat husks from 7.2 to 14.1 g/year, the lowest oil absorption is birch and activated carbon. Walnut shells, birch charcoal and activated carbon have the lowest water absorption capacity (from 1.3 to 2.1 g / g).

most intensively during the first 30 minutes as a result of the rapid occurrence of the adsorption process. They wet the surface of the adsorbent and then more slowly penetrate the porous structure, filling all existing voids under the action of capillary forces [4].

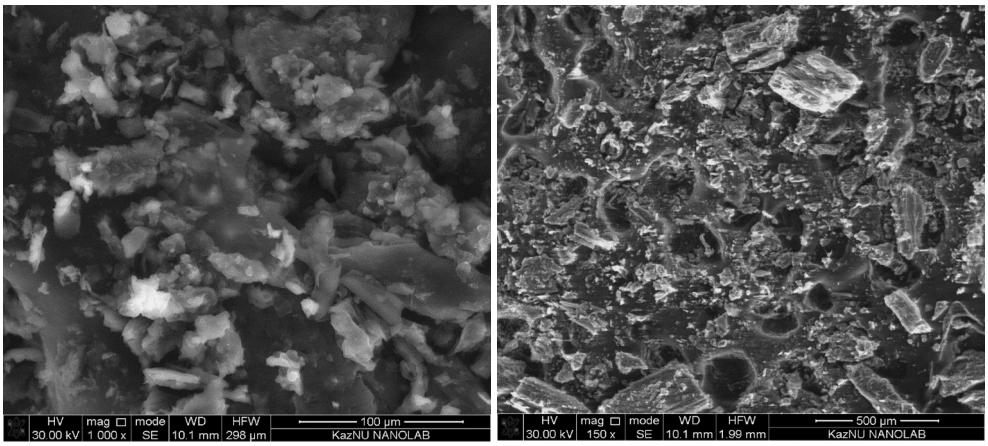
Since the sorbents under study are volumetric porous materials, they are characterized by the presence of a volumetric structure, and their porosity is due to the presence of voids (Figure 3) .

The figure shows pores and bulges on the surface of sorbent particles that are formed as a result of heat treatment. This is explained by the fact that an increase in temperature causes thermal decomposition of the organic substances of the sorbents and, consequently, the number of pores and bulges increases. The cell walls around the pores are fragmented, some are ordered, covered with a reticulate pattern.

Research has been carried out to establish at or more optimal temperatures for the formation of the porous structure of sorbents and increasing their sorption capacity.



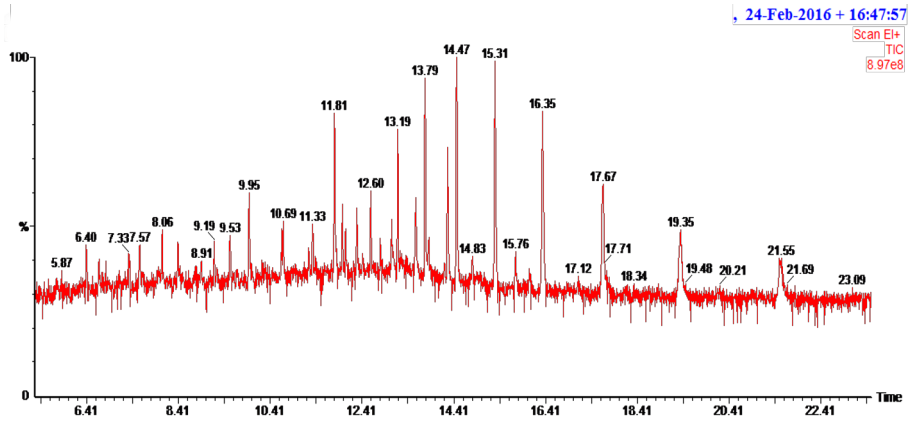
a) birch charcoal



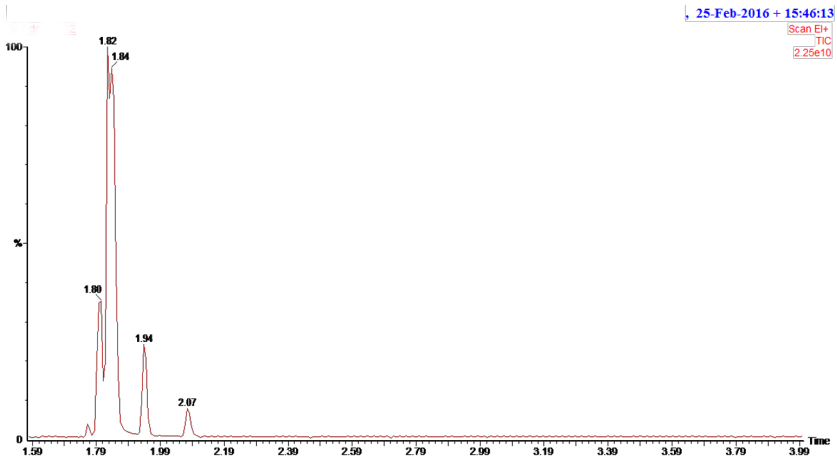
b) sunflower millcake

Fig. 3. Internal structure of sorbents based on plant waste

Gas chromatographic (GC) and gas chromatography-mass spectroscopic (GC-MS) methods make it possible to determine a number of individual compounds in an oil sample. In the case of relatively light fractions of oil and oil (up to approximately C-12), these methods can almost completely determine the individual composition of mixtures. In the case of heavier distillates, individual chromatographic peaks correspond mainly to n- alkanes and some isoalkanes . The remaining petroleum hydrocarbons are eluted in the form of a diffuse peak formed by the sum of unresolved organic compounds [5, 6].



a)



b)

Fig. 4. Chromatograms of model solutions a) before and b) after purification of oil-contaminated water with sorbents based on corn cobs

Methods for determining PP in water make it possible to obtain information about the total content of non-polar and polar hydrocarbons of petroleum origin and to identify individual hydrocarbons [5-7]. An analysis of the purified water was carried out based on identification by GC using chromatographic spectra before and after purification.

4 Conclusions

1. Studies of the kinetics and dynamics of sorption of priority oil pollutants from wastewater confirm the effectiveness of sorbents based on plant raw materials and sorption purification technology can be used for environmental monitoring of water bodies.
2. Sorbents based on corn cobs, grain waste, buckwheat husks, and the smallest - sorbents based on birch and activated carbons. Walnut shells, birch charcoal, and activated carbon have the lowest water absorption capacity (from 1.3 to 2.1 g/g).
3. Sorption technology for treating wastewater from oil industry enterprises using sorbents based on recycled plant materials provides high quality purification, is easy to operate, does not require large costs, and ensures maximum recycling water supply.

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