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Management of ecological safety by obtaining a sorbent from waste and using it for wastewater treatment

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Abstract. The methodology for ensuring ecological safety has been approved: follow-up of biogeochemical processes, modification of adsorbents from peat, purification of waste water from petroleum products and ions of important metals by them, distillation of the adsorbent for the purification of bottling of petroleum products on nature them waterways. The modification of adsorbent from peat was eliminated by drying methods and acid activation with sulfate acid. Installed physical and chemical parameters of the adsorbent. The deposition of adsorption capacity of adsorbents in pH was determined. The use of modified peat adsorbents allows you to change the peat in the Poltava region, to establish a potential problem for the necessary environment, and also to increase the level of ecological safety by way of minimizing the pollution of sewage waters in fluorine products and important metal ions.

Key words: methodology of ecological safety, peat adsorbent, purification, sewage water.

Introduction

Every year in Ukraine millions of cubic meters of waste water, which are contaminated with petroleum products are formed. Therefore, it is relevant to find new methods, materials and technologies for water treatment, which will minimize revenues to the oil hydrosphere and its processing products. Wastewater treatment with an adsorption method is effective, widely available and economically beneficial. The adsorption method allows to remove a wide range of man-made and natural pollutants. After purification, the adsorbent is not regenerated, but exposed, for example, burial or burning along with the pollutant. This method is suitable for adsorbents. The latter must have high oil intensity, floating, low water absorption and a high porous surface. The main requirement for materials that adsorb carbohydrate oil is the presence of a highly developed porous structure with a hydrophobic surface (Bezdeneznych et al., 2020). On the Poltava region there are deposits of peat with a total area of 3.2 hectares (Titova, 2023).

Perspective adsorption materials, in addition to high adsorption properties, must be met other requirements: easy to use and utilize, be non-toxic, cheap ones available (Shmandiy et al., 2010). Such requirements satisfy adsorbents obtained by modifying natural materials in order to improve their adsorption properties. One of the most promising natural materials for the creation of oil administrators is a peat, which is widely used in unmodified form to clean various liquid environments (Shmandiy et al., 2020).

The adsorption material based on peat is traditionally obtained in recuperative furnaces by heat treatment, in which the change in the structure of the peat as a result of the thermal destruction of organic substances, contained in it. Carbon high-porous adsorbent is formed However, this method of processing peat is associated with significant energy consumption and a long time of obtaining process, as well as significant temperature gradients (400°C) there is a high probability of peat fire.

An alternative way to modify peat is to carry out thermal destruction with a path on a new microfluidic (UHF) vitreous treatment without access to sour, which allows you to take a similar high-porosity hydrophobic material, energetically more efficiently.

Scientific novelty consists in the scientific substantiation of the process of obtaining adsorbents from peat, ensuring effective treatment of sewage from petroleum products and heavy metal ions.

The aim of the work is to create a methodological framework for ensuring ecological safety by studying the processes of acid modification of peat adsorbents, their treatment of wastewater from oil products and heavy metal ions, in comparison with activated carbon and an adsorbent from plant waste, namely sunflower husk.

Materials and methods

We used moss peat with a particle size of less than 5.0 mm, hanging in front to a moisture content of 20-25%. The division of peat into fractions and the determination of the fractional warehouse of peat were carried out by the sieve method (Khoroshavin et al., 2013).

The main physical and chemical indicators of peat were assigned to standard methods (Alferov, 2007).

To clean the surface of the water from the motor oil, we used 2 dm^3 of water, 100 cm^3 of Mobil Ultra brand motor oil, 300 g of peat.

Modification was carried out by acidic treatment of peat with boiling water with 10% sulfuric acid. An alternative method of modifying peat is a thermo-depletion by influencing it with microwave radiation without oxygen access, which allows to receive similar highly porous hydrophobic material, energy more efficiently.

Results

Peat is primarily a natural ion exchanger (Lishtvan et al., 1975). The practical use of peat is due to its ecological safety, availability and cheapness. The main physico-chemical indicators of peat are: humidity, acidity, ash content, heat combustion, degree of decomposition, moisture content, porosity, structure, thermal conductivity, volumetric mass, chemical composition (Lishtvan, 1999). The use of peat as an adsorbent is determined primarily by its microstructure and dispersion, porosity, a sufficiently significant proportion of the surface (Kislov, 2011).

The dried peat is represented as an adsorbent for the absorption of petroleum products, oils, fuel oil and other liquid nonpolar pollutants of hydrocarbon nature (Kislov, 2011).

The dried peat has the following properties:

- not toxic, it is exclusively natural material,
- there are powders of dark brown color of various dispersion: particle size 10 - 2000 μm, bulk density to 0.4 - 0.45 g / cm^3;
- sterile, does not contain pathogenic microorganisms, explosion-proof;
– does not cause a violation of an ecological equilibrium in ecosystems, does not negatively affect biotypes of various trophic levels, does not lead to mutagenesis on the gene level in the objects of the biosphere;
- it is allowed by sanitary organs for use as a natural substance that does not require hygienic normalization;

The basis of our research is the methodology of ensuring ecological safety, which consists in the use of peat as an adsorbent to reduce the concentration of harmful substances in wastewater.

After adding peat adsorbent (dry peat) to the model wastewater, the efficiency of absorption of petroleum products at a pH of 2-9 was investigated. The results of the effectiveness of the adsorption of petroleum adsorbent are shown in Fig. 1.

In the study of sewage treatment with a peat dried adsorbent, it has been found that the degree of absorption depends on the pH and the contact of sewage with an adsorbent. The largest adsorption efficiency is observed at pH = 5. In addition, the decrease and increase of pH leads to a decrease in the degree of absorption of petroleum products.

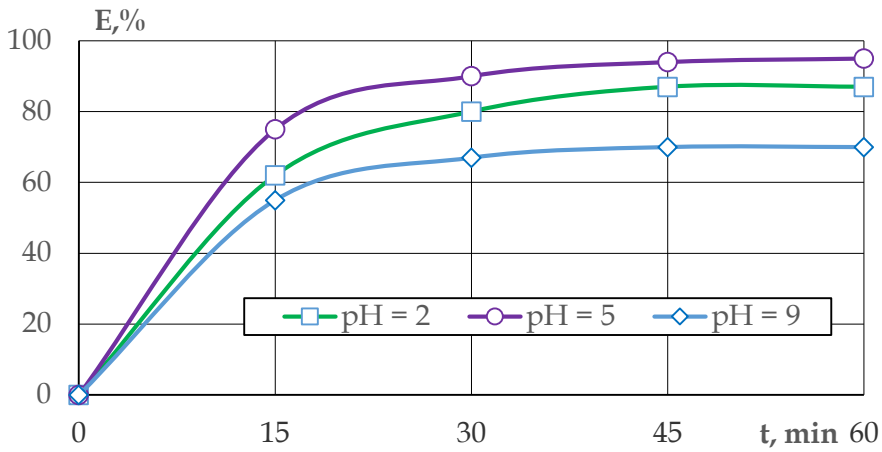

Fig. 1. Adsorption efficiency (E) of petroleum products by adsorbents from the contact time of phases and pH

Regarding the treatment of waste water from petroleum products, the adsorbent was compared with activated charcoal and plant adsorbent at pH=5. The results of adsorption of petroleum products are shown in Fig. 2. It has been established that a peat adsorbent has sufficiently similar values of the efficiency of sewage treatment from petroleum products in comparison with activated charcoal and plant adsorbent.

To test the efficiency of the drying route modified by the peat, the peat was additionally cleaned with water from the engine oil. Drying peat to rob the adsorbent as hydrophobically as possible, so there is more peat on the surface. After the collection of the adsorbent and filtering, the excess of engine oil was lower than the permissible norms.

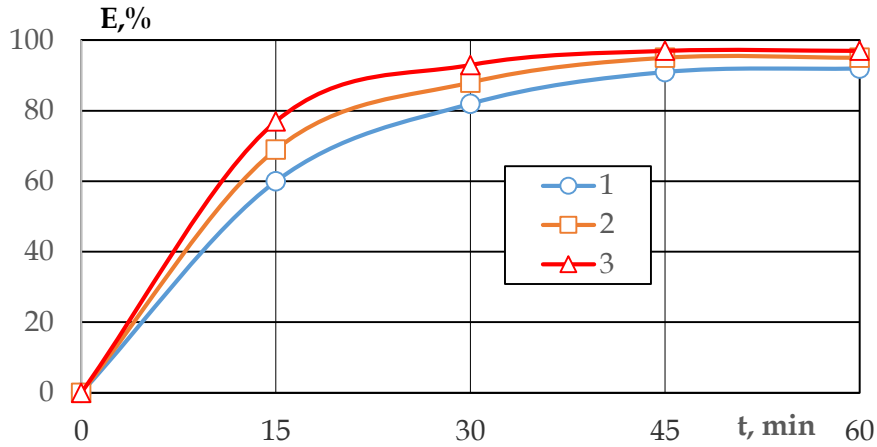

Fig. 2. Effect of adsorption of petroleum products from the time of contact phases at pH = 5 (1 – peat adsorbent, 2 – activated carbon, 3 – vegetable adsorbent).

An assessment of the level of ecological danger was carried out in order to ensure sustainable development of the modern city in the following positions:

- management (transformation of the states of the object in the desired direction);
- forecast of the situation;
- development of general scientific representations;
- determination of the suitability of territorial formations for the residence of people and the existence of certain types of living organisms, the implementation of one or another type of economic activity.

In assessing the level of ecological danger, the following features were taken into account:

- dynamism of assessment - the situation not only at the moment, but also the tendency of its change, that is, the preliminary and predictable situation;
- processes and phenomena that define man-made danger can be constant in time, periodic, episodic, one-time;
- the corresponding system response is not a mirror reflection of influence, since the system has the properties of elasticity, inertia, which are detected in the time delay of the reaction to influence;
- imposing actions of various factors;
- a manifestation of danger may be a consequence of processes that took place before.

As characteristics that define each type of man-made danger, those indicators of the state of the environment, which are changed as a result of man-made exposure were used. These include concentrations of harmful substances, levels of physical and biological influences, indicators of transformation of landscapes. The latest indicators are used to analyze the degree of security of the Kremenchug socio-economic zone by the territories where it is stored in a small form of a residence medium characteristic of it species of flora and fauna. Such territories we consider objects of the natural reserve fund (NRF).

Some scientists (including hygienists) believe that the content of harmful substances at a concentration below the MPC corresponds to the norm, that is harmless. We adhere to another opinion: it is necessary to assess the dangers of any concentrations or levels of influence on a person and the environment (Shmandiy et al., 2015; Shmandiy et al., 2018). The chemical factor defining the level of technologic component of environmental danger has the following form:

$$A_{ij} = \frac{C_1}{MPC_1}$$

where: C_1 – real concentration of petroleum products in sewage; MPC_1 – a maximum permissible concentration of petroleum products in water.

The concentration of petroleum products in model sewage is 5 mg/dm^3. We have $A_{ij} = 17$. The concentration of petroleum products in model sewage after purification (95%) is: $C_2 = 0.25$. The level of technological danger of petroleum products in model sewage after purification $A_{ij} = 0.83$.

The promising direction of modification of peat is oxidative destruction, that is, the decomposition of complex molecules of substances that form peat, more simple under the influence of various oxidizers (oxygen of air, nitrate and sulfuric acids, potassium permanganate and others). The activity of peat used for sewage treatment can be increased when treated with acids. In this case, the adsorption capacity increases.

In this case, not only a significant part of mineral substances, but also easily hydrolysis compounds are removed from the composition of the peat. On the output we have a product consisting mainly of free humic acids and lignin.

Physical and chemical parameters of peat activated by sulfuric acid are determined (Table 1).

Table 1. Physico-chemical parameters of adsorbent

Adsorbent parameters	**Adsorbent**
Storage	**Peat**
Organic substances,% by weight	not less than 85
Ash content,% to organic substances	13 – 14
Humidity,% by weight	2
Bulk density, g/cm^3	0.44
Buoyancy, day	not less than 24
Color	dark brown
Acidity, pH	5 – 6
Granulometric warehouse, mm	1 – 0.5
Degree of decomposition, %	15

The most common pollution of surface water is caused by petroleum products (Zelenko et al., 2019), biological pollution (Nykyforov et al., 2016), ammonium ions (Malovanyy et al., 2019; Sakalova et al., 2019) and heavy metals (Kostenko et al., 2017).

The absorption of heavy metals ions by a peat adsorbent depends on the time of contact of the adsorbent with a model sewage containing Zn^{2+} and Fe^{2+} ions. The results of further adsorption are shown in Fig. 3. It has been brought to light that at pH = 9, the efficiency of purification decreases. The change in the pH value within 5 - 9 affects the adsorption capacity of the peat adsorbent. With a decrease in pH, the efficiency of purification increases.

The results of the study of the effectiveness of adsorption of petroleum products and heavy metal ions into adsorbents are presented in the diagram (Fig. 4). Based on the data received, we state that the type of adsorbent significantly affects the magnitude of the absorption of petroleum products and heavy metal ions.

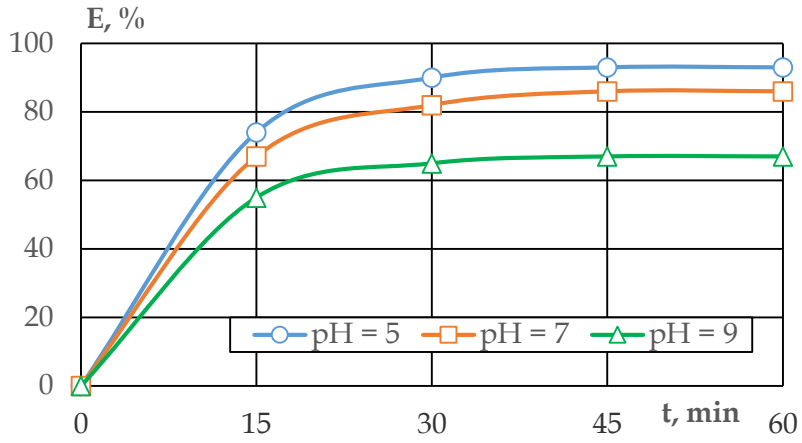

Fig. 3. Effect adsorption of heavy metals ions with oxide peat depending on the time of contact of phases at different pH.

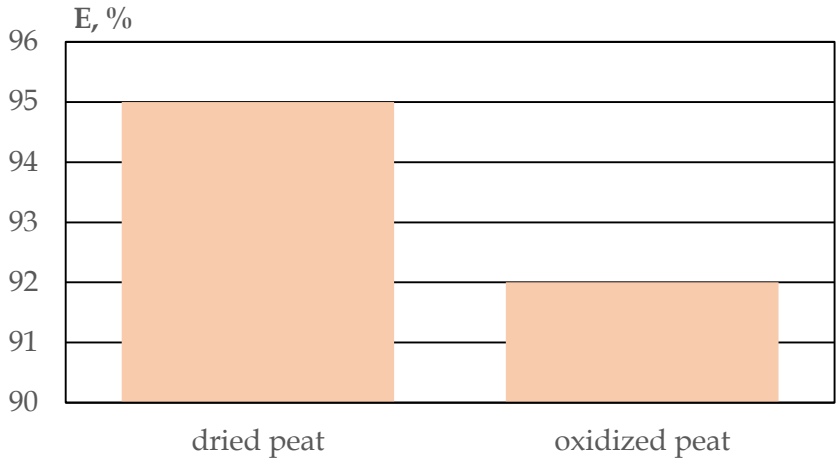

Fig. 4. Effect adsorption of petroleum products and heavy metals ions from the type of adsorbent

Discussion

The modification of adsorbent from peat was removed by drying methods and acid activation. Sufficiently high adsorption capacity of peat is due to the developed surface and porosity. Specific on the surface of peat stores 350 - 800 m^2/g, adsorption power in a significant world to lie in the structure, size of pores, distribution of them by size. The structure of peat significantly affects the rate of adsorption. Macropores and transition pores usually play the role of transport channels, and the adsorption capacity is mainly determined by the micro porous structure of peat (Kislov, 2011).

Drying peat does not have a negative influx on the present medium, shards of naphtha and others in carbohydrates, clayed with adsorbents, are completely mitigated by them, which allows you to safely dispose of the adsorbent, and cleaning the objects of the outer medium from oil products it is a natural route and an ecologically safe final process; may have water powers, do not get wet with water and do not disperse by the water. On the surface of the water, it is spread, and when oil is blocked, it plays the role of a bar, which surrounds the zones of brooding and irreversibly absorbing oil, making the oil widen as wide as it is deeper; buoyancy not less than 24 day guarantees the selection of the adsorbent with the use of physical methods; simplicity and rich variability of methods of utilization of the processed adsorbent with the use of natural low-ash raw material.

In case of acid modification with sulfuric acid in the warehouse of peat, not only a significant part of mineral rehavins is seen, but also lightly hydrolyzing soil, a product appears, which is mainly composed of humic acids and lignin. The bonding of ions with peat is due to the surface and ion-exchange powers of the adsorbent.

In our opinion, it would be promising to use magnetically sensitive adsorbents, which, after the adsorption process and wastewater treatment from contaminants, could be easily separated from the treated medium by magnetic separation (Ptashnyk, 2020; Soloviy, 2020).

The technologies of remediation and restoration of disturbed soils are also a promising area for the use of sorbents and natural minerals (Tymchuk, 2021).

We consider it appropriate to apply the following methods of utilization of desiccated peat adsorbents:

- incineration to generate heat energy at existing power plants without their conversion;
- use as a plasticizing component in the production of road surfaces;
- use as a component for the production of impervious surfaces;
- disposal at a landfill;
- recycling at household waste disposal facilities (with preliminary extraction of oil products) and subsequent incineration or application of the adsorbent to the soil.

In general, all methods of utilization of spent adsorbent are environmentally friendly and do not require significant costs.

Conclusions

1. A methodology for ensuring the ecological safety of environmental elements using peat is proposed.
2. Modified peat adsorbents were obtained by drying and acid activation. Their physical and chemical parameters were determined.
3. The dependence of the adsorption capacity of adsorbents on pH was determined.
4. The expediency of using the dried adsorbent for the elimination of oil spills in natural reservoirs and the absorption of heavy metal ions has been experimentally proved.

The practical use of peat is due to its availability and cheapness, which allows to reduce the volume of peat deposits in Poltava region, which pose a potential danger to the environment.

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