ABSTRACT AND REFERENCES

ECOLOGY

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**DEVELOPMENT OF EFFECTIVE TECHNIQUE FOR THE DISPOSAL OF THE PRUNUS ARMENIACA SEED SHELLS (p. 4-9)**

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We proposed a new technique for the disposal of solid plant waste in the food industry, specifically solid shell of Prunus armeniaca seeds, by oxidative treatment with a hydrogen peroxide solution in an acetic acid medium, which makes it possible to obtain effective sorbent materials. We investigated the effect of oxidant concentration and time of the process on structural and sorption properties of plant sorbents. The experimental-statistical models of the process were obtained by employing a method of mathematical planning based on the mathematical processing of acquired experimental data. The optimal conditions for conducting the process using the generalized Harrington desirability function were determined. It was established that the optimal parameters that make it possible to obtain effective sorbents with the yield, the content of cellulose, lignin, and the efficiency of extracting methylene-blue from an aqueous solution of 50.3 %, 58.2 %, 12.7 % and 91.4 %, respectively, are the concentration of peroxide hydrogen of 9 % and a process time of 120 min. The application of the proposed technology enables efficient disposal of solid plant wastes, and obtaining the sorbents with high sorption characteristics. Such materials could be used in environmental science to solve the problems related to the contamination of water bodies by organic compounds, as well as enterosorbents in medicine and veterinary medicine.

**Keywords**: shell of Prunus armeniaca seeds, oxidative treatment, sorbent, full factorial experiment, optimization.

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**MATHEMATICAL MODEL OF THE REVERSE WATER POSTPURIFICATION AT MINING ENTERPRISES WHEN USING ELECTROMAGNETIC FOCUSING OF CONTAMINANTS (p. 10-16)**

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This study addresses the post-purification of reverse water by the electromagnetic focusing of charged particles in contaminants of polychlorinated biphenyls at mining enterprises. We established functional dependences of the Larmor radius of focusing of contaminant ions on operating parameters of the electromagnetic post-purification system (current strength of the focusing coil, length of the focusing coil), which allowed us to justify the required current of 0.025 A in the focusing coil for the post-purification of a liquid from polychlorinated biphenyls. The developed model of the electromagnetic system for water post-purification from the ions in contaminants made it possible to select the required Larmor radius for focusing the polychlorinated biphenyls in order to remove them effectively from a flow of liquid. As a result of post-purification, the contaminants are focused along the axis of the main flow that enables their removal through an additional branch pipe. Under the effect of the orbital moment that occurs due to magnetic induction, the motion vector of contaminants changed, and they are focused in the center of the fluid flow. We established the logarithmic dependence of height of the focusing paraboloid, which decreases from 0.057 m to 0.032 m with an increase in current of the focusing coil from 0.01 A to 0.1 A. This is due to an increase in the kinetic energy, transmitted by the charged particles, and an increase in the centripetal force. Determining the height of the focusing paraboloid makes it possible to effectively place the equipment for the removal of contaminations from the flow, and purify it.

**Keywords**: electromagnetic post-purification of liquid, Larmor radius, charged particles, focusing of contaminant impurities.

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**RESEARCH INTO EMISSIONS OF NITROGEN OXIDES WHEN CONVERTING THE DIESEL ENGINES TO ALTERNATIVE FUELS (p. 16-22)**


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We conducted theoretical and experimental research into emissions of nitrogen oxides in exhaust gases of the diesel engines, re-equipped for gas.

The research is important because the emissions of nitrogen oxides in the exhaust gases are one of the biggest environmental problems at the present stage of development of designs for internal combustion engines. Therefore, reducing the emissions of nitrogen oxides in diesel engines by re-equipping them to gas fuel is an important task for specialists in design and operation of internal combustion engines.

The result of theoretical research is the mathematical model that we constructed in order to calculate emissions of nitrogen oxides in the exhaust gases of diesel engines and the engines, converted to gas fuel. Based on experimental research, we have established dependences of emissions of nitrogen oxides in exhaust gases of the diesel engines, re-equipped for gas, on loading and the crankshaft rotation frequency. Studies have shown that diesel engines, which are converted to alternative gas fuel, reduce emissions of nitrogen oxides in the exhaust gases in a range from 13.9 % to 47.1 % depending on engine rotation and load. The results obtained make it possible to reduce the emissions of harmful substances in exhaust gases of automobile engines and optimize design of the systems for exhaust gases recirculation.


**Keywords**: alternative fuels, diesel engine, nitrogen oxides, engine re-equipped for gas fuel.

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**TWOSTAGE TREATMENT OF SOLID WASTE LEACHATES IN AERATED LAGOONS AND AT MUNICIPAL WASTEWATER TREATMENT PLANTS (p. 23-30)**

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The two-stage technology of treatment of the leachates of the municipal solid waste (MSW) dumps in aerated lagoons and at municipal wastewater treatment plants (WWTP) has been studied. The study objective was to develop a technology that can be implemented at existing MSW dumps and landfills. Static and dynamic modes of implementation of both stages of the technology were investigated on the model units. Static 16-day mode was experimentally studied in the aerated lagoon conditions. As a result, we have managed to achieve almost a 2-fold reduction of COD and more than a 3-fold decrease in concentration of ammonium ions.

Dynamic mode studies have established that the optimal time of leachate staying in the reactor was 10 days. Change of the relative concentration of ammonium nitrogen in the leachate largely depends on the process temperature, so in real conditions, it is necessary to adjust the modes of realization of the individual stages depending on the ambient temperature. It has been established that for treatment of leachate at municipal WWTP in a static mode at the value of the ratio of leachate dilution with municipal sewage of 1:1000, the maximum effect of treatment of both from ammonium ions and COD was achieved. The study of leachate treatment at municipal WWTP in a dynamic mode has confirmed stability of maintaining the treatment indicators in time. By implementation of the two-stage technology of leachate treatment, it will be possible to minimize environmental hazard from surface and ground water contamination in the zone of influence of MSW dumps and landfills.

**Keywords**: leachate of municipal solid waste dumps, aerated lagoon, biological treatment, immobilization of biocenosis.

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**DEVELOPMENT OF THE TECHNIQUE FOR RESTRICTING THE PROPAGATION OF FIRE IN NATURAL PEAT ECOSYSTEMS (p. 31-37)**

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In order to reduce the scale of peat fires, we suggest using fire barriers made of mineralized materials. The incombustible materials are proposed, specifically sand and bentonite clay, to be used for filling up artificial slits cut in a peat layer. Construction of anti-fire barriers requires a one-time expenditure, in contrast to the existing techniques for fire prevention that require continuous pumping of water in order to increase moisture content in peat.

Mathematical modeling of thermal processes in the system peat layer–fire barrier was performed. The time of reaching the dangerous temperature by the protected layer, for the barriers made of river sand with a thickness of 300 mm, and for those made of bentonite clay with a thickness of 180 mm, is not less than 1 day. Given this, we have proven the effectiveness of the proposed barriers.

By using mathematical modeling of the processes of fire development, a parabolic dependence was built of the thickness of fire protection barrier b, mm, on time τ, hours, required to protect an object. We established parameters for regression dependences of thickness of a barrier on the time required to protect a peat layer.

The result of present research is the proposed technique for designing fire protection barriers made of river sand and bentonite clay, based on the obtained patterns and regression dependences.

Research results could be used in the process of designing fire protection barriers for actual peatlands.

**Keywords**: temperature of peat layer, mineral fire barrier, fire safety of peat.

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**COMPUTER MODELING OF WATER CLEANING IN WETLAND TAKING INTO ACCOUNT OF SUFFOSION ANG COLMATATION (p. 38-43)**

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The mathematical model of filtering with regard to colmatation and suffusion in the system bioplato-filter 2. This saturated porous medium is considered in terms of a complex heterogeneous system "fill"-"concentration of pollutants in porous liquid-concentration of colmatating particles. Mutual influences of system parameters are taken into account through:

1) the dynamic change of the porosity of the backfill in the process of filtering;

2) nonlinear dependence coefficient filter porosity of backfill;

3) dependence of velocity of filtration coefficient of filtering and gradient heads, and hence – and porosity.

Taking into account the following interplays allowed to increase the adequacy of mathematical models for the study of physical processes, however, led to the necessity of the study of nonlinear boundary value problems for systems of differential equations in partial derivatives. Nonlinearity of the boundary value problem does not allow to speak about her analytical solutions. Numerical solutions of the problems found by the method of finite elements with a software implementation of the relevant algorithms in FreeFem ++.

Computer modeling showed that when taking into account nonlinear dependence coefficient of filtration from the concentration of colmatating particles and dynamic changes of porosity in the process of filtering, predictive performance bioplato for six months reduced by 25 % . Therefore, it is necessary to develop engineering solutions for reducing the influence of the colmatation-suffusion processes on the processes of filtering. The forecasting work bioplato relevant conduct on the design stage in order to implement predictive calculations. It is done by means of mathematical and computer modeling.

**Keywords**: bioplato-filter, the problem of filtration, colmatation, suffusion, finite element method, FreeFem ++.

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**A STUDY OF ENVIRONMENTALLY FRIENDLY RECYCLING OF TECHNOGENIC CHROMIUM AND NICKEL CONTAINING WASTE BY THE METHOD OF SOLID PHASE EXTRACTION (p. 44-49)**


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The study has revealed the regularities of the effect produced by increasing the content of scale of steel 12Cr18Ni10Ti in the charge from 5 to 75 mass % on the contents of the products of carbon thermal reduction of oxide waste of corrosion-resistant steels. The concentration of Ni is increased from 0.8 to 7.0 mass % when the Cr content ranges from 15.9 to 17.1 mass %. The concentration of Cr in the extraction products within the range of 16.1–17.1 mass% is provided with the content of scale of 95Cr18 steel in the charge in the range from 5 to 55 mass %. It has been found that metallization products mainly consist of a solid solution of alloying elements in α-Fe. $Fe_3O_4$, $Fe_3C$, and $Fe_2C$ were also identified. The microstructure of the extraction products is spongy and disordered. The particles are sintered, with varying Cr and Ni contents in the ranges of 7.47 to 18.03 mass % and 2.97–10.40 mass %, respectively. The study has helped achieve environmentally safe conditions for solid-phase extraction of chrome and nickel containing industrial wastes from the production of corrosion-resistant steels with the return of the alloyed product to the welding industry.

**Keywords**: waste processing, corrosion-resistant steel, carbon thermal reduction, phase analysis, microstructure, resource efficiency.

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**EXPERIMENTAL STUDY OF THE FLUCTUATIONS OF GAS MEDIUM PARAMETERS AS EARLY SIGNS OF FIRE (p. 50-55)**

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The results of the experimental study of fluctuations of dynamics of hazardous factors of gaseous medium at early ignition of combustible materials in the chamber, simulating pressurized premises, are presented. The authors considered a non-traditional approach to research into dynamics of hazardous factors, based on current window estimation of the Pearson lag correlations for fluctuations of the main parameters of gaseous medium as non-stationary processes. In contrast to the known approaches, a given approach makes it possible to perform reliable localization in time of an early ignition of materials in premises.

It was established that early ignition of materials has a significant effect on correlations of temperature fluctuations, concentrations of carbon monoxide and smoke in gaseous medium. It was shown that correlations of fluctuations of carbon monoxide and smoke concentrations are most informative for localization of early ignitions. Temperature fluctuations are more informative at localization of early ignition of alcohol and paper. The results of current window evaluation of the Pearson lag correlations show that in the absence of ignitions, fluctuations can be considered uncorrelated. In this case, existence of ignition leads to occurrence of non-stationary fluctuations of correlations.

It is indicated that fluctuations of parameters of gaseous medium in the general case are described by autoregression processes of higher order, depending both on the type of combustible material and the stage of ignition development. A sustainable sign of early ignition of combustible materials in the simulation chamber is a significant increase in the correlation interval of non-stationary temperature fluctuations, as well as concentrations of carbon monoxide and smoke in gaseous medium. In equilibrium of gas medium, fluctuations of its parameters have a much smaller correlation interval, characteristic for uncorrelated processes.

**Keywords**: fire, early ignition, gaseous medium, simulation chamber, correlations of fluctuations, window estimation.

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**ELECTROEXTRACTION OF HEAVY METALS FROM WASTEWATER FOR THE PROTECTION OF NATURAL WATER BODIES FROM POLLUTION (p. 55-61)**

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The most promising methods of eluates recycling are electrolysis and electrodialysis. It is possible to obtain metals and purified regeneration solutions for repeated regeneration in case of application of electrochemical methods. The processes of electrolysis of solutions of cadmium and zinc sulfates and chlorides in electrolysers of different types were explored, the influence of conditions of electrolysis on effectiveness of extraction and separation of metals, obtaining inorganic acids for repeated usage in regeneration processes was determined.

Single- and double-chamber electrolysers, in which cathode was made of stainless steel and titanium anode was covered with ruthenium oxide, were used. Cathodic and anodic areas in double-chamber electrolysers were separated by the anion exchange membrane MA-41.

Solution of cadmium sulfate or of zinc sulfate was found in the cathodic chamber in double-chamber electrolysers. Solution of sulfuric acid with concentration of 50 mg-equiv./dm$^3$ was in the anodic chamber.

It is recommended to carry out electrolysis for two hours when using a single-chamber electrolyser at a voltage of 5 V with the purpose of removing cadmium from sulfuric acid solution and reusing regeneration solution of sulfuric acid. Almost complete removal of cadmium ions and concentration of sulfuric acid in anolyte is achieved in case of using a double-chamber electrolyser. However, in terms of power saving, release of cadmium should be performed in single-chamber electrolysers.

However, it is recommended to perform zinc removal from eluates in double-chamber electrolysers. In this case, zinc ions are almost completely removed within four hours at voltage of 25 V. The maximum current efficiency is 42–80 %.

Conditions of separation of zinc and cadmium in the eluate are associated with acidity of the solutions. A stage-by-stage removal of metals – cadmium followed by zinc, is observed during electrolysis of the mixture of cadmium and zinc chlorides in a single-chamber electrolyser. Current efficiency of metals is 30–68 %. In the case of electrolysis of a mixture of zinc and cadmium sulfates, only cadmium (B=100 %) is removed from the solution, while zinc ions completely remain in solution. Zinc is released only at the transfer of the electrolyte to a double-chamber electrolyser.

**Keywords**: ion exchange, electrochemical methods of water treatment, wastewater, used regeneration solution.

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**RESEARCH INTO THE INFLUENCE OF VERTICAL DRAINAGE ELEMENTS ON THE OPERATIONAL EFFICIENCY OF RAPID FILTERS (p. 61-69)**

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To improve the efficiency of removal of suspended solids at rapid filters, we designed improved structure of the device. The improvement is based on the application, simultaneously with a granular filter layer, of vertical drainage elements with porous fibrous shells. Such a solution makes it possible to shift part of the load to the shells of drainage elements, reduce colmatation and head losses in a granular filter layer, as well as to more evenly distribute contaminants along its height. This increases the duration of operation of the filter under filtering mode and brings down the cost of regeneration of a filter layer. A filtration equation was derived to describe parallel filtration of a low-concentrated suspension through a granular medium and a fibrous medium. The mathematical model also includes equations of mass transfer, mass exchange and dependences to account for the impact of colmatation and parameters of filtering media. For a granular filter layer, we considered filtering with a gradual blocking of pores; for a porous shell – the formation of a sediment layer at its surface. Using a mathematical model, we conducted numerical experiments. The following significant parameters for the filter with improved design were determined: equivalent diameter of particles in a filter layer, working height of the vertical drainage element, duration of washing a porous fibrous shell. We give examples of calculations for determining the values of basic parameters at which the effectiveness of application of vertical drainage elements is maximal.

**Keywords**: rapid filter, vertical drainage element, porous fibrous shell.

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