

ABSTRACT AND REFERENCES

ECOLOGY

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**ANALYSIS OF DETECTION OF ECOLOGICAL HAZARD
BASED ON COMPUTING THE MEASURES OF
CURRENT RECURRENCE OF ECOSYSTEM STATES
(p. 6-13)**

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Analysis of the early detection of an environmental hazard in ecosystems was performed. New measures of the current recurrence of states that allow their use for the early detection of an environmental hazard in ecosystems were proposed. Calculations of the measures under consideration are based on the distribution of the known measure of global recurrence for the case of the calculation of measures of current recurrence in moving square windows. In this case, one of the measures under consideration is based on the implementation of a moving square window along the main diagonal of the recurrent plot of state. Another measure is based on the use of a moving window of the specified size along the horizontal (vertical) axis of recurrence plots. The latter made it possible to obtain a constructive current measure for calculation of recurrence to identify dangerous states in ecosystems based on the temporal localization of zero recurrence of states at minimum sizes of a moving window. In accordance with the proposed measures of current recurrence, the possibilities of using the measures for the early identification of an environmental hazard for gas medium with the ignition center of combustible material, such as alcohol, were analyzed. It was shown that the window measure of current recurrence at a horizontal moving small-size window is the most suitable of the considered measures. It was found that for such a measure, window sizes must be in the range from 5×5 to 15×15 counts. In this case, the values of region ϵ of neighborhood for the considered states must be selected in the range from 0.01 to 0.15. It was determined theoretically and experimentally that the specified measure of current recurrence of states with a horizontally moving window can be considered as a structural current measure of recurrence to ensure a reliable early detection of hazardous states in different ecosystems.

Keywords: ecosystem, hazardous ecological state, recurrence plot, measure of recurrence, current recurrence in window.

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ANALYSIS OF INTERACTION BETWEEN A CONFIGURABLE STONE AND A WATER FLOW (p. 14-20)

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Erosion and destruction of riverbeds, foundations of flooded engineering structures are accelerated during natural phenomena, accompanied by a significant increase in the rate and wetted perimeter of river flows, the acquisition of mobility by the riverbeds' particles. We have analyzed the interaction between a water flow and a separate stone of spherical, cylindrical, pyramidal, and other configurations. In particular, we have further developed a traditional approach to determining the force action of fluid on a solid barrier, a stone, for the case of compression of a water jet and taking into consideration the relative flow around a

stone with the predefined geometrical characteristics: diameter, volume, and configuration.

It has been proposed to employ the following parameters for interaction between the flow of water and rocks of various configurations: a compression ratio and a streamline coefficient. We have derived analytical dependences of the flow rate limit, which sets a stone into motion, its weight, and configuration. For spherical smooth stones these ratios are identical with the classical results. The coefficients, introduced for consideration, were categorized, depending on the configuration of a single stone, in tables and charts, which is convenient to apply when calculating bank-protecting structures. It has been proposed to use a stone shape factor, which is the ratio of the actual flow rate limit, enabling the mobility of a stone of arbitrary configuration taking into consideration its streamlining, to the flow rate limit of a spherical stone of the same mass with a reduced diameter. A shape factor should be applied as an adjustment multiplier in the calculation of the minimum mass of stones for bank-protecting structures and during hydro-engineering works. For the wedge-shaped stones a value of the adjustment coefficient can sometimes amount to 0.170, which indicates high efficiency of applying such stones compared to those of spherical shape. In addition, the proposed coefficient could be used to refine the water flow rate limit in terms of loss of stability by existing bank-protecting structure.

We have identified directions for further studies: analysis of the impact interaction between configurable stones and elements of bank-protecting structures; determination of motion parameters for water-stone flows.

Keywords: river flows, stone configuration, action of flow on obstacle, flow rate limit, bank-protecting structure.

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EXAMINING THE EFFICIENCY OF ELECTROCHEMICAL PURIFICATION OF STORM WASTEWATER AT MACHINE-BUILDING ENTERPRISES (p. 21-27)

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We have examined the composition of polluted storm water discharged from the territory of a machine-building enterprise. It was established that the territory was unevenly polluted, with the surface wastewater from the area adjacent to the production shops dominated by ions of copper, to 1.1 mg/dm³; zinc, to 2.0 mg/dm³; nickel, to 1.6 mg/dm³; chromium, to 0.93 mg/dm³, and lead, to 5.0 mg/dm³. It was found that the removal of metals' ions during

electrocoagulation treatment is significantly influenced by the following factors: a flow rate of the wastewater sent for purification; duration of wastewater settling upon electrocoagulation, and current density during electrolysis. We have defined optimal parameters for the wastewater treatment process.

Based on experimental research, we have built graphic dependences of purification effectiveness on current density and water settling time. The optimal parameters were determined for the wastewater treatment process, which ensure sufficiently high efficiency of water purification from heavy metals' ions (to match the values for discharge standards) at an acceptable amount of electricity. It was established that the best conditions for deposition of nickel and lead are a current density of 50 A/m³ and a time of settling after electrocoagulation of 9 hours. The optimal conditions for depositing copper and zinc are 12 hours, and it is possible to lower the concentration of chromium to safe concentrations at a current density of 10 A/m³ and a time of settling of 4 hours. It was revealed that the effectiveness of purification from metals' ions increases significantly with an increase in the current density and settling time; in addition, the efficiency of settling is 1.4–3 times higher than the increase in current density. It is shown that prolonging the time of settling might not always compensate for the decrease in current density during electrocoagulation, which requires selecting the optimal balance of all factors. The experimental data that we acquired are necessary to calculate the technological process parameters.

By applying a method of full-factor experiment, we have constructed mathematical models of the process, which include the dependence of response (the residual concentration) on the above-mentioned factors. The proposed models could make it possible to control the process of electrocoagulation by influencing those factors on which the efficiency of purification depends.

Keywords: electrocoagulation, machine building, surface-drain wastewater, heavy metal contamination, current density, settling.

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DEVELOPMENT OF A CRITERIA-BASED APPROACH TO AGROECOLOGICAL ASSESSMENT OF SLOPE AGROLANDSCAPES (p. 28-34)

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For the forecast and management of erosion processes in order to protect the environment, information is needed on the state of its components and impact factors as well as the results of this impact. The existing methods for assessing the catchment area are mainly descriptive and cannot be used in mathematical prediction problems. The most accurate formulation of the problem of quantitative assessment of the catchment area is carried out during hydrological calculations. It seems expedient to develop theoretical prerequisites for agroecological assessment of slope agrolandscapes on the stability of a network of temporary watercourses by using the Lokhtin criterion.

Slope agrolandscapes are erosive dangerous objects. The existence of a continuously changing system of microstreams generated by precipitation on slopes greatly complicates the situation. Criteria are proposed to determine the main trends in the development of watercourses of river systems by washing away or depositing soil. Conclusions about the catchment area as a whole can be obtained by examining a certain area of a microstream flow for a long time and comparing field observations with laboratory experiments. To determine the sustainability of a watercourse, a theoretically reasonable value has been proposed, which allows quantifying the network of temporary streams. When conducting research, data on the catchment area of the Tsvil river (Chuvash Republic, Russia) from 1950 to 2010 were used.

A quantitative assessment of the erosion resistance of the microstream system was carried out both for periods of snowmelt and for rains, conventionally divided into summer and autumn. The theoretical background considered is confirmed by the data of long-term observations on the Great Tsvil river for sixty years. The dependences obtained make it possible to compile an adequate forecast of the direction of evolution of the catchment area in relation to the processes of soil deposition or its washing out. The criteria developed are applicable both to a specific catchment area of microstreams and to the catchment area of a river system as a whole.

Keywords: sloping agrolandscape, erosion resistance, soil wash-out, microstream, water catchment, microwatercourse resistance.

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A STUDY OF MODELING OF FLUE GAS PATTERNS WITH NUMBER AND SHAPE VARIATIONS OF THE CATALYTIC CONVERTER FILTER (p. 35-41)

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Exhaust gas in motorized vehicles is the main source of air pollution in the environment. Pollution of motor vehicle exhaust can be reduced by paying attention to the maintenance system, modern engine control concepts, fuel cleaning, and reduction of exhaust emissions. Catalytic converters are the most effective tool to fight pollutants in our environment because they reduce nearly 80 % of the harmful gases that result from incomplete combustion of the engine. To find out the flow phenomena that occur, a simulation of the pattern of exhaust gas flow is made with variations in the number and shape of the Catalytic converter filter. This research begins with the making of a Catalytic converter design which includes: filter-not-cut and filter-cut dimensions. Then design the frame dimensions of the Catalytic converter with a variety of filters: 2, 3, 4 and 5 pieces and do the simulation. The simulation results show that the increase in speed percentage is caused by the exhaust gas flow passing through the small holes in the filter so that the gas pressure changes to an increase in speed. Installation of 2 filter-not-cut pieces is recommended because there is no vacuum area. The addition of the number of filters increases the vacuum area that occurs, this is related to the durability of the Catalytic converter. The simulation results suggest using the 3 most durable filter-cut pieces compared to using filters: 2, 4 and 5 pieces. In filter-not-cut (3, 4 and 5 pieces), the random pressure distribution is caused by the non-uniform pressure. This non-uniform flow decreases the efficiency and durability of the Catalytic converter. Unlike the case with 3 filter-cut pieces that have a more regular pressure distribution, are more solid and fused.

Keywords: exhaust gas, air pollution, environment, reduction of exhaust emissions, Catalytic converter, simulations, filter-not-cut, vacuum area, filter-cut, non-uniform pressure.

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PURIFICATION OF WASTEWATER FROM THE IONS OF COPPER, ZINC, AND LEAD USING AN ELECTROLYSIS METHOD (p. 42-48)**Nikolai Gomelya**National Technical University of Ukraine
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Heavy metals penetrate water reservoirs as a result of natural and anthropogenic processes, thereby accumulating in soil, bottom sediment, sludge, and can further migrate into groundwater and surface water. The main sources of heavy metals penetration into natural waters are the insufficiently treated waste waters from many branches of industry. That renders relevance to the problem of removing heavy metals from wastewater in order to prevent excessive pollution of water reservoirs. Among existing methods of water purification from heavy metals' ions at significant volumes of industrial wastewater, the electrochemical methods are rather promising. The advantage of this method is a possibility to recycle the used regeneration solutions with obtaining metals that are suitable for reuse.

This paper reports results of research into the processes of electrochemical removal of heavy metals' cations from diluted aqueous solutions in one-and two-chamber electrolyzers. When conducting the study in a two-chamber electrolyzer, the anode and cathode regions were separated by the anion-exchanging membrane MA-40. A dependence of the influence of hardness, solutions' pH, anodic current density, and the duration of electrolysis on efficiency of the removal of heavy metals' ions was investigated. It is shown that the ions of zinc, copper and lead are effectively removed from aqueous solutions using the electrolysis at a starting concentration of 10 mg/dm³. It was established that at the low concentrations of ions, the output for current, when reducing metals, reached (4–20)·10⁻⁴ % and changed little with concentration. It was determined that the efficiency of water purification from heavy metals' ions using electrolysis increases with an increase in pH of the medium and with a decrease in the hardness of water. In the two-chamber electrolyzers, these factors exert almost no effect on purification efficiency. The paper shows the prospect of using electrolysis for the selective removal of heavy metals from tap, softened and natural water. A given purification method makes it possible to not only post-clean wastewater to the maximally permissible concentrations, but also enables the purification of water from natural water bodies to the quality of drinking water.

Keywords: waste water, heavy metals, water purification, water hardness, output for current, anion-exchanging membrane, electrolyzer, electroextraction.

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STUDYING THE EFFICIENCY OF SOIL DECONTAMINATION WHEN USING A DEVICE WITH THE BIOSORBENT “ECONADIN” (p. 49-55)

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We have investigated the efficiency of soil decontamination from petroleum products using the patented perforated device of cylindrical shape with a diameter of 0.04 m, with an area of openings of 0.04 m^2 , with the biosorbent “Econadin”. The process of soil decontamination lasted over a period of 35 days. Petrol of grade A92 was used as a model pollutant.

The present study was conducted in order to improve the process of purification from petroleum products by transporting the biosorbent into deep layers of soil. The result of the study is the established dependence of the concentration of a pollutant (C) in soil on a distance (R) to the device: $C = -0.00009134R^2 - 0.001017858R + 0.07274845$. The dependence, established to control the process of purification, makes it possible to compile methodological recommendations on the use of the proposed device.

Based on the Malthus model, combined with a diffusion process, we acquired the data that explain the mechanism of neutralization of gasoline with bacteria located in the examined device. Under the assigned conditions, purification is enabled through the migration of bacteria into soil with a diffusion coefficient $D = 0.08801 \text{ cm}^2/\text{day}$ and a constant of the natural population growth rate $r = 0.165168$.

The obtained results are useful and important to control the process of purification and to devise methodical recommendations on the use of the proposed design. A given approach makes it possible to calculate the neutralization of gasoline at a change in the boundary conditions, for example, a radius of the cylinder of a specialized device with a biosorbent, the limit of distance from it, and the duration of effective utilization of the device. For other soils and pollutants, a combined method has been proposed, including the Malthus method, based on the description of a diffusion process; it could also be applied upon determining the parameters r , D and C_0 experimentally.

Keywords: oil pollution, device with a biosorbent, control over process of soil decontamination, diffusion, biosorbent.

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DEVELOPMENT OF THE METHODOLOGICAL APPROACH TO THE SELECTION OF TECHNOLOGIES FOR ENVIRONMENTALLY-SAFE WATER DRAINAGE IN POPULATED AREAS (p. 55-63)

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The methodological approach to the selection of a technological measure of environmentally safe water drainage in populated area located on the eutrophied water sites was developed. The use of this approach makes it possible to involve professionals of various fields from local authorities in the management of ecological safety of populated areas from the positions of their sustainable development.

The essence of the methodological approach implies using the analytic hierarchy process (AHP). The criteria stated as constituents of sustainable development – environmental, social, and economic-technological – were proposed and used for it. Appropriate specialists as experts relied on the information of various types (statistics, prediction, and direct measurement data) on a particular populated area, give their own judgments regarding priority advantages of criterial features. The results of processing the judgment of experts in accordance with a formal AHP procedure form the basis for decision making when selecting technological measures of environmentally safe water drainage in a particular populated area.

The multicriterial hierarchical structure of the selection of technological measures is represented by a sequence of actions comprising three stages: construction of a hierarchical model for comparison of criterial features; formation of matrices of pairwise comparisons of the elements of each hierarchy level and determining their weight coefficients; determining global weight coefficients, consistency index and selection of the best option. The advantage of the proposed multicriterial methodological approach is the possibility to unite into a single decision-making algorithm the source data that differ in both their content (environmental, social, and economic-technological) and in their form of representation (statistical, predicting, direct measurement data, expert estimations).

Testing the developed methodological approach was carried out using the example of a typical populated area, located at the eutrophied water site – the source of drinking water supply and of recreational use. The obtained results, despite a fairly large dimensionality of the hierarchy members array, revealed the achievement of a suitable consistency level, which demonstrates their reliability.

The developed methodological approach can be used to substantiate the improvement or construction of a new drainage system of a populated area, located on the eutrophied water site.

Keywords: environmental safety, populated area, technological measure of the environmentally safe water drainage, analytic hierarchy process.

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DEVELOPMENT OF A SPATIAL-DYNAMICAL MODEL OF THE STRUCTURE OF CLUMPS OF TOXIC CYANOBACTERIA FOR BIOSAFETY PURPOSES (p. 64-75)

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We have devised a spatial-dynamic model that describes the structure of clusters of toxic cyanobacteria over large water areas. The application of the constructed model has been demonstrated in order to identify the structure of a cluster in digital photographs. The character of bioproductive processes that define the risk of accumulation of toxic microorganisms is determined by a series of parameters that can be measured remotely using aerospace methods (taking photographs). The proposed model, based on a digital image, makes it possible to restore the spatial-dynamic pattern of clusters by determining the state of bioproductive processes in different parts of the cluster. Information about such states is of great importance in order to optimize measures for eliminating the threat of toxicity.

Development of a given spatially-dynamic model is related to the need to identify the structure of clusters of toxic cyanobacteria in water areas in order to eliminate the threats to biosecurity. Such clusters are extremely complex objects and are not reproduced by either theoretical or full-scale models.

The constructed spatial-dynamic model makes it possible to discover a dynamic pattern of bioproductive processes in different parts of the accumulation of microorganisms. The applied significance of the results obtained is associated with increasing the effectiveness of measures for elimination of the threat of toxicity; in other words, given the model that we constructed, it becomes possible to detect the most effective plots in terms of eliminating the threat.

The result of employing the model to the digital images of toxic cyanobacteria agrees well with the hydrobiological realization of this type of objects.

Keywords: spatial-dynamical model, cyanobacteria, bioproductive processes, colorimetric parameters, biosecurity.

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DEVELOPMENT OF GEO-MODEL FOR CONCENTRATION DETERMINATION OF HAZARDOUS CHEMICALS IN THE ATMOSPHERE (p. 76-83)

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A critical analysis of the approaches to the development of a model for determining the concentration of hazardous chemicals (HC) in the atmosphere, which are the basis of computer-aided environmental monitoring systems (CEMS) has been carried out. It has been established that the lack of effective functioning of the existing CEMS is determined by the imperfection of the models used to determine the concentration of atmospheric chemical concentration in the atmosphere. In addition, the organic disadvantage of such systems is their departmental affiliation and, as a result, the limited number of potential users. To improve the efficiency of the discussed class of systems, a concept of integrated use has been proposed, within the CEMS framework, elements of information and analytical systems for environmental monitoring, satellite image processing tools, geoinformation technologies, and also mathematical software for calculating the concentration of various types of atmospheric HCs. Building a CEMS based on this concept will provide an opportunity to significantly improve the efficiency of their functioning in the aspects of reducing the time for making decisions, as well as reducing the risk of making wrong decisions. The mathematical support of the CEMS is based on the “Gauss-

ian” statistical model of HC emission, and is intended, along with geographic information technologies, to synthesize a geo-model of ground-level atmosphere pollution by HCs. As an illustrative example, the situation of the release of chemical waste in the area of Bila Tserkva (Kyiv region, Ukraine) is considered. Theoretical results form the methodological basis for the implementation of the applied information technology for the creation, deployment and operation of a decision support system for eliminating the consequences of an emergency situation caused by the proliferation of chemical water in the atmosphere.

Keywords: hazardous chemicals, geoinformation system, geo-model, information and analytical system, atmosphere monitoring.

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