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ENVIRONMENTAL SAFETY

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THE METHODIC OF MODELING AND CALCULATIONS OF THE OXYGEN REGIME AT THE PURIFICATION OF THE WASTE WATERS IN AEROTANKS WITH SUSPENDED AND FIXED BIOCENOSIS

Abstract. *The methodic of mathematical modeling and calculations of oxygen regime at biological treatment of waste waters from organic contaminants in aerotanks with suspended and fixed biocenosis is given. The peculiarities of the simulation of oxygen supply during purification in aerotanks-mixers and aerotanks-displacers are considered at this.*
Keywords: *model*; *purification; oxygen; organic pollution; aerotank-mixer; aerotank-displacer; biofilm; active sludge.*

Introduction

In biological waste waters treatment reactors in particular in aerotanks the removal of organic contaminants (OC) occurs in aerobic conditions that is when oxygen is consumed for biooxidation of OC and self-oxidation of cell material and also used in other processes that may occur at this time. Therefore the modeling and development of the aeration system is to provide such an oxygen regime in the reactor in which the rate of the biological treatment process should not be limited by the amount of oxygen contained in the reactor. In such reactors the processes of dissolution and consumption of oxygen develop simultaneously and are interconnected. In well-known bioreactors – aerotanks the removing of OC occurs under normal conditions only owing to suspended biocenosis (active sludge) and these processes are sufficiently thoroughly considered in the special literature.

In this paper the peculiarities that occur at the modeling of the oxygen regime in the aerobic biological treatment of waste waters in aerotanks-mixers and aerotanks-displacers with suspended and fixed biocenosis are considered for conditions when the process of biochemical oxidation is provided with oxygen in sufficient quantities and the oxygen supply will not limit the kinetics of biooxidation (removal) of OC in aerotanks with suspended and fixed biocenosis [1].

The main features of the proposed methodic

It is known that depending on the hydrodynamic conditions of the flow of the waste waters in bioreactors its are divided on the aerotanks-mixers and aerotanks-displacers [1–4]. If we take into account that oxygen supply takes place using the most commonly used in practice pneumatic (bubble) oxygen delivery technology in the volume of aerotanks due to the use of air then the indicated features of using oxygen with suspended and fixed biocenosis in particular are as follows. If suspended biocenosis (particles of active sludge) is directly used for oxidation of oxygen dissolved in waste waters from oxygen bubbles then in the case of fixed biocenosis (in the form of a biofilm loaded on the surface of the material) it is necessary to determine the flow of dissolved oxygen that enters to the biofilm surface through the boundary layer of the liquid and carry out a quantitative assessment of the consumption of oxygen by microorganisms in the thickness of the biofilm. The solution of these questions allows us to estimate the amount of oxygen needed for biooxidation by suspended and a fixed biocenosis and moreover allows solving such an important question which of the substrates (oxygen or OC) will limit the oxidation process in the biofilm. It has been established by research that at considerable (saturated) arrangement in the aerotank (reactor) of the elements of loading the oxygen can enter in the biofilm not only from the volume of liquid (dissolved oxygen) but also as a result of so-called inter-surface transfer (IST) directly from the bubbles adhering to the surface of the biofilm. The account of IST allows in some cases to increase the concentration of oxygen entering to the biofilm up to 20% [2].

In both cases of the removing of organic contaminants by suspended and fixed biocenosis in aerotanks for growth and livelihoods of microorganisms it is necessary to provide the uninterrupted supply of oxygen and to control its consumption in the amount necessary to maintain the kinetics of reactions with a high rate of utilization of OC in these conditions of the aerobic process. In this work in order to evaluate and analyze the oxygen regime in aerotanks-mixers and aerotanks-displacers under the indicated conditions a general mathematical model was constructed which reduces to the realization of the corresponding equations of the material balance recorded relative to the concentration of oxygen C.

So for aerotank-mixer we have

$$W_p \frac{\partial C_a}{\partial t} = Q_a (C_0 - C_a) + W_p \alpha K_C a (\beta C_p - C_a) - F_{\delta_l} N_c - R_{a_c} W_p, \qquad (1)$$

and for the aerotank-displacer we have

$$\varepsilon \frac{\partial C_a}{\partial t} = D_c \frac{\partial^2 C_a}{\partial x^2} - v \frac{\partial C_a}{\partial x} + \varepsilon \alpha K_C a (\beta C_p - C_a) - \frac{F_{\delta_l}}{W_p} N_c - R_{a_c}, \qquad (2)$$

$$R_{a_c} = R_{c_a} + R_{c_c}.$$

In practical calculations it is enough to consider equations (1)–(2) in stationary conditions and to evaluate their members taking into account the known diffusion criterion of Peckle $Pe = \frac{vl}{D_c}$ according to [1]. For further implementation let's bring them to the form:
for aerotank-mixer

$$C_0 - C_a + \alpha K_C a\left(\beta C_p - C_a\right)T_a - R_3 = 0, \qquad (3)$$
$$R_3 = \frac{F_{\delta_l}}{Q_a} N_c + R_{a_c} T_a, \qquad T_a = \frac{W_p}{Q_a},$$

for aerotank-displacer

$$-v\frac{dC_a}{dx} + \varepsilon\alpha K_C a\left(\beta C_p - C_a\right) - \lambda_e N_c - R_{a_c} = 0, \qquad \lambda_c = \frac{F_\delta}{F}. \qquad (4)$$

In general case in the above equations the value of the flow of oxygen entering to the biofilm through its surface is determined by the equation:

$$N_c = -D_c\frac{dC}{dz} = (1-\eta)K_C\left(C_a - C\big|_{z=0}\right) + \eta\alpha K_{Cn}\left(\beta C_p - C\big|_{z=0}\right), \qquad (5)$$

where η – the ratio of the surface area of the biofilm in contact with air bubbles to the total surface area of the biofilm.

In other words the equation (5) takes into account the possible additional flow of oxygen into a biofilm both from the volume of liquid in the form of dissolved oxygen and as a result of the so-called inter-surface transfer (IST) directly from the bubbles adhered to the biofilm. The expediency of taking into account IST takes place with sufficiently significant (saturated) of loading of the elements in the aerotank (reactor) which takes place for example in flooded filters with sand-gravel material of loading. In aerotanks with fixed biocenosis (biofilm) it is possible ignoring the IST and some possible positive impact of IST will go into the stock of the calculations. In this case at implementing models it is necessary to take $\eta = 0$ and take into account only the flow of dissolved oxygen from the volume of liquid to the biofilm due to diffusion:

$$N_C = -D_C\frac{dC}{dz} = K_C\left(C_a - C\big|_{z=0}\right). \qquad (6)$$

Note that the determination of the flow of oxygen through the surface of the biofilm N_c and for the quantitative estimation of the removal of the OC by the biofilm depending on their parameters in particular which of the substrates (pollution or oxygen) limits the purification process in the biofilm is obtained as a result of

solving the following equations which characterize the consumption of oxygen in the removal of OC by a fixed biocenose (biofilm).

In general this equation for a biofilm has the following form:

$$\frac{\partial C}{\partial t} = D_C \frac{\partial^2 C}{\partial z^2} - R_C \tag{7}$$

In the case of cylindrical loading elements in which the biofilm is formed the equation for the biofilm will be as follows:

$$\frac{\partial C}{\partial t} = D_C \left[\frac{\partial^2 C}{\partial r^2} + \frac{1}{r} \cdot \frac{\partial C}{\partial r} \right] - R_C \tag{8}$$

According to the analysis the solution of equations (7)–(8) for practical calculations is sufficient to solve for stationary conditions that occur fairly quickly that is when $\frac{\partial C}{\partial t} = 0$.

The solution of equation (7) is performed under the following boundary conditions, namely: N_c for $z = 0$, and $\frac{\partial C}{\partial z} = 0$ for $z = \partial$, which allows us to determine the change in the concentration of oxygen in the thickness of the biofilm l and in subsequent calculations to determine the concentration on the surface of the biofilm $C\big|_{z=0} = C\delta$.

In the general case the reaction rates are described by the following equations:

$$R_c = \alpha_1 R_L + \alpha_2 b_c \frac{C}{K_{m_C} + C} X, \tag{9}$$

$$R_L = \frac{\mu_m}{Y} \frac{L}{K_{m_L} + L} \cdot \frac{C}{K_{m_C} + C} X, \tag{10}$$

$$R_{c_a} = \alpha_{1a} R_{\grave{a}_L} + \alpha_{2a} b_{a_C} \frac{C_a}{K_{ma_C} + C_a} X_a, \tag{11}$$

$$R_{a_L} = \frac{\mu_{ma}}{Y} \frac{L_a}{K_{ma} + L_a} \cdot \frac{C_a}{K_{ma_C} + C_a} X_a. \tag{12}$$

In the above equations and dependencies we have C, $\tilde{N}_\delta$, C_a, C_0 – respectively the concentration of oxygen in the biofilm, on the surface of the biofilm, in the aerotank and in the waste waters at the entrance to the aerotank; C_p – concentration of saturation (soluble) oxygen in the liquid; R_c, R_{a_c} – the rate of reactions of using oxygen in a biofilm and aerotanks, taking into account the oxidation velocity of the isolated substances during the death of microorganisms; W_a, W_p, W_δ – respectively the

aerotanks working volume, the volume of the liquid in the aerotank, the volume of the elements of the established loading with the fixed biocenosis $F_{\delta l}$, F_{δ} – respectively the total surface area of the biofilm in the aerotank (reactor), the surface area of the biofilm per unit length of the aerotank (reactor); $K_C a$, K_{cn}, K_C – respectively the volumetric mass transfer coefficient, the coefficient between the surface transfer of oxygen in the biofilm, the coefficient of mass transfer of oxygen in the liquid film. The denotation of other variables in the above equations is given in [1, 3].

To assess the impact of these mechanisms of supply and consumption of oxygen in the removal of OC it is advisable to consider the limiting cases of the work of the aerotanks in the system of biological waste water treatment.

1. In the absence of fixed biomass (additional loading) the removal of OC occurs only with the suspended active sludge and for the supply and consumption of oxygen the given equations are solved with $N_c = 0$. In this case the calculation of the parameters of the oxygen regime taking into account the specifics of the oxygen supply systems and the work regime of the aerotank was considered in [4].

2. In the case when the removal of OC occurs only on the biomass fixed on the load that is without taking into account the action of suspended active sludge the given equations are solved at $R_{a_c} = 0$.

3. In the case when the removal of OC in aerotanks occurs at the expense of suspended and a fixed biocenosis in determining the optimal parameters of its work the various variants of its location in the volume (in the plan) of the aerotanks and the required area of the surface of the biofilm surface $F_{\delta l}$ (loading elements) are possible.At this the loading elements (nozzles, grids, etc.) can be located throughout the aerotank volume or more densely and compactly only in its individual sections. Depending on the technological scheme of the location of the elements in the aerotank for length (in volume) and in connection with the received reactions in the biofilm and aerotank the general equations can be greatly simplified. Let's consider further the possible following technological schemes:

a) The load elements are not sufficiently close distributed throughout the length of the aerotank. In this case in the above equations we adopt $\eta = 0$ that is the inter-surface oxygen transfer may not be taken into account and with sufficient justification the removal of OC in the volume of aerotanks occurs by reaction of zero order and in biofilm by the first order reaction.

Since in equations (9) and (11) $K_{m_C} <<$ C and $K_{ma_C} << C_a$ then for oxygen in practical calculations the oxidation occurs by the reaction of zero order in a biofilm and in aerotank. So for reactions we have:

$$R_c = \alpha_1 R_L + \alpha_2 b_c X \; ; \tag{13}$$

$$R_L = k_L L = \frac{\mu_m \mathrm{X}}{Y K_{m_L}} L \; ; \tag{14}$$

$$R_{c_a} = \alpha_{1a} R_a + \alpha_{2a} b_{a_c} X_a \; ; \tag{15}$$

$$R_a = \frac{\mu_{ma} X_a}{Y_a} \; . \tag{16}$$

Determination of the concentration of OC in a biofilm $L(z)$ and in particular on its surface L_δ is given in [5]. Determination of the concentration of oxygen C in the biofilm and in particular on its surface $C\delta$ occurs as a result of the solution of equations (7), (8) depending on the construction of the loading elements on which the biofilm is formed for example or in the form of flat plates with holes or a net of separate cylindrical rods. At the same time with some approximation we can take for the determination of the reaction R_{c_L} the next dependence:

$$R_{c_L} = \alpha_1 k_L L_{\delta p} + \alpha_2 b_c X \,, \tag{17}$$

where $L_{\delta p}$ is an averaged concentration of OC in a biofilm [5].

b) The loading elements are located at the beginning of the aerotank in its first part – the reactor 1 in which the removal of the OZ occurs due to the fixed biomass and in the second part of it – in the reactor 2 where the removal of OC occurs by a suspended biomass (active sludge) that is a reactor 2 works like a regular aerotank (Fig. 1a).

c) The elements of the load are located at the end of the aerotank in its second part in the reactor 2 in which the removal of the OC occurs due to the fixed biomas and in the first part – the reactor 1 the removal of OC occurs due to the suspended biomass (active sludge) that is the reactor 1 works as a regular aerotank (Fig. 1b).

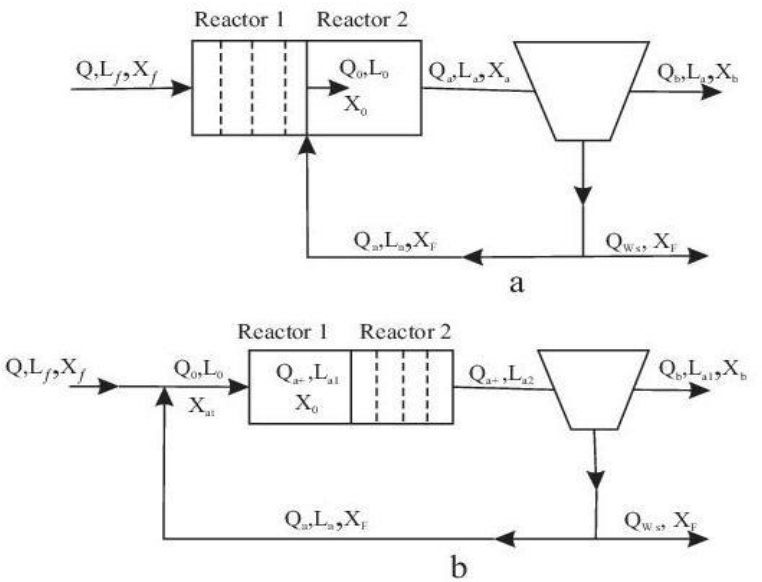

Fig. 1 – Scheme of biological purification in aerotanks: a – fixed biomass in reactor 1; b – fixed biomass in the reactor 2

Depending on the adopted hydrodynamic regime of the liquid flow the reactors 1 and 2 can work as bioreactors-mixers and bioreactors-displacers. The supply of oxygen for removal of OC in reactors takes place in accordance with the given general mathematical model that takes into account the accepted reactions of OC utilization and oxidation.

The theoretical substantiation and the methods of calculations of the oxygen regime in aerotanks-mixers and aerotanks-displacers for the above described different technological schemes are considered respectively in [6, 7].

To implement the proposed models and calculations we consider some of the features and prerequisites that have been adopted in the formation of the oxygen regime in aerotanks with an fixed biomasses.

Thus in the above models when we remove OC by the suspended and the fixed biocenosis the linear kinetics of the reactions of the first and the zero orders are accepted and the limits of use of which are limited in particular the values of the concentrations of waste waters which enter to the purification. Therefore in the general case with a sufficient justification in the special literature at the removing of the OC it is proposed to use in the models mainly the kinetics of reactions which is described by the known nonlinear Mono equation [5]. Based on the use of the obtained solutions for the reactions of the first and the zero orders the approximate methods for calculating the required parameters are proposed in accordance with the Mono equation [5]. As a result of the aforementioned in [8] and on the base of the implementation of the above mathematical models a methodic of calculations of the removal of the OC in aerotanks with suspended (active sludge) and with fixed biocenosise (biofilm) in which the kinetics of reactions is described by the nonlinear Mono equation is developed, namely:

$$R_L = \frac{\rho_m L}{K_{m_L} + L}, \qquad \rho_m = \frac{\mu_m L_a}{Y_a} \tag{18}$$

$$R_a = \frac{\rho_{ma} L_a}{K_{m_L} + L_a}, \qquad \rho_m = \frac{\mu_{ma} L_a}{Y_a} \tag{19}$$

At the removal of OC by fixed biomass in the reaction of an oxygen regime of zero order instead of a variable concentration L with sufficient justification its average value $L\delta_p$ is taken according to the following dependence:

$$L\delta_p = 0{,}5\left(L\delta_{r=0} + L\delta_{z=\delta}\right) \tag{20}$$

where $L\delta_{r=0}$ is the concentration of OC on the outer surface of the biofilms (z = 0), $L\delta_{r=\delta}$ is the concentration of OC on the inner surface of the biofilm (z = 0).

In order to determine the concentrations $L\delta_{z=0}$ and $L\delta_{r=\delta}$ the solutions of problems for determining the concentration changes in biofilms at different kinetics of reactions are given in the works [5, 6, 9]. Thus the following equation was obtained in [9] which connects the concentrations $L\delta_{z=0}$ and $L\delta_{r=\delta}$ to the conditions of the nonlinear Mono equation:

$$L\delta_{z=0} = \overline{L}\delta_{z=\delta} - \overline{K} m_L \ln\left|\frac{L\delta_{z=0} + \overline{K}_{m_L}}{L\delta_{z=\delta} + \overline{K}_{m_L}}\right| + \frac{\beta_L^2}{2\alpha_L}\left(\overline{L}\delta_{z=0} - 1\right) \tag{21}$$

$$N_L = K_L\left(L_a - L\delta_{z=0}\right) = \lambda_L\beta_L\left(1 - \bar{L}\delta_{z=0}\right) \tag{22}$$

where $\bar{L} = \frac{L}{L_a}, \bar{K}_{m_L} = \frac{K_{m_L}}{L_a}, \alpha_L = \frac{\mu_m X\delta^2}{YD_L L_a}, \beta_L = \frac{K_L\delta}{D_L}, \lambda_L = \frac{D_L}{\delta}L_a$.

In the case of the necessity of considering the interfacial transfer (IST) according to equation (5) the solution of the problem in particular the determination of oxygen concentration on the surface of the biofilm $C\delta$ was obtained in [9].

In an aerotank (reactor) where the removal is due to an active sludge it is usually necessary to recirculate the discharge Q which will be determined by the following formula:

$$Q_a = Q(1+r) \tag{23}$$

where Q – estimated wastewater discharge, m^3/h, r – the degree of recirculation of active sludge which is taken according to the work [10].

An important question when using the proposed models and methods for calculations the oxygen supply of the processes the removal of OC is the definition of unknown mass transfer coefficients $K_C a$ and K_{C_n} and related to their determination other parameters. If the technological schemes of supplying oxygen and the peculiarities of its use in aerotanks with active sludge were investigated in to a sufficient extent but in the structures in which the removal of OC occurs by fixed on the loading elements biomasses(biofilm) the study of the oxygen regime was provided insufficient. It was assumed at this that the process of removing of OC is not limited by oxygen that is provided in sufficient quantities of oxygen and is maintained mainly at a concentration close to the concentration of saturation. Among other the processes of oxygen supply of microorganisms in the fixed biofilm and in the form of suspended flakes of active sludge are somewhat different that need to take into account when calculating the consumption of oxygen in the utilization of contaminations by fixed and suspended biomasses.

Taking these features into account when calculating the oxygen regime in reactors with suspended and a fixed biomasses allows more basically to substantiate the determination of the coefficients $K_C a$ and K_{C_n} as is shown in [1].

In the future on the base of the proposed models and methods of calculations it is necessary to analyze and evaluate their impact in order to ensure the supply of the required amount of oxygen to the place of reactions and the utilization of OC.

As an example of the calculation (simulation) of the oxygen regime consider the aerotank-mixer in which in the reactor 1 the removal of the OC occurs by suspended biocenosis (active sludge) and in the reactor 2 the removal of the OC occurs due to the fixed biomass (biofilm) on the installed load (Fig. 1). This technological scheme of purification from a practical point of view will be more appropriate and more consistent with the current requirements for providing oxygen treatment because in existing traditional aerotanks to provide the proper more higher quality of the waste waters treatment is too difficult and uneconomical.

Conclusions

Thus the implementation of the proposed models allows with known geometric and other characteristics to evaluate the influence of oxygen regime on the processes of purification in aerotanks at the different conditions of their operation and to substantiate an economical and efficient technological supply system with oxygen taking into account the features of removing of OC in aerotanks with suspended and a fixed biocenosis. In this case it is possible to substantiate the criteria in which the biochemical oxidation process will be adequately supplied with oxygen that is it will be not limit the kinetics of biooxidation both suspended and fixed biocenosis.

REFERENCES

1. Oliynik O.J., Airapetian T.S. Reports of National Academy of Sciences. - 2015. - №5. 55-59.
2. Lee K.M., Stensel H.D. Aepation and substrate utilization in a sparged packed - biofilm reactor // WPCF, vol. 58, №11. 1065-1073.
3. Maslun G.S.Problemy vodopostachannya, vodovidvedennya ta gidravliky. - 2013. - 21. 123-142.
4. B.N. Repin, V.I. Bazhenov. Vodni Resursy. - 1991. - №1. 122-130(in Russian).
5. Oliynik O.J., Kolpakova O.A. Ekologichna bezpeka ta pryrodokorystuvannya. - 16. - 2014. 68-86.
6. Oliynik O.J, Airapetian T.S. Modeling and calculations of the oxygen regime at the removing of the organic pollutions in aerotanks-mixers with suspended and fixed biomasses. Problemy vodopostachannya, vodovidvedennya ta gidravliky. 2016,-27. 269-279.
7. Oleinik A., Airapetian T. Oxygen regime in research on the work of plug flow aeration tanks with fixed biomasses. // Eastern-Europian Journal of Enterprise Technologies, Kharkiv, 2017, 4/10(88). – P. 4-11.
8. Perez J., Pissioreanu C., Van Loosdrecht M. Modeling biofilm and floc diffusion processes based on analytical solution of reaction-diffusion equations. // Water Research, 2005, vol. 39, issue 7. – P. 1311-1323.
9. Oleynik A., Kalugin Yu., Airapetian T. The use of nonlinear Mono kinetics in modeling a mixing aeration tank with a biofilm on additional loading // Eastern-Europian Journal of Enterprise Technologies, Kharkiv, 2017, 6/10(90). – P. 17-23.
10. SBN V.2.5.-75.2013. Sewerage system. External nets and structures. Main regulations in projecting. K., Ukrainian region ministry, 2013. - 128 p.

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Т.С. Айрапетян, С.В. Телима, О.Я. Олійник

МЕТОДИКА МОДЕЛЮВАННЯ І РОЗРАХУНКІВ КИСНЕВОГО РЕЖИМУ ПРИ ОЧИСТЦІ СТІЧНИХ ВОД В АЕРОТЕНКАХ ЗІ ЗВАЖЕНИМ І ЗАКРІПЛЕНИМ БІОЦЕНОЗОМ

Анотація. Наводиться методика математичного моделювання і розрахунків кисневого режиму при біологічній очистці стічних вод від органічних забруднень в аеротенках зі зваженим і закріпленим біоценозом. При цьому розглядаються особливості моделювання подачі кисню при очистці в аеротенках-змішувачах і в аеротенках-витискувачах.

Ключові слова: модель; очистка; кисень; органічне забруднення; аеротенк-змішувач; аеротенк-витискувач; біоплівка; активний мул.

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EXPANSION OF THE RANGE OF WET AIR I-D DIAGRAM FOR ENVIRONMENTAL SAFE HEAT PRODUCTION

Abstract. *For environment protection, condensing boilers may be used instead of emission of high temperature combustion products. For condensing combustion, high moisture content in exhaust gases is typical. I-d diagram can be used for condensing economizer development, but it is primary built for heating, ventilation and air conditioning. In the work, new approach to build I-d diagram is proposed that allow widening of the range of parameters without precision loose. It allows obtaining higher precision for calculation of condensing economizers.*
Keywords*: exhaust gases; condensing boiler; condensing economizer; I-d diagram; wet air; enthalpy.*

Introduction

The most environment-safe technology of fuel combustion is condensing boiler. It saves from 3% (by the datasheets of ÖkoFEN, 2015) of hard fuel to 10...12% of gas fuel. There is a less volume of combustion products. Some pollutants are absorbed by the condensate. They can be utilised more easily than from the smoke. One of the problems developing the condensing heat exchangers is precise calculation of the thermodynamic processes. The most easier tool for wet air calculations is I-d diagram also known as Ramzin diagram or Mollier diagram. The main purpose of it is heating, ventilation and air conditioning (HVAC) systems. Often, laboratory researches of heat-mass transfer in the condensing heat exchangers are performed on very wet and hot air. Authors tried using the diagram for researches for new condensing polymer economizer [1]. Precision of the calculations was not enough because the basic parameters of enthalpy calculation are heat of vaporization and isobaric specific heat at temperature $t = 0$ °C. In is enough for HVAC systems because of low temperature range – up to 40 °C. In the temperature range of condensing heat exchangers – up to 100 °C and higher, – the physical properties are different from the values above. To avoid difficult integration, the averaged values in the range of experimental studies are used. But an universal precision tool that can be used in the wide temperature range from HVAC to combustion systems may be preferred.

Basic equations for I-d diagram building

Relative humidity can be found from the following equation using the pressure of saturated vapour p_{sat} [Pa]:

$$\varphi = p_{vap} / p_{sat}. \quad (1)$$

The work [2] uses very rough quadratic approximation of the pressure of saturated vapour. Moisture content d [kg/kg dry air] is dependent on partial pressure of the vapour p_{vap} [Pa] and the pressure of the process p [Pa] (usually equal to the barometric pressure):

$$d = 0.623\, p_{vap} / (p - p_{vap}) = 0.623\, \varphi\, p_{sat} / (p - \varphi\, p_{sat}). \quad (2)$$

In the equation (2) 0.623 is the ratio between the specific gas constant for the dry air and the vapour $R_{d.a.} / R_{vap}$. The precise value, used in this work, is $R_{d.a.} / R_{vap} = 18.016/28.96 = 0.6221$.

The standards of I-d diagram building are described in the work [2]. The enthalpy [kJ/kg dry air] can be calculated by the following simplified formula:

$$I = 1.005\, t + (2500+1{,}8\, t)\, d. \quad (3)$$

In the equation (3) the numerical values are the physical properties at $t = 0$ °C: specific heat of the dry air $c_{d.a.} = 1.005$ kJ/(kg K), of the moisture (vapour) $c_{vap.} = 1.8$ kJ/(kg K) and the heat of vaporization of water $r = 2500$ kJ/kg. All of the values are dependent on temperature and will be represented below.

These equations are valid in temperature range of HVAC systems. If we need more precise calculations for wide temperature range, the equations will be more complex. If we pass any process from the starting point O ($t = 0$°C, $d = 0$) to some point C (with current enthalpy I [kg/kg dry air], temperature t [°C] and moisture content d [kg/kg dry air]), there are some non-answered questions, how to integrate the heat, required for the process. The most important is: what heat of vaporization [kJ/kg] we need? It is dependent on the temperature. However, the vapour is superheated except the curve $\varphi = 1$. Thus, what temperature does correspond to the vaporization?

Principles for wide-range I-d diagram building

To answer the question above, it is possible to use the property of isobaric processes that no work will is performed. All heat q [kJ/kg] necessary for a process is equal to the difference between ending and starting enthalpy [kJ/kg] and independent on the process curve. Therefore, we can introduce a basic process (possible or fictitious) from a point with known enthalpy (the best choice is a point with $I = 0$) to the calculation point C. The process may be easy calculated with minimum assumptions and simplifications (fig. 1).

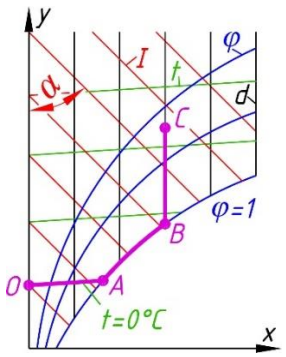

Fig. 1 – Scheme of I-d diagram with basic process
(*x* and *y* are the coordinates of graphic window for plotting, units)

We will start the basic process from the point O and perform it along three lines:

OA – isothermal humidification at (t = 0 °C) up to φ = 1 and the moisture content d_A, kg/kg dry air. As we have very low moisture content (up to 0.001 kg / kg dry air), it is possible to use heat of vaporization at zero temperature $r_0 = r(t = 0\ °C)$ without significant error. The necessary heat [kJ/kg dry air] is

$$q_{OA} = r_0\, d_A. \tag{4}$$

AB – the process of humidification and heating along the curve φ = 1. The heat of the process consists of vaporization heat, heating of the dry air and the already vaporized water. The necessary heat [kJ/kg dry air] is

$$q_{AB} = \int_{d_A}^{d} r d d_{sat} + \int_0^{t_B} c_{d.a.} dt + \int_0^{d_{t_B}} c_{vap} d(d_{sat} t), \tag{5}$$

where d is the differential operator (straight and bold in contrast with moisture content – italic, not bold); d_{sat} is the moisture content of the air at φ = 1. It is called by the different index because it can be found easy.

BC – heating with constant moisture content d [kg/kg dry air]. The heat of the process consists of heating of the dry air and the vapour. The necessary heat [kJ/kg dry air] is

$$q_{BC} = \int_{t_B}^{t} \left(c_{d.a.} + c_{vap} d\right) dt. \tag{6}$$

The enthalpy [kJ/kg dry air] of the air at the calculation point C is equal to the sun of the equations (4–6)

$$I = q_{OA} + q_{AB} + q_{BC} =$$

$$= r_0 d_A + \int_{d_A}^{d} r d d_{sat} + \int_0^{t_B} c_{d.a.} dt + \int_0^{d_{t_B}} c_{vap} d(d_{sat} t) + \int_{t_B}^{t} \left(c_{d.a.} + c_{vap} d\right) dt =$$

$$= r_0 d_A + \int_{d_A}^{d} (r + c_{vap} t) d d_{sat} + \int_0^{t_B} (c_{d.a.} + c_{vap} d_{sat}) dt + \int_{t_B}^{t} \left(c_{d.a.} + c_{vap} d\right) dt. \tag{7}$$

Replacing the moisture content by the temperature in the first integral of the equation (7) can simplify the expression but cause additional derivative dd_{sat}/dt. The derivative can be found only using table data for saturated vapour pressure. This is possible only numerically with additional error and can be recommended only for rough calculations.

Physical properties of dry air and water vapour can be found by author's interpolations (preserving all table digits) of the data [3]. Specific heat [kJ/(kg·K)] in temperature ranges, corresponding, t = – 73,15 ... 276,85 C and t = 0 ... 130 C

$$c_{d.a.} = (0.00394\,(t/100) + 0.0016)\,(t/100) + 1.00583; \quad (8)$$

$$c_{vap} = ((0.0352\,(t/100)^2 + 0.1058)\,(t/100) + 0.0282)\,(t/100) + 1.86443. \quad (9)$$

Heat of vaporization [kJ/kg] by [3] with deviation of 0.087 kJ/kg or 0.0038% at t = 0...100 °C:

$$r = ((5.434 - 12.85\theta)\,(t/100) - 236.28)\,(t/100) + 2500.97. \quad (10)$$

Pressure of saturated vapour [Pa] can be found by the following author's interpolation (repeats all digits of the table data) of data in [4] at temperature range t = 0...105 °C

$$p_{sat} = 610.753 + (442.91 + (144.6448 + (24.2836 + (5.45193 + (0.66836 - \\ - 0{,}006354(t/10))(t/10))(t/10))(t/10))(t/10))(t/10) + \\ +(0.209 - 1.8172(t/10)^4)\sqrt{t/10}. \quad (11)$$

Method of wide-range I-d diagram building

From the equation (2) it is possible to find the pressure of saturated vapour at φ = 1:

$$p_{sat} = \frac{p}{\frac{R_{d.a.}/R_{vap}}{d}+1} = \frac{pd}{(R_{d.a.}/R_{vap})+d} \approx \frac{p}{\frac{0.623}{d}+1}. \quad (12)$$

If temperature is known, the pressure can be found by numerical solution of the equation (11) at known pressure p_{sat} [Pa] and unknown temperature t [°C]. Using the equation (12) it is possible to find the temperature t [°C] of saturated vapour using the moisture content d [kg/kg dry air] and the pressure p [Pa].

By the equation (11) at zero temperature $p_{sat}(t = 0)$ = 610.753 Pa. Therefore, by the expression (2) at the point A moisture content [kg/kg dry air]:

$$d_A = 379.949 / (p - 610.753). \quad (13)$$

The equations (2) and (11) dives the opportunity to find moisture content on the line φ = 1 at known temperature t [°C] and pressure p [Pa].

If we create functions in computer algebra system (or using some programming language) by the equations (8–13), we can use it to calculate integrands in the expression (7). The integrals may be numerically computed using any quadrature formula. Desired precision can be achieved using some known adaptive quadrature

algorithm. Therefore, the equation (7) can give enthalpy I [kJ/kg dry air] by known temperature *t* [°C], moisture content *d* [kg/kg dry air] and pressure [Pa]. The function that computes it, is enough to build isotherms (*t* = const) in coordinates (*I*, *d*).

To operate with relative humidity, partial pressure of the vapour is necessary. It can be found from the equation (2):

$$p_{sat} = p\,d / \left((R_{d.a.} / R_{vap}) + d\right). \tag{14}$$

Using the equations (14), solving the equation (11) and substituting the results to the function created by the equation (7) it is possible to build a function that calculates enthalpy at known moisture content d [kg/kg dry air], relative humidity φ, and pressure *p* [Pa]. This function allows building curves of relative humidity (φ = const) in coordinates (*I*, *d*) at constant pressure *p* [Pa].

I-d diagrams usually use oblique-angled coordinates. Lines of constant moisture content [kg/kg dry air or g/kg dry air] are vertical. Lines of constant enthalpy [kJ/kg dry air] and vertical axis form an angle α. One of the convenient values is $\alpha = \pi / 4$ (or 45°). Let us use scales for enthalpy C_I [units/(kJ/kg dry air)] and for moisture content C_d [units/(kg/kg dry air)]. As the value of the moisture content is very small, usually C_d = 1000 units/(kg/kg dry air) and the axis is often labelled in g/kg dry air. The transformation to/from the euclidean coordinates (*x*, *y*) [units] can be performed by the following equations:

$$x = C_d\,d\,. \tag{15}$$

$$y = C_I\,I - \frac{x}{\tan(\alpha)}. \tag{16}$$

$$d = x / C_d. \tag{17}$$

$$I = \left(y + \frac{x}{\tan\alpha}\right) / C_I = \frac{y\tan(\alpha) + x}{C_i \tan\alpha}. \tag{18}$$

Example of wide-range I-d diagram building

Let us build an I-d diagram for standard barometric pressure *p* = 101325 Pa (Fig. 2). The calculations and plotting are performed in SciLab 5.5.2 [5–10].

Let us compare it with I-d diagram in the work [2]. The maximum moisture content is 30 g/kg dry air or 0.03 kg/kg dry air. The maximum value of temperature that allows easy take enthalpy at the maximum moisture content is 48 °C. The corresponding enthalpy by the equations (7–13) is 124.79 kJ/kg dry air. By [2] it is 125.8 kJ/kg dry air. The deviation by enthalpy is 0.8%. At the same moisture content, but the temperature 32 °C the enthalpy is, corresponding, 107.77 kJ/kg dry air and 108.9 kJ/kg dry air. The deviation is 1.05%. It is enough for engineering calculations.

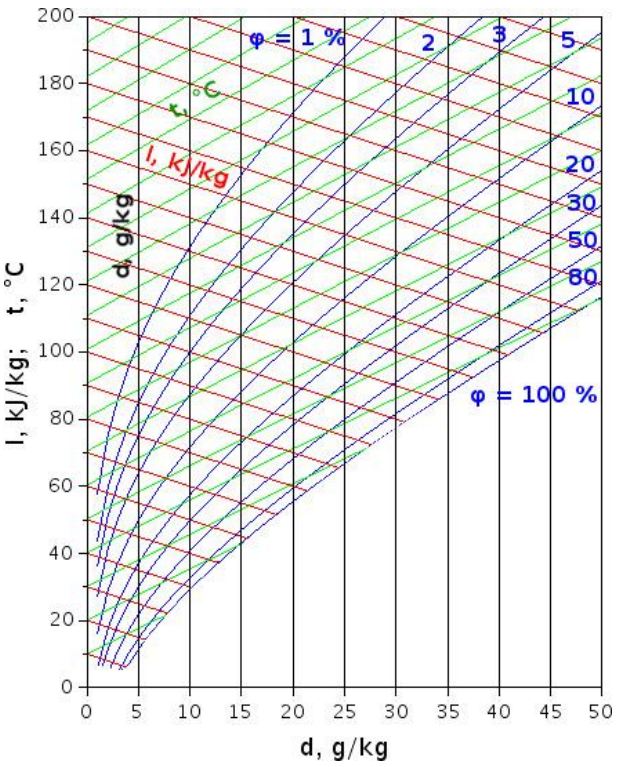

Fig. 2 – Fragment of I-d diagram for p = 101325 Pa

At moisture content 15 g/kg dry air or 0.015 g/kg dry air and temperature 24 °C the enthalpy has no deviation: 62 kJ/kg dry air. At the same moisture content and temperature 60 °C the corresponding values of enthalpy are 99.30 kJ/kg dry air and 99.5 kJ/kg dry air. The deviation is comparable with line thickness on the diagram [2].

At moisture content 4 g/kg dry air or 0.004 g/kg dry air and temperature 4 °C the enthalpy has no deviation: 14.06 kJ/kg dry air. At the same moisture content and temperature 60 °C the corresponding values of enthalpy are 70.86 kJ/kg dry air and 70.8 kJ/kg dry air. The deviation is comparable with line thickness on the diagram [2].

Therefore, the enthalpy deviation is near to zero, but at the right part, close to d = 0.030 kg/kg dry air, it has tendency of increasing. At high moisture content, typical for condensing economizers, the deviation may reach 3% - energy saving of hard fuel condensing boilers. Let us test a point, typical for the economizers: t = 60°C, d = 0.1 kg/kg dry air. The equation [2]

$$I = 1.005\,t + (2500 + 1.8\,t)\,d = 1.005 \cdot 60 + (2500 + 1.8 \cdot 60) \cdot 0.1 = 321.1 \text{ kJ/kg dry air.}$$

By the equations (7-13) the value is I = 313.33 kJ/kg dry air. The deviation is 7.8 kJ/kg dry air or 2.5%. It is comparable with energy saving on hard fuel condensing boiler (near to 3%). We can make a mistake calculating such devices up to twice. At moisture content d = 0.2 kg/kg dry air the deviation reaches 3.3%.

If we use standard I-d diagram, we need to include the deviation into the total uncertainty of the experimental results. This can be avoided using proposed method.

Therefore, the standard I-d diagrams are acceptable for rough calculations. For more precise calculations, the proposed method is recommended.

Conclusions

Proposed method provides results that have good agreement with I-d diagrams for HVAC. At high temperature and moisture content the results allow refining the diagram. The deviation is comparable with energy saving of hard fuel condensing boilers (3%). Therefore, the standard I-d diagrams are acceptable for rough calculations. For more precise calculations, the proposed method is recommended.

REFERENCES (TRANSLATED AND TRANSLITERATED)

1. Dzjubenko V.G. Doslidzhennja plivkovyh teploobminnykiv dlja kondensacijnyh kotloagregativ indyvidual'nogo teplopostachannja / V.G. Dzjubenko // Mistobuduvannja ta terytorial'ne planuvannja: Nauk.-tehn. zbirnyk. – K.: KNUBA, 2015. – Vyp. 57. – S. 163–168. (in Ukrainian)
2. Otoplenie I ventiljacija: uchebnik dlja VUZov. V 2 ch. Ch. 2. Ventiljacija / red. V.N. Bogoslovskij. – M.: Strojizdat, 1976. – 439 s. (in Russian)
3. Vargaftik N.B. Spravochnik po teplofizicheskim svojstvam gazov i zhidkostej / N.B. Vargaftik. – M.: Nauka, 1972. – 720 s. (in Russian)
4. Fizicheskie velichiny: Spravochnik / Pod red. I.S. Grigor'eva, E.Z. Mejlihova. – M.: Jenergoatomizdat, 1991. – 1232 s. (in Russian)
5. Affouf M. Scilab by examples / M. Affouf. – CreateSpace, 2012. – 114 p. (in English)
6. Hema Ramachandran. SciLab (A Free Software to MatLab) / Hema Ramachandran, Achuthsankar S Nair. – S. Chand Publishing, 2012. – 216 p. (in English)
7. Vande Wouwer A. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications / A. Vande Wouwer, P. Saucez, C.V. Fernández. – Springer, 2014. – 406 p. (in English)
8. Roux P. SciLab. From Theory to Practice P. I. Fundamentals / P. Roux. Translated by P. Mathieu. – France.: SciLab Enterprises, 2016. – 410 p. (in English)
9. Audibert T., Oussalah A. Informatique. Programmation et calcul scientifique en Python et SciLab / T. Audibert, A. Oussalah. – France.: Ellipses, 2014. – 528 p. (in English)
10. Faes G. Scilab: Eine Einführung in das Mathematikprogramm Scilab. – Deutchland.: Herstellung und Verlag, 2014. – 216 s.

REFERENCES

1. Дзюбенко В.Г. Дослідження плівкових теплообмінників для конденсаційних котлоагрегатів індивідуального теплопостачання / В.Г. Дзюбенко // Містобудування та територіальне планування: Наук.-техн. збірник. – К.: КНУБА, 2015. – Вип. 57. – С. 163–168.
2. Отопление и вентиляция: учебник для ВУЗов. В 2 ч. Ч. 2. Вентиляция / ред. В.Н. Богословский. – М.: Стройиздат, 1976. – 439 с.
3. Варгафтик Н.Б. Справочник по теплофизическим свойствам газов и жидкостей / Н.Б. Варгафтик. – М.: Наука, 1972. – 720 с.
4. Физические величины: Справочник / Под ред. И.С. Григорьева, Е.З. Мейлихова. – М.: Энергоатомиздат, 1991. – 1232 с.
5. Affouf M. Scilab by examples / M. Affouf. – CreateSpace, 2012. – 114 p.
6. Hema Ramachandran. SciLab (A Free Software to MatLab) / Hema Ramachandran, Achuthsankar S Nair. – S. Chand Publishing, 2012. – 216 p.
7. Vande Wouwer A. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications / A. Vande Wouwer, P. Saucez, C.V. Fernández. – Springer, 2014. – 406 p.
8. Roux P. SciLab. From Theory to Practice P. I. Fundamentals / P. Roux. Translated by P. Mathieu. – France.: SciLab Enterprises, 2016. – 410 p.

9. Audibert T., Oussalah A. Informatique. Programmation et calcul scientifique en Python et SciLab / T. Audibert, A. Oussalah. – France.: Ellipses, 2014. – 528 p.
10. Faes G. Scilab: Eine Einführung in das Mathematikprogramm Scilab. – Deutchland.: Herstellung und Verlag, 2014. – 216 s.

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В.Г. Дзюбенко, В.О. Мілейковський, І.А. Саченко
РОЗШИРЕННЯ ДІАПАЗОНУ I-D ДІАГРАМИ ВОЛОГОГО ПОВІТРЯ ДЛЯ ЕКОЛОГІЧНО БЕЗПЕЧНОГО ВИРОБНИЦТВА ТЕПЛОТИ

Анотація. Для захисту навколишнього середовища замість викидів високотемпературних продуктів згоряння можуть використовуватися конденсаційні котли. Для конденсаційних котлів типовим є високий вологовміст відвідних газів. I-d діаграма може бути використана для розробки конденсаційних економайзерів, однак вона побудована в першу чергу для опалення, вентиляції та кондиціонування повітря. У роботі запропоновано новий підхід до побудови I-d діаграми, що дозволяє розширити діапазон параметрів без втрати точності. Це дозволяє отримати більш високу точність для розрахунку конденсаційних економайзерів.

Ключові слова: відвідні гази; конденсаційний котел; конденсаційний економайзер; I-d діаграма; вологе повітря; ентальпія.

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GIS-BASED ASSESSMENT OF ANTHROPOGENIC INFLUENCE IN WESTERN POLISSYA REGION LIMNOLOGICAL ECOSYSTEMS

Abstract. *Results of expeditionary researches of limnological systems in Western Polissya region of hydroacoustic methods complex using and information-analytical technologies are presented. Remote sensing monitoring method for lakes eutrophication processes research is considered. The concept of lake passport information model is proposed.*
Keywords: *environmental safety; influence assessment; limnological systems; eutrophication; environmental monitoring; Earth remote sensing methods; geographical information systems.*

Theme importance

The problem of environmental conditions, water resources restoration and delivering high quality drinking water to consumers is one of the key problems not only in environmental sphere but one of the most important problems for humankind. This supposition confirms by assessment of qualified expert groups from different countries all over the world and international organizations. For example, among the

latter, the analytical report of World Economic Forum experts "The Global Risk Report 2018"can be cited. In this assessment, the risk of "water crisis" is in the 5th place in the global risks impact rating. Also, the water resources condition indirectly affects the other specific influential risk: "mankind unpreparedness to climate change" (4th place), "natural disasters" (3rd place), "extreme weather conditions" (2nd place by influence and 1st – by probability of occurrence risk). Surely, for Ukrainian territory the named risks are also relevant.

When speaking about solving the issues around water supply, water quality and water resources protection, the Ukrainian society and government regulates the above in a number of bylaws and international agreements, particularly, the Law "About main principles (strategy) of the state environmental policy in Ukraine for the period to 2020". There are agreements that are also dedicated to environmental policy transformation in accordance with sustainable development foundation. Problems of water resources monitoring, water quality control in natural reservoirs and hydro ecosystems sustainable functioning ensuring are in this list. Researching the limnological systems, i.e. lakes, water reservoirs, ponds are the part of these tasks. Its importance is linked to the increased requirements for the efficiency and information completeness during monitoring. The latter is carried out both by contact and remote sensing methods [1, 2]. However, current development level of infrastructure and information technologies enables to increase effectivity of these both methods combination. Contact methods allow to research physical, chemical, biological parameters simultaneously [3]. The remote sensing not only obtains geographic binding, but also water level dynamics monitoring, water area 3D-model creating, anthropogenic influence on coastal areas to water conditions assessment.

Fulfillment of the listed tasks with modern information technologies will allow to estimate anthropogenic impact peculiarities with more precision. In turn, it can lead to a refinement of the environmental assessment. Results can be used in water resources and environmental safety operation procedures.

The purpose of the research is to create and to improve information technologies for its usage in environmental safety management of limnological objects (lake ecosystems) of Ukraine as strategic sources of fresh water.

Main content of research

In the paper, authors considered the problem of monitoring efficiency increasing and assessment of limnological ecosystems ecological conditions on the example of Ukrainian lakes through creating and implementation of modern information technologies for further usage of the results in the system of territorial environmental management. Domestic and foreign research analysis show that the problem of hydro ecosystems conservation and restoration can be solved using geographic information system (GIS-based) technologies, remote sensing, integrated monitoring of ecosystems based on ecological indicators, databases with complex and local monitoring results, analytical technologies for remote sensing results processing and landfill and gauge measurements [4]. Authors made conclusion about expeditions of contact and remote limnological objects monitoring methods integration in order to solve named task.

After the analysis of Ukrainian limnological ecosystems, authors concentrated researches on a number of lakes located mainly in Western Polissya region. Lakes

as Svityaz, Nobel, Lyubyaz, Bile and a number of smaller water objects [5, 6]. In the period since 2010 to 2017, numbers of expeditions were carried out for every water object from the list. Expeditions consisted of the field research stage, when contact methods of lakes environmental monitoring and remote sensing data processing and analysis were used.

In the course of expeditions, a number of hydrochemical and hydrobiological measurements were performed, notably for Nobel and Lyubyaz lakes. In particular, transparency, salt content, pH parameters have got, samples of bottom sediments were taken using specialized developed equipment (geological tube). The results of field research made it possible to draw conclusions about the peculiarities of anthropogenic influence to these limnological ecosystems. In particular, intensive eutrophication of lakes' surface was observed due to changes in water chemical composition. It is being caused by mineral fertilizers flushing from agricultural lands and the active increasing of uncontrolled tourism and recreation scale [7]. Also, the water regime of the lakes gradually changes, in particular under the influence of climate factors. The anthropogenic disturbance level on these ecosystems is currently low, but there is continuous intensification of economic and recreational impact, that begins to influence on limnological objects negatively as a whole.

The authors propose the following algorithm to research anthropogenic influence in limnological systems using remote sensing methods:

- Selection of remote sensing data, cartographic materials and descriptive information;
- Creation of lake water area and coasts detailed digital map using ultra-high resolution remote sensing data;
- Determination of seasonal variability of the lake using time-varying images;
- Conducting the classification of the coastal territory to determinate coastal vegetation and anthropogenic impact on water object;
- Sources of anthropogenic influence determination;
- Classification of aquatic vegetation;
- Lake temperature regime determination using time-sensitive images in thermal channel;
- Measurements on the ground and water surface, test areas selection;
- Comparison and calibration of the results using remote sensing data processing and above-ground measurements;
- Limnological system geodatabase creating.

In order to increase the monitoring efficiency using remote sensing data, base of space images was created. It made it possible to research the dynamics of the environmental parameters. Limnological systems of Nobel lake (Rivne region), Lyubyaz (Volyn region, Pripyat – Stohid Natural Park) were considered as an example of the integrated application of remote sensing possibilities [6]. High-resolution images such as Spot, GeoEye, DigitalGlobe, Sich-2 with various ranges were used to analyze man-caused impact on the water areas of listed lakes and their coastal zones. Selection of remote sensing data, cartographic materials and descriptive information has been performed.

The analysis of eutrophication effect using space images processing methods is based on diffuse reflection coefficient of light by surface and subsurface water layers variation analysis. Coefficient changes when concentration of phytoplankton increases which in turn causes a diffuse reflection of light due to increased light

scattering back to microalgae [8]. On the other hand, this process is accompanied by phytoplankton pigments content increasing that absorb light in specific intervals intensively. This process leads to a decrease in diffuse reflection of light in certain areas of the spectrum. It should be taken into account during remote monitoring for different periods of year.

For absorption processes, skin-effect impact is considered. It leads to decrease in the electromagnetic waves depth penetration into the thickness of conductive environment. Based on the Maxwell equations and the expression for electric power density vector, according to the Ohm law in differential form ($j = \sigma E$, E – vector of electric field strength; μ – magnetic permeability; σ – specific electrical conductivity; j – electric current density vector; ω – frequency of electromagnetic wave), the basic model and Δ – thickness of the skin layer (absorption layer) $\Delta = \sqrt{2/\sigma\mu\omega}$. It determines the effectiveness of light depth penetration in the conducted environment (in the case of water) for a given wavelength (frequency), which was chosen as 430 – 450 nm. If the absorption of light effect and processes of its scattering and reflection is considered simultaneously, we can establish the total effect accuracy and determine the optimal wavelength, which was confirmed experimentally. As a result, we can confirm that there are three independent effects (reflection, scattering and absorption) which affect on the lake bottom image quality (depending on its depth).

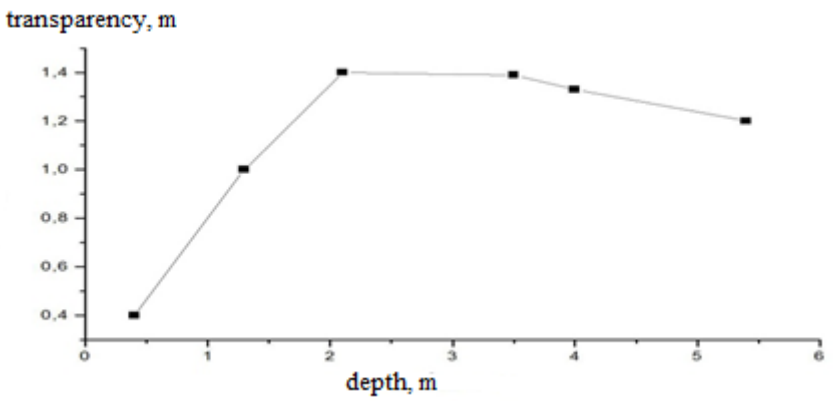

Fig. 1 – Dependence of transparency from depth (research of Nobel Lake)

The obtained data at one point for different depths (fig. 1) allowed constructing a functional dependence on the received light flux. Deducting of this dependence offers an opportunity to determine the influence of each of the three effects for a particular limnological object for each period of the year. That is why we can determine the content of suspended particles, presence and thickness of the water film the accuracy of depth remote measurement. It has been established that fixing continuous data for depth from 0 to 10 m provides the opportunity to obtain the most accurate result of measurement.

Equipment with available blue coastal canal (0,40 – 0,45 microns) was used for limnological objects monitoring. Today there are only three satellites have such equipment on board – Landsat-8, WorldView-2, WorldView-3. Canal choice was due

to penetration of sunlight in this spectral range at a greater depth. It allowed analyzing the spectral brightness of the main classes of natural objects in Nobel Lake basin.

LAI – Leaf area Index ***NDVI Normalized difference vegetation index***

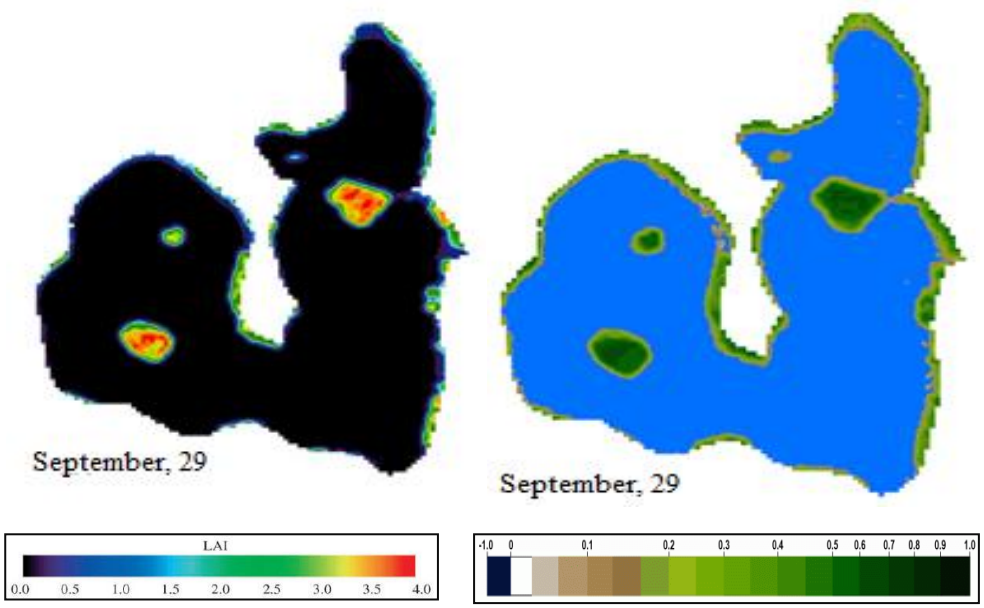

Fig. 2 – Classification of aquatic vegetation on Nobel Lake using LAI and NDVI indexes

The main periods of limnological objects seasonal variability were identified as a result of time-dependent remote sensing data analysis (fig. 2). In particular, it was discovered that in the warm period of the year there is an active reproduction of phytoplankton and algae in most lakes. During the cold season, water has maximum transparency and algae are falling to the bottom. Therefore, for aquatic vegetation monitoring, remote sensing data should be used for the summer period (July – August). The depth definition measurement needs images for October and November. As a result, detailed digital map of water basin and coastal area was made using ultra-high spatial resolution space images.

Also, during the expeditions, hydroacoustic bathymetry of the water areas was conducted. On the measurement results, interactive maps of the bottom relief were constructed, as well as 3D-modeling of underwater relief. Fig. 3 shows one of the created lake bathymetry maps, for Lyubyaz Lake (Pripyat – Stohid Natural Park). The lake refers to flood-plain-channel way type, has irregular shape, the surface area is 519 hectares, the average depth is 5 meters. The coastline of the lake is low, sandy, mostly waterlogged, with an island.

In addition to direct depth measurements during expedition the echolocation method based on remote sensing was used on Nobel Lake [8, 9]. Results proved that using “WorldView-2” satellite images deliver more detailed bathymetry results (fig. 4).

Relative depths transformation into absolute values was carried out using reference points, which were selected using echolocation equipment. It allowed us to obtain data for constructing a depth map and a three-dimensional model of Nobel Lake.

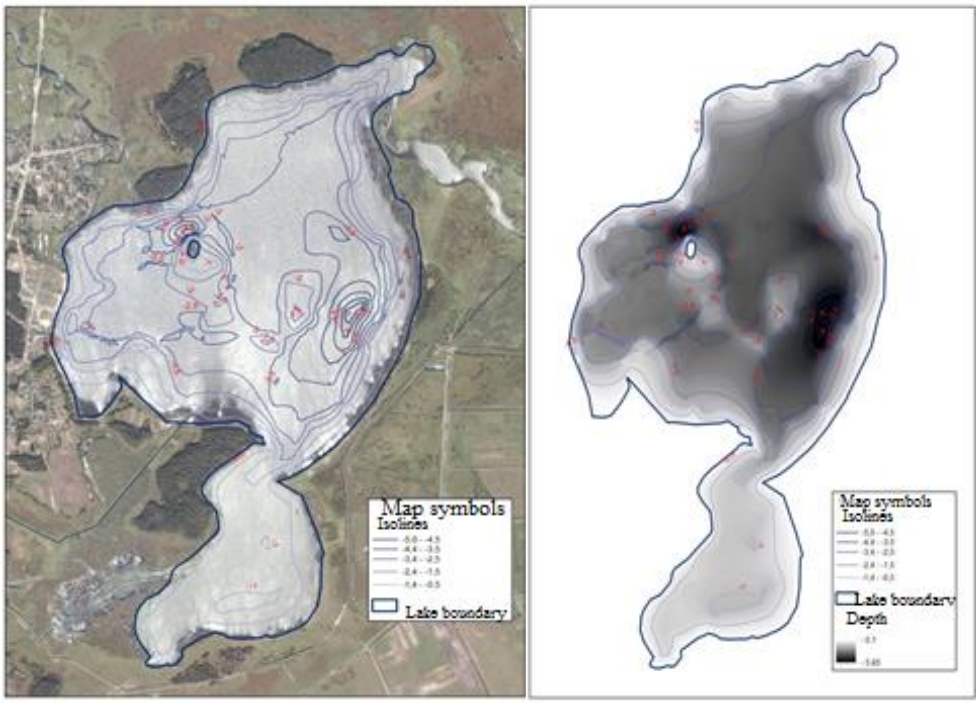

Fig 3 – Bathymetric map of Lyubyaz Lake limnological system (Pripyat – Stohid Natural Park)

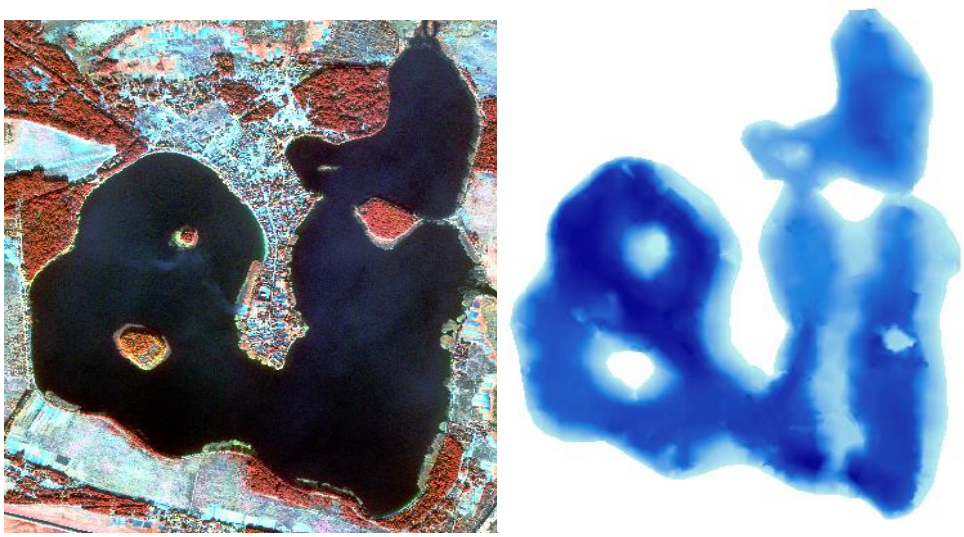

Fig. 4 – Nobel Lake satellite image (WorldView-2 remote sensing data) and bathymetric map based on result of its decoding

The results of experiments, measurements and remote sensing data allow to systematize individual parameters and to offer information technology for classifying the limnological object conditions in the form of passport [8, 10]. For passport creating, methods for determine lake and coastal territories hydrochemical characteristics, satellite image processing, sub-satellite experiments, statistical

analysis and processing physical, chemical, electrolytic, physicochemical, biological researches, spatial data GIS-processing were used. Basis for the passport creating is the ground binding of processed satellite images optical-spectral characteristics to the water area hydroecological conditions and landscape conditions of the limnological ecosystem territory.

Based on the ontology method, data package, collected during expeditions, the MS Excel toolbox (primary data spreadsheets) the lake passport information model was created. Also the query constructing rules were defined for forming user interface. These rules are essential for working with passport of limnological object through web-interface. Passport databases are implemented in Oracle environment. Passport technology proposes a sequential algorithm using to find information based on ontology method [11]. This method allows to obtain the exact information quickly, that is necessary for different groups of users. Ontology concept used to create limnological object passport has allowed reflecting the semantic properties of the research environment information resources logically.

The logical structure of lake e-passport shows object features and taking into account using requirements. Semantically, limnological object passport structure is represented in the scheme shown on Fig. 5.

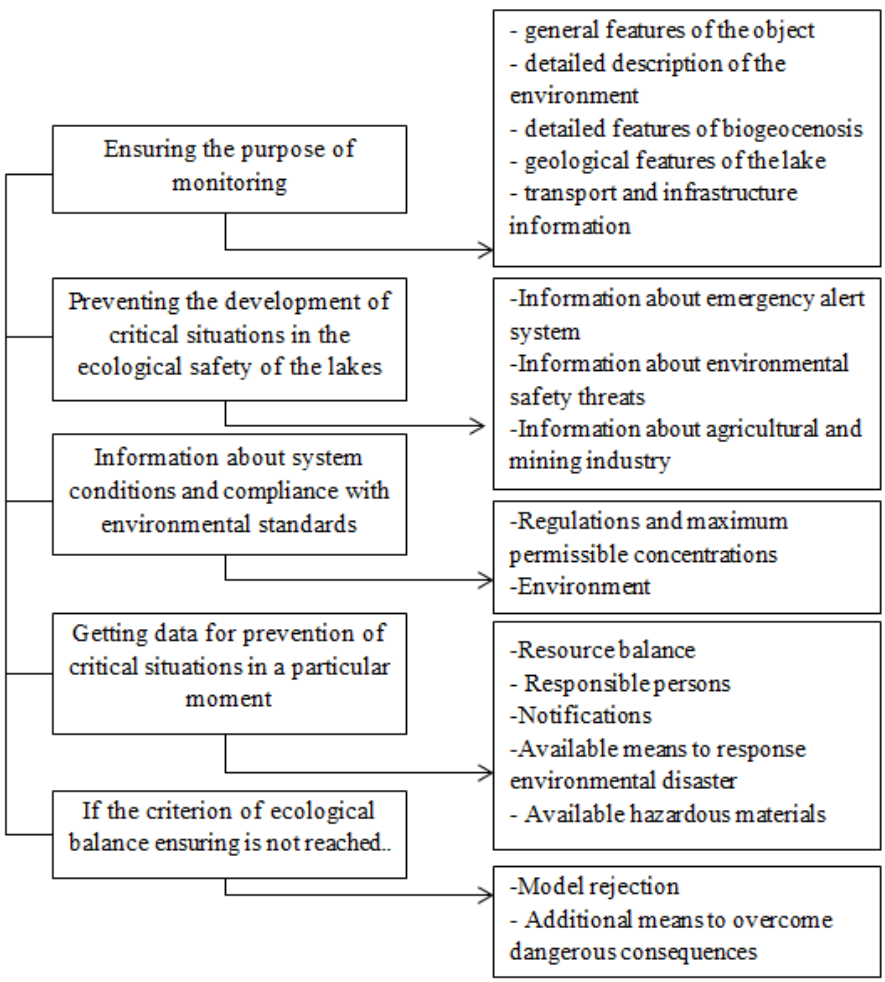

Fig. 5 – The structure of limnological object passport

This scheme is based on mathematical models and satellite images processing results. It gives an idea of what questions this information model can answer of a particular limnological object in general. Also passport data should provide data for forecasting, that is, mathematical model creation. It allows the specialists in different areas to coordinate their efforts quickly and to take steps for environmental conditions stabilization.

After the passport was developed, the effectiveness parameter of user speed in the search of words in passport was determined. User interface of limnological object passport is preferable even for users with limited training. The average time of the operation of entering a search word to the search query in the system is 16,1 s. Recommendations for implementation of limnological object passports indicate that the focus should be on natural reserves and natural parks.

Conclusions and practical significance of the research result

Authors proposed, grounded and applied the integration of ground-based monitoring for limnological ecosystems with space monitoring of water areas. Water regime of lakes in Western Polissya region was analyzed using presented methods. An increasing tendency of eutrophication effect has been established in Nobel Lake ecosystem. New technique to research absorption and dispersion effects was proposed and grounded mathematically. The methods, modern devices and software for bathymetric mapping of lakes were used. Method of hydroacoustic analysis of bottom lake relief for morpholithogenetic analysis of lake basins with different origins has been worked out, bathymetric mapping has been carried out. E-passport of the Nobel lake has been developed, a list of biotesting methods was presented with defined logical structure. Based on the collected data package, lake passport information model was created with the use of ontology method. The query constructing rules were defined for forming user interface. The passport implements the use of sequential algorithm to find information.

The practical significance of the results consists of satellite information base creation for the ecological monitoring in Western Polissya region. It allows to control the situation in water ecosystems, to analyze anthropogenic load on limnological objects. Technologies of environmental condition assessing for limnological ecosystems based on satellite information decoding methods (for freshwater reservoirs) was developed. Lake e-passport information technology was created. It allows to carry out situational environmental management depending on the intensity of anthropogenic influence.

REFERENCES (TRANSLATED AND TRANSLITERATED)

1. Informatyzacija aerokosmichnogo zemleznavstva / V.Y. Ljal'ko, S.O. Dovgyj, O.M. Trofymchuk [ta in.]; NAN Ukrai'ny, In-t geol. nauk, Centr aerokosm. doslidzhen' Zemli [ta in.]. – K. : Nauk. dumka, 2001. – 606 s. (in Ukrainian)
2. Remote sensing of the environment: an Earth resource perspective / J.R. Jensen. – Prentice Hall, 2000. – 544 p. (in English)
3. Tehnoekologija: navch. posib. dlja stud. vyshh. navch. zakl. / V.M. Udod, V.V. Trofimovych, O.S. Voloshkina, O.M. Trofymchuk // KNUBA, In-t telekomunikacij i global'nogo informacijnogo prostoru NANU. – K., 2007. – 195 s. (in Ukrainian)

4. Monitoryng navkolyshn'ogo seredovyshha z vykorystannjam kosmichnyh znimkiv suputnyka NOAA / [O.M. Trofymchuk, V.V. Radchuk, G.Ja. Krasovs'kyj, I.V. Radchuk] // Pid red. S.O. Dovgogo. – K., FOP Ponomarenko Je.V., 2013. – 316 s. (in Ukrainian)
5. Marynych O. Pro l'odovykovi ta vodno-l'odovykovi formy rel'jefu Ukrai'ns'kogo Polissja / O. Marynych // Nauk. zap. Kyi'v. derzh. un-tu. – 1958. – T. XVII. – Vyp. 1. – S. 115–121. (in Ukrainian)
6. Nacional'nyj park "Pryp'jat' – Stohid" // Mizhderzhavni pryrodno-zapovidni terytorii' Ukrai'ny / Pid zag. redakcijeju d.b.n. T.L. Andrijenko, G.V. Parchuk, P.T. Jashhenko – Mizhvidomcha kompleksna laboratorija naukovyh osnov zapovidnoi' spravy NAN Ukrai'ny ta Minekobezpeky Ukrai'ny. – K., 1998 . – S. 67–76. (in Ukrainian)
7. Rudenko V.P., Trofymchuk O.M. Ukrai'ns'kyj pryrodno-resursnyj potencial: Serija ocinkovyh kartoshem: Ch.2 // K., UINS, 2000. – 186 s. (in Ukrainian)
8. Information support of conception of environmental safety of water supply and wastewater treatment / [V.I. Mokryy, O.M. Trofimchuk, I.V. Radchuk, V.V. Radchuk, C.A. Zagorodnia, and other] // Water Supply and Wastewater Removal. – Politechnika Lubelska, edited by Henryk Sobczuk, Beata Kowalska. – Lublin. – 2016.– P. 132–145. (in English)
9. Informacijne zabezpechennja gidroakustychnogo monitoryngu ozer Zahidnogo Polissja / O.M. Trofymchuk, V.I. Mokryj, V.V. Radchuk, I.V. Radchuk, S.A. Zagorodnja // Ekologichna bezpeka ta pryrodokorystuvannja. – 2015. – № 17. – S. 5–14. (in Ukrainian)
10. Information Technology in Environmental Monitoring for Territorial System Ecological Assessment / [O. Trofymchuk, D. Kreta, M. Myrontsov, V. Okhariev, V. Shumeiko, S. Zagorodnia] // J. Environ. Sci. and Engineering. – 2015. – A4. – P. 79–84. (in English)
11. Stryzhak O.Je. Instrumenty informacijno-analitychnogo suprovodu procesiv monitoryngu / O.Je. Stryzhak // Ekologichna bezpeka ta pryrodokorystuvannja – K., 2014. – Vyp. 14. – S. 180–191. (in Ukrainian)

REFERENCES

1. Інформатизація аерокосмічного землезнавства / В.И. Лялько, С.О. Довгий, О.М. Трофимчук [та ін.]; НАН України, Ін-т геол. наук, Центр аерокосм. досліджень Землі [та ін.]. – К. : Наук. думка, 2001. – 606 с.
2. Remote sensing of the environment: an Earth resource perspective / J.R. Jensen. – Prentice Hall, 2000. – 544 p.
3. Техноекологія: навч. посіб. для студ. вищ. навч. закл. / В.М. Удод, В.В. Трофімович, О.С. Волошкіна, О.М. Трофимчук // КНУБА, Ін-т телекомунікацій і глобального інформаційного простору НАНУ. – К., 2007. – 195 с.
4. Моніторинг навколишнього середовища з використанням космічних знімків супутника NOAA / [О.М. Трофимчук, В.В. Радчук, Г.Я. Красовський, І.В. Радчук] // Під ред. С.О. Довгого. – К., ФОП Пономаренко Є.В., 2013. – 316 с.
5. Маринич О. Про льодовикові та водно-льодовикові форми рельєфу Українського Полісся / О. Маринич // Наук. зап. Київ. держ. ун-ту. – 1958. – Т. XVII. – Вип. 1. – С. 115–121.
6. Національний парк "Прип'ять – Стохід" // Міждержавні природно-заповідні території України / Під заг. редакцією д.б.н. Т.Л. Андрієнко, Г.В. Парчук, П.Т. Ященко – Міжвідомча комплексна лабораторія наукових основ заповідної справи НАН України та Мінекобезпеки України. – К., 1998 . – С. 67–76.
7. Руденко В.П., Трофимчук О.М. Український природно-ресурсний потенціал: Серія оцінкових картосхем: Ч.2 // К., УІНС, 2000. – 186 с.
8. Information support of conception of environmental safety of water supply and wastewater treatment / [V.I. Mokryy, O.M. Trofimchuk, I.V. Radchuk, V.V. Radchuk, C.A. Zagorodnia, and other] // Water Supply and Wastewater Removal. – Politechnika Lubelska, edited by Henryk Sobczuk, Beata Kowalska. – Lublin. – 2016.– P. 132–145.

9. Інформаційне забезпечення гідроакустичного моніторингу озер Західного Полісся / О.М. Трофимчук, В.І. Мокрий, В.В. Радчук, І.В. Радчук, С.А. Загородня // Екологічна безпека та природокористування. – 2015. – № 17. – С. 5–14.
10. Information Technology in Environmental Monitoring for Territorial System Ecological Assessment / [O. Trofymchuk, D. Kreta, M. Myrontsov, V. Okhariev, V. Shumeiko, S. Zagorodnia] // J. Environ. Sci. and Engineering. – 2015. – A4. – P. 79–84.
11. Стрижак О.Є. Інструменти інформаційно-аналітичного супроводу процесів моніторингу / О.Є. Стрижак // Екологічна безпека та природокористування – К., 2014. – Вип. 14. – С. 180–191.

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ГІС-ОЦІНКА АНТРОПОГЕННОГО ВПЛИВУ В ЛІМНОЛОГІЧНИХ ЕКОСИСТЕМАХ ЗАХІДНОГО ПОЛІССЯ

Анотація. Наведені результати експедиційних досліджень лімнологічних систем Західного Полісся на основі комплексного використання гідроакустичних методів та інформаційно-аналітичних технологій. Розглянуто методику дистанційного моніторингу евтрофікаційних процесів озер, запропонована концепція інформаційної моделі паспорту озера.

Ключові слова: екологічна безпека; оцінка впливу; лімнологічні системи; евтрофікація; екологічний моніторинг; дистанційні методи зондування Землі; геоінформаційні системи.

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ОСНОВИ ПРИРОДОКОРИСТУВАННЯ
NATURAL RESOURCES

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ANALYSIS OF THE STABILITY OF WATER BODIES TO THE ACTION OF DESTABILIZING FACTORS

Abstract. *Methodical approaches to the assessment of ecological safety of ecosystems based on the establishment of a comprehensive indicator of the degradation of environmental components have been developed, which will allow us to assess non-additive properties of different-scale aquatic ecosystems. The analysis of methods for assessing the stability of water bodies to change the parameters of natural and anthropogenic regimes is carried out. Investigation of the nature of resistance of water bodies has revealed not only their desire for balance, but also a complex fight against regular and irregular (fluctuations) forces.*
Keywords: *ecosystem; ecosystem safety; stability; anthropogenic impacts; properties; parameters; environment; entropy.*

Introduction

Today, we meet various global ecological problems such as the formation of ozone holes, the elimination of forests, the formation of deserts, the lack of clean water, the appearance of greenhouse effect, the reduction of species of animals and plants). One of the central issues among them is the problem of environmental safety of water bodies (lakes, rivers, reservoirs and seas). In the practice of modern nature management, we do not have the single general method to assess of the non-additive properties of ecological systems: stability, environmental well-being of reservoirs, etc. It makes us seek for techniques and develop the methods for evaluation the non-additive properties of the complex systems in nature and society.

At the end of the 1960s – the beginning of the 1970s the scientific community got interested in the assessment of the stability and variability of natural ecosystems, the ecological well-being of ecosystems at the different levels of the hierarchy, their sensitivity to external impacts.

On the one hand, it can be explained by the successes, achieved by the classical ecology and the rapid development of mathematical ecology. On the other hand we can highlight it by the need for quantitative estimates of man-caused loads on ecosystems, which lead to an «ecological catastrophe». The latter means the destruction of the ecosystem. In addition, we can determine it by the search for non-additive criteria to assess the properties of natural and anthropogenic-transformed complex systems.

Taking into account the above-mentioned, there is a lack of research on the assessment of non-additive properties of various scales of aquatic ecosystems and the need to zone territories and aquatories by the degree of vulnerability to external man-caused impacts.

Purpose of Research

The purpose of the research is to analyse the methods to assess the stability water bodies to change the parameters of natural and anthropogenic regimes.

Results of Research

Stability is a fundamental concept of the ecological systems theory [1]. We use it to find out the maximum permissible level of human intervention in the natural environment.

The stability of aquatic ecosystems means their ability to change under the influence of external factor and to return to their original state after them. There are several properties of this complex phenomenon. So, aquatic ecosystems have different resistance to various types of influence. The single ecosystem can be resistant to one type of violations and unstable to others at the same time. The important property is the emergentism of the stability. Thus, the stability of individual components does not ensure the stability of the entire ecosystem as a whole, but the stability of the ecosystem is always higher than the stability of its subsystems or components.

Thus, the stability of the water body to change the parameters of the regimes is its ability to maintain its properties and parameters of the regime in the conditions of external and internal loads. Therefore, the bodies, which are not able to save their specified properties at the certain time interval of their functioning, are vulnerable to changing the regime's parameters.

There are two methodological approaches to the definition of the concept «stability» in the environmental literature. They differ. The first approach defines stability as the ability of the ecosystem to exist for a long time, saving its basic properties either in a constant environment or in the environment, which changes are not taken into account by the researcher. The second one explains the stability as the ability of the ecosystem to withstand external influences, retaining its properties.

Regarding the above-mentioned, the scientists assess the following properties [2]:

- inertia of the system means the ability of the ecosystem to save the initial state for some time under the influence of external impacts;

- plasticity of the system means the ability of the ecosystem to move from one state of equilibrium to another, retaining internal connections;
- restoration of a system means the ability of the ecosystem to return to its original state after temporary external influences.

The technique of the assessing the stability of water bodies is associated with solving the problem of quantitative description of many processes that determine the properties of ecosystems and the ability of systems to keep these properties unchanged, or to return to the original state after losing it for a while.

The assessment of the stability to the change in the properties of the natural system is not limited only by one property. It is obtained as a result of taking into account many properties, characterized by a large set of evaluation parameters. The physical-geographical and climatic conditions and the nature of anthropogenic influence are key among them. It should also be noted that the stability of aquatic ecosystems of the cyclic (lakes, slightly flowed reservoirs, ponds) and transit (rivers, highly flowing reservoirs) types is determined by the different natural mechanisms. The stability of the first type is called «adaptive», whereas the stability of the second type is «regenerative». In the first case, the most important property of the natural system is its ability to maintain its original state or smoothly transform into another state, preserving internal links (inertia, plasticity). However, in the second case, the ability of the system to restore its properties many times, to return to the initial state after temporary external influence (recovery) plays the leading role. In addition, the abiotic and biotic components of the ecosystem also differ in their mechanisms of stability. The stability of the abiotic components is achieved by physical-mechanical and chemical processes of transferring, dilution, sorption, migration of matter. The stability of the biotic ones is determined by the ability of the adaptation of organisms to influence, caused by the internal resistance of the biochemical organization as well as the ability to biochemical decomposition of toxic compounds and changes in the specific rates of metabolic processes in the ecosystem under the influence of their actions.

The development of the technique of the assessing stability of aquatic ecosystems of the cyclic type is carried out according to the type of adaptive stability, whereas the watercourses and transit aquatic ecosystems is based on the type of regeneration. Researching the patterns of the influence of environmental factors on hydrobionts, it is very important to choose the optimal criteria for the stability of the communities, which should be the basis of the method of its quantitative assessment. Today, within the framework of the above-mentioned concepts of stability, the scientists distinguish its various features, whereas the gradations and the assessment scales of stability are little researched in the Ukrainian and foreign literature. The scholars often apply quantitative characteristics of various forms of stability, which are based on integral indicators of abundance (traditionally - biomass, the number of organisms in the community or biota as a whole, and rarely – the energy indicators). Formally, we can evaluate all forms of stability according to this principle, whereas the stability of the ecosystem, considered without any impact on it, can be analysed only by the degree of constancy of these quantitative characteristics. Obviously, it is not enough. With this basis, it is impossible to obtain environmentally determined norms, regulate and predict any impacts.

Assessing the sustainability of aquatic ecosystems, we get a problem of finding right criteria. We can use a thermodynamic (entropy) concept of stability as one of the approaches. Besides the spatial-temporal structure, the aquatic ecosystem is

thermodynamic. The structure, functions and evolution of the aquatic ecosystem depend on the exchange of matter and energy with the environment, as well as on the relationships among processes that increase or decrease the entropy within the ecosystem [3]. This approach to the assessment of environmental sustainability is based on non-equilibrium thermodynamics. We can choose I. Prihozhin's position as a basic principle [4]. According to it, the states, corresponded to the minimum entropy production in linear non-equilibrium thermodynamics, are automatically stable. If we influence the ecosystem by the perturbation, the entropy production will increase. However, the system will respond by returning to the state with the least entropy production. The limit of the perturbation characterizes the magnitude of the stability of the aquatic ecosystem and the level of its self-organization. With the probability of the development of the process in different directions, which are allowed by the principles of thermodynamics, we can see the realization of the factor that provides a minimum of energy dissipation. So the natural evolutionary development of the aquatic ecosystem is always aimed at reducing the growth of entropy that maintains its environmental sustainability [5]. The process of self-organization begins in the cases of the changing one or more control (bifurcation) parameters, and exceeding certain limits of stability. Thus, the aquatic ecosystem transforms into a new state [6]. Here it becomes stable again. Thus, the aquatic ecosystem that develops in the direction of lowering entropy through its passage or decline in production, is more resistant to external influences.

All processes, which contribute to the growth of the ecosystem's order (condensation, polymerization, compression, crystallization, coagulation, differentiation, or another process, which leads to the decrease of the number of states of matter), are accompanied by a decrease in entropy. Entropy increases with the enlargement of the number of particles and states (dissolution, dissociation, evaporation, peptization, erosion). Depending on the combination of the influence of external and internal factors, the ecosystem can be at different stages of growth, instability and survival. According to the theory of I. Prihozhin [7] the order is formed in a non-equilibrium system of chaos. During this process, the energy of the system dissipates and the so-called dissipative structure spontaneously arises. The dissipation means the decrease in energy in the system and the increase its entropy by itself. However, in non-equilibrium conditions, the energy losses are offset by its external influx, which contributes to the self-organization of the system. It needs prevent the system from equilibrium, which is possible only when it exchanges the material-energy flows with the environment. It is sensitive to external perturbations. Given the non-linearity of the processes, small external perturbations can get stronger and generate large-scale changes in ecosystems [8]. If we denote energy by – ε, the entropy of the ecosystem by – η, and the lower index for variation (δ) is the amount, which, in this case, does not change – energy (ε), the equilibrium criterion will be written as: $(\delta\eta)\ \varepsilon \leq 0$.

It means that for all possible changes in the state of the isolated ecosystem with its constant energy, the variation in the entropy of an equilibrium ecosystem is zero or negative.

To distinguish the types of equilibrium with respect to their stability, we take into account the absolute values of variations (signature by the symbol Δ) that do not neglect infinitely small higher orders.

Then the necessary and sufficient conditions for different types of the ecosystem's equilibrium are formulated in a such a way [9]:

- for stable equilibrium: $(\Delta\eta)\ \varepsilon < 0$;
- for the indifferent equilibrium, there are changes in the state of the ecosystem, for which $(\Delta\eta)\ \varepsilon = 0$;
- In the case of the unstable equilibrium, there are changes in the state of the ecosystem, for which $(\Delta\eta)\ \varepsilon > 0$.

It is quite clear the ecosystem is always in equilibrium if it has the maximum entropy for this energy. In this case, the ecosystem may have several equilibrium states. The state, which corresponds to the highest of the maximum of entropy, has absolute stability.

With anthropogenic pollution of the aquatic environment, the extent of the maximum permissible impact is the volume of pollutants, which can assimilate the ecosystem. Two groups of the mechanisms of the sustainability determine the assimilation capacity. The first one includes the destruction (transformation) and the disposal of pollutants, which lead to their removal from the geochemical cycle. The second group combines the processes of removal outside of this aquatic ecosystem and the conservation (temporary burial) of toxic substances.

The first step in assessing the stability of the aquatic environment to technogenic pollution is to find out the main features that determine the assimilation capacity and balance of entropy. There is some limit significance of man-caused impacts on water bodies. If the system achieves them, it corresponds to a sharp deterioration of the state of the aquatic ecosystem. Thus, the ecosystem loses its stability. Let's imagine that there are perturbations, caused by pollution, in an aquatic ecosystem. It can make the ecosystem be instability. So, we should evaluate the risk of the transformation of the aquatic ecosystem into the state of instability during the period of time. In this case, the risk of instability is the probability of the transition of the aquatic ecosystem from one point of the phase space, where it is at an initial point of time, to the critical area of the space, where the ecosystem becomes unstable. The given model is used to analyse different scenarios and evaluate the probability of transition of the aquatic ecosystem to unstable states.

The numerical significance of the probability characterizes the «risk» of the aquatic ecosystem to become unstable. Recently, the specialists in the theory of stability has been using synergistic ideas about the order and chaos [10].

We can see sudden and cut transitions in the behaviour of the ecosystem, when it reaches the points of bifurcation. There we can highlight the choice of the group of possible trajectories under the influence of small shift of parameters. Such trajectories are unpredictable radically change the pattern of the behaviour of the system. Therefore, the bifurcation is the qualitatively new behaviour of the ecosystem with the small change in its parameters. The example of it can be the evolution of the ecosystem with the development of the trajectory of its movement. In the context of the theory of ecosystem development, we can see rather strange combination of different stages in the process of changing ecosystems, where slow and fast, smooth and sharp phases converge. That is why the subject of the study of synergetics is the significance of the parameters of the system, which determine its bifurcation and self-organization in the new complex structures. In this case, the bifurcation phenomena are always considered by the catastrophe theory, which studies the radical rearrangements of the ecosystem in the process of slow, smooth and small changes in its parameters.

In such ecosystem the scientists distinguish two types of the instability – dynamic and static. The dynamic instability (the effect of «galloping») leads to the chaos and

the complete destruction of the system. To prevent it we should conduct structural changes in it. The static instability is characterized by the jump transition from one equilibrium state of the ecosystem to another (static bifurcation).

We can observe the static instability in ecosystems with a significant and prolonged deviation of two or more variables змінних from optimal ratios. In the catastrophe theory [11] the bifurcation of the state of equilibrium and the involuntary process make the stability be non-equilibrium, caused by the change in the parameter of the ecosystem. With the approximation of the parameter to the bifurcation value, the ecosystem loses the state of equilibrium, going to other equilibrium states or creating the new pair of states of equilibrium. Moreover one of the equilibrium states is stable, another is unstable.

In the catastrophe theory scientists use the ordinary differential equations, applying so-called «strange attractors», which concern the thresholds of stability and «bifurcation points». So, they are associated with the concept of the stability. The peculiarity of the approach is the fact that in the «points of bifurcation» the dynamic system becomes unstable regarding to fluctuations. The transition through the bifurcation point can be considered as the accidental process that can be compared to flipping a coin. Randomness (chaos), in some extent, always governs the dynamics of ecosystems. The role of chaos at bifurcation points is quite significant. At bifurcation points or at critical threshold points, the behaviour of the ecosystem becomes unstable and can evolve into several alternatives corresponding to different steady modes. In this case, we can only deal with opportunities, and nothing will allow us to predict what kind of mode the ecosystem will choose. The simplest bifurcation point corresponds to a situation where a stable state becomes unstable, whereas two other possible stable states arise symmetrically. The scenario of the loss of a stable equilibrium state involves two possible variants that differ in the phase portrait (space of states) of the ecosystem. The first one is the degeneration of the equilibrium position into the limit cycle that means the transition of the state of equilibrium from stable to unstable (Fig. 1, Upper row). The second option is the situation of unstable equilibrium and the ecosystem becomes unstable (Fig. 1, Lower row).

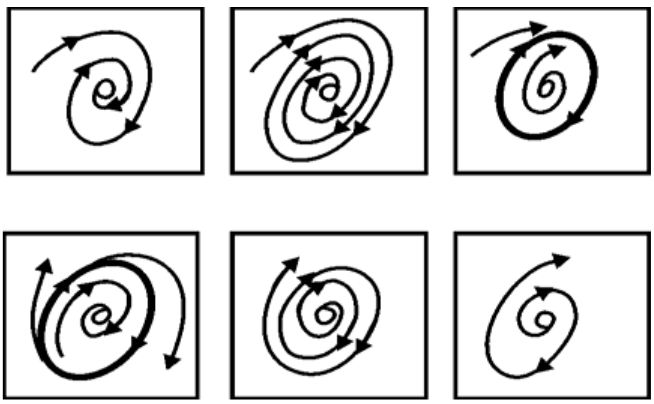

Fig. 1 – Phase portrait of an ecosystem during the loosing of the stability

The first variant is characterized by the slowed-down «swinging» system to its quasi-equilibrium state, which moves from stable to unstable. Such a smooth loss of stability of the equilibrium of the ecosystem will be called soft. We can see it in the nature of the change in equilibrium position by oscillatory periodic processes (Fig. 2)

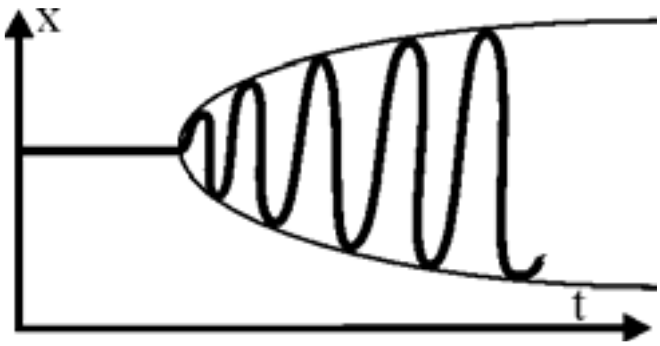

Fig. 2 – Soft loss of the stability of the ecosystem's equilibrium state

Comparing to the first one, the second variant is inherent to the more unstable ecosystem within the high-risk zone. The system with the destructive dynamics deforms and its quasi-equilibrium becomes unstable. The sharp loss of stability of equilibrium is called rigid, which corresponds to a jump-like transition of the ecosystem from stationary behaviour to another mode (Fig. 3).

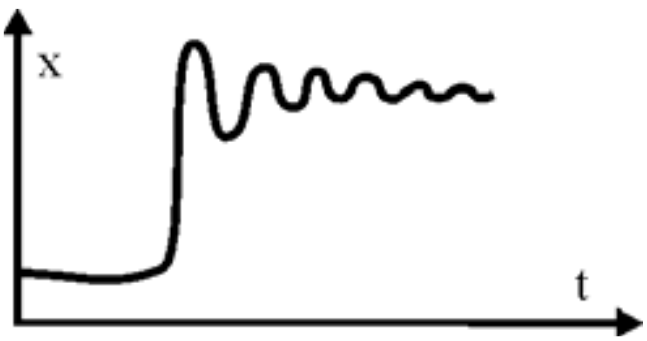

Fig. 3 – Rigid loss of stability of the equilibrium state of the ecosystem

However, in the future the regime, which occupies the ecosystem, may be far from equilibrium or oscillating with a strict period. Therefore it is called the strange attractor (attraction - attracting a lot of phase space) that can be represented by phase divergent, which are curving (Fig. 4).

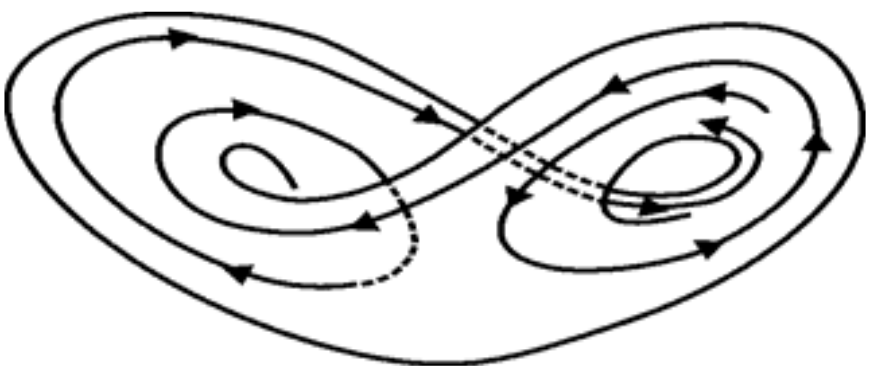

Fig. 4 – Chaotic attractor

Such a process is the dynamic chaos. So it is the non-periodic movement in the deterministic system. The process of transition from the stable equilibrium to a strange attractor can take place both in hard and soft loss of stability, whereas the cycle, which occurs in the second case, loses stability. These non-periodic variations are sensitive to little changes in initial conditions. Maintaining the stability of the averaged characteristics, they reflect the turbulent behaviour of the ecosystem.

Conclusions

Thus, the stability of the aquatic ecosystem is the relative invariance of its properties, which can be observed under the influence of permissible perturbations: the ability of the ecosystem to remain within certain limits, despite the interference with perturbations, provided by the task. At the same time, depending on the field of initial perturbations, the scientists distinguish such types of the stability as «in small», «in large» and «in general». According to the nature of the coincidence of the perturbed state to the unsolvable, we can say about the usual and asymptotic stability. The research of the nature of the water bodies' stability has found out their desire for equilibrium as well as the complex fight between regular and irregular (fluctuations) forces, which makes the achievement of equilibrium in real conditions complicated. Under the influence of perturbations, the chaotic state of the aquatic ecosystem can undergo restructuring, when the choice of its steady state depends on the transition process at moments of the bifurcation.

REFERENCES (TRANSLATED AND TRANSLITERATED)

1. Grodzyns'kyj M.D. Stijkist' geosystem do antropogennyh navantazhen' / M.D. Grodzyns'kyj. – K.: Likej, 1995. – 233 c. (in Ukrainian)
2. Stijkist' ekosystem do radiacijnyh navantazhen' / I.V. Matvejeva, S.I. Azarov, Ju.O. Kutlahmedov, O.V. Harlamova. – K.: NAU, 2016. – 396 s. (in Ukrainian)
3. Strashkraba M., Gnauk A. Presnovodnye jekosistemy. Matematicheskoe modelirovanie. Per. s angl. M.: Mir, 1989. – 376 s. (in Russian)
4. Prigozhin I. Ot sushhestvujushhego k voznikajushhemu. Per. s angl. / Pod red. Ju.L. Klimantovicha. – M.: Nauka, 1985. – 328 s. (in Russian)
5. Prigozhin I. Poznanie slozhnogo. Vvedenie / G. Nikolis, I. Prigozhin : per. s angl. – 2-izd., ster. – M. : Editorial URSS, 2003. – 344 s. (in Russian)
6. Prigozhin I., Stengers I. Porjadok iz haosa (Novyj dialog cheloveka s prirodoj). – M.: izd-vo «Editorial URSS», 2003. – 310 s. (in Russian)
7. Prigozhin, I. Vremja, haos, kvant : per. s angl. / I. Prigozhin, I. Stengers. – M.: Izdatel'skaja gruppa «Progress», 1999. – 268 s. (in Russian)
8. Haken G. Sinergetika. Per. s angl. / Pod red. Ju.L. Klimantovicha, S.M. Osovca. M.: Mir, 1980. – 404 s. (in Russian)
9. Haken G. Sinergetika: Ierarhija neustojchivostej v samoorganizujushhihsja sistemah i ustrojstvah : per. s angl. / G. Haken. – M. : Mir, 1985. – 423 s. (in Russian)
10. Vladimirov V.A. Upravlenie riskom: Risk. Ustojchivoe razvitie. Sinergetika / V.A. Vladimirov, Ju.L. Vorob'ev, S.S. Salov i dr. – M. : Nauka, 2000. – 431 s. (in Russian)
11. Arnol'd V.I. Teorija katastrof / V.I. Arnol'd. – 3-e izd., dop. – M. : Nauka, 1990. – 128 s. (in Russian)

REFERENCES

1. Гродзинський М.Д. Стійкість геосистем до антропогенних навантажень / М.Д. Гродзинський. – К.: Лікей, 1995. – 233 с.
2. Стійкість екосистем до радіаційних навантажень / І.В. Матвєєва, С.І. Азаров, Ю.О. Кутлахмедов, О.В. Харламова. – К.: НАУ, 2016. – 396 с.
3. Страшкраба М., Гнаук А. Пресноводные экосистемы. Математическое моделирование. Пер. с англ. М.: Мир, 1989. – 376 с.
4. Пригожин И. От существующего к возникающему. Пер. с англ. / Под ред. Ю.Л. Климантовича. – М.: Наука, 1985. – 328 с.
5. Пригожин И. Познание сложного. Введение / Г. Николис, И. Пригожин : пер. с англ. – 2-изд., стер. – М. : Едиториал УРСС, 2003. – 344 с.
6. Пригожин И., Стенгерс И. Порядок из хаоса (Новый диалог человека с природой). – М.: изд-во «Едиториал УРСС», 2003. – 310 с.
7. Пригожин, И. Время, хаос, квант : пер. с англ. / И. Пригожин, И. Стенгерс. – М.: Издательская группа «Прогресс», 1999. – 268 с.
8. Хакен Г. Синергетика. Пер. с англ. / Под ред. Ю.Л. Климантовича, С.М. Осовца. М.: Мир, 1980. – 404 с.
9. Хакен Г. Синергетика: Иерархия неустойчивостей в самоорганизующихся системах и устройствах : пер. с англ. / Г. Хакен. – М. : Мир, 1985. – 423 с.
10. Владимиров В.А. Управление риском: Риск. Устойчивое развитие. Синергетика / В.А. Владимиров, Ю.Л. Воробьев, С.С. Салов и др. – М. : Наука, 2000. – 431 с.
11. Арнольд В.И. Теория катастроф / В.И. Арнольд. – 3-е изд., доп. – М. : Наука, 1990. – 128 с.

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АНАЛІЗ СТІЙКОСТІ ВОДНИХ ОБ'ЄКТІВ ДО ДІЇ ДЕСТАБІЛІЗУЮЧИХ ФАКТОРІВ

Анотація. Розроблено методичні підходи до оцінки екологічної безпеки екосистем, які базуються на встановленні комплексного показника деградації компонентів природного середовища, що дозволить оцінювати неадитивні властивості різномасштабних водних екосистем. Проведено аналіз методів оцінки стійкості водойм до зміни параметрів природного і антропогенного режимів. Дослідження природи стійкості водних об'єктів виявило не тільки прагнення їх до рівноваги, а й складну боротьбу регулярних та нерегулярних (флуктуацій) сил.

Ключові слова: екосистема; безпека екосистем; стійкість; антропогенні впливи; властивості; параметри; середовище; ентропія.

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ECOLOGICALLY CLEAN EVAPORATION-CONDENSATION METHOD APPLICATION FOR OBTAINING OF ELECTRICAL CONTACTS BASED ON COPPER COMPOSITE MATERIALS

Abstract. *In this paper is considered the electron-beam technology on new materials creation, including copper and its alloys, as one of the most promising directions of modern electrometallurgy. The formation process of condensed composite materials (CCM) using this technology is absolutely environmentally clean, because it occurs in a vacuum, in addition, similar materials are obtained in a single technological cycle, what is economically profitable.*

It is shown that this method was used for the first time to obtain structural composite materials Cu-Mo, Cu-W, Cu-Cr (massive sheet condensates weighting up to 30 kg separated from the substrate), which were used for electrical contacts and electrodes. The most industrial applications found the condensed from the vapor phase CM of Cu-Zr-Y-Mo and Cu-Cr-Zr-Y-Mo systems for discontinuous electrical contacts.

The mechanical properties of materials of Cu-Zr-Y-Mo system have been studied and it is shown that these materials are characterized by a sufficiently high electrical conductivity, hardness, strength and satisfactory plasticity, and mostly allows to refuse from silver-containing contacts, since they are not inferior, and in some cases exceed them for their operational reliability.

Key words: *method; evaporation-condensation; copper; composite materials; electrical contacts.*

Introduction

Historically, emissions of sulfur dioxide, which amount – 75%...80% of the total amount of pollutants produced during melting in the off-gas, are the most urgent environmental problem connected with the production of copper and its alloys. The main quantities of pollutants, except sulfur dioxide, fall on such elements as dust, nitrogen oxides, carbon monoxide generally presenting emissions of non-ferrous metallurgy enterprises and copper smelters in particular.

The presence of gases, vapors, particles of liquid and solid substances in the air adversely affect man and the surrounding biosphere. In terms of dust emissions, non-ferrous metallurgy is also one of the main polluting industries, its part is 2.8%. Therefore, to capture emissions of process gases in the production of copper and its alloys, more attention is paid to thorough design of process plants and processes, which requires additional material expenses and, accordingly, leads to a rise of the production process cost.

Main part

Modern technology requires for its development the elaboration of new and improvement of existing materials using production methods that do not harm the surrounding atmosphere [1]. One of such promising directions for creating fundamentally new materials, including copper and its alloys, is electron-beam technology [2, 3]. The process of condensed composite materials (CCM) formation is absolutely environmentally clear, as it occurs in a vacuum, in addition, similar materials are obtained in a single technological cycle, what is economically profitable.

Evaporation and subsequent condensation of metal and non-metal in vacuum is a relatively new scientific and technological direction in materials science. Until recently, evaporation-condensation processes exclusively were used as application of protective coatings (corrosion-resistant, heat-shielding, etc.) on products. For the first time this method was used in the SPE "Eltechmash" to produce constructional composite materials Cu-Mo, Cu-W, Cu-Cr (massive sheet condensates weighing up to 30 kg separated from the substrate), which were applied for electrical contacts and electrodes. For the first time, it has become possible to obtain bulk (massive) nanocrystalline materials at a deposition temperature above 300^{o}C, which have a complex of properties that are not specific of traditional polycrystalline materials (Fig. 1).

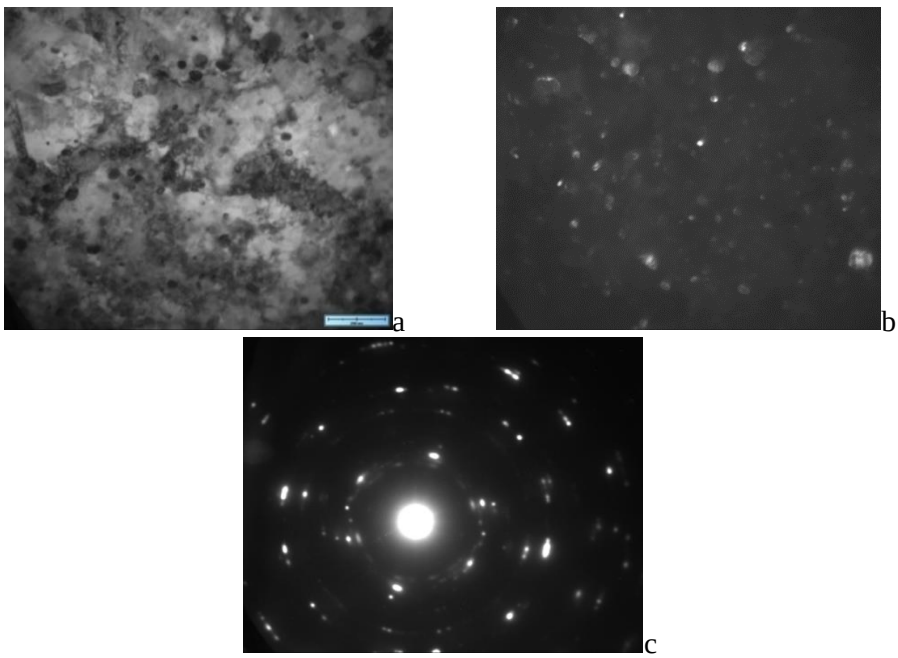

Fig. 1 – Light-field (a), dark-field (b) electron microscopic image of the structure and microelectronogram (in) CM (Cu-0.1% Zr, Y) -8-12% Mo

Application of CCM mostly allows to refuse from silver using, as the Cu-W contact materials are not inferior, and in some cases exceed the silver-containing compositions in terms of their operational reliability. Their cost is approximately in 1.5–1.7 times lower compared to powders and in 2–2.5 times lower compared to silver-containing compositions, and according to operational characteristics they correspond to them or 1.5 times higher depending on operating conditions.

To produce composite materials for electrical contacts, industrial equipment (installation L-5) has been developed (Fig. 2).

This makes it possible to produce about 12 tons of condensed composite materials per year, from which about 1 million electrical contacts and various electrodes can be produced (Fig. 3). Payback of such equipment is 2–3 years.

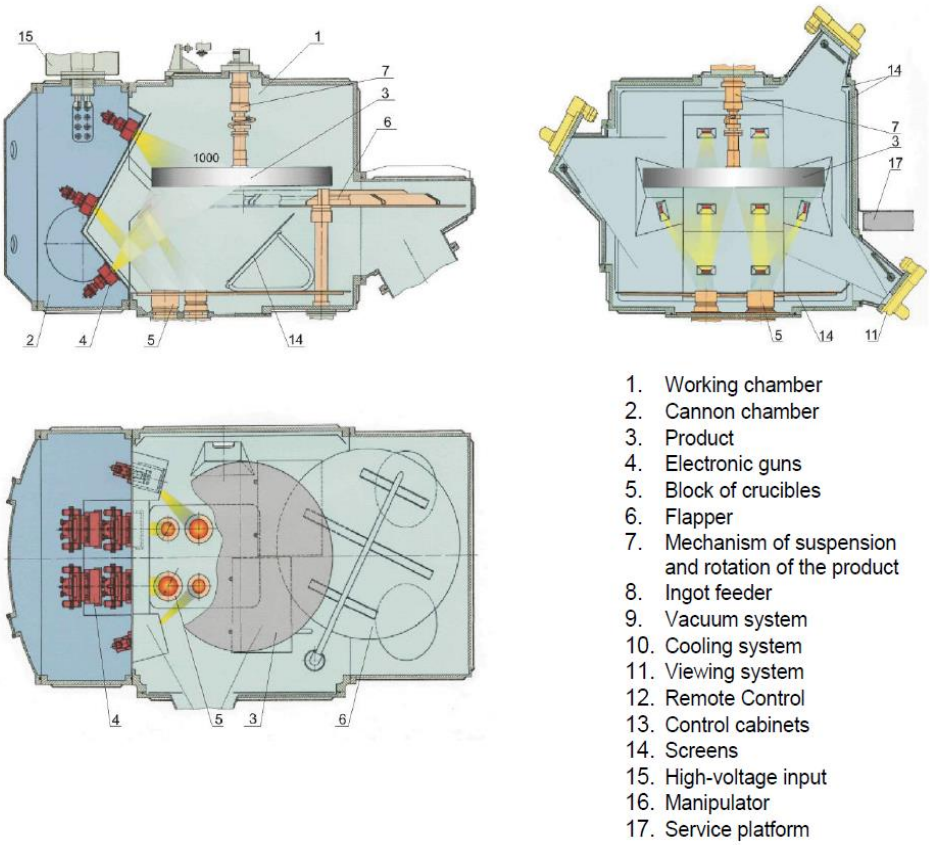

Fig. 2 – Installation L-5 scheme

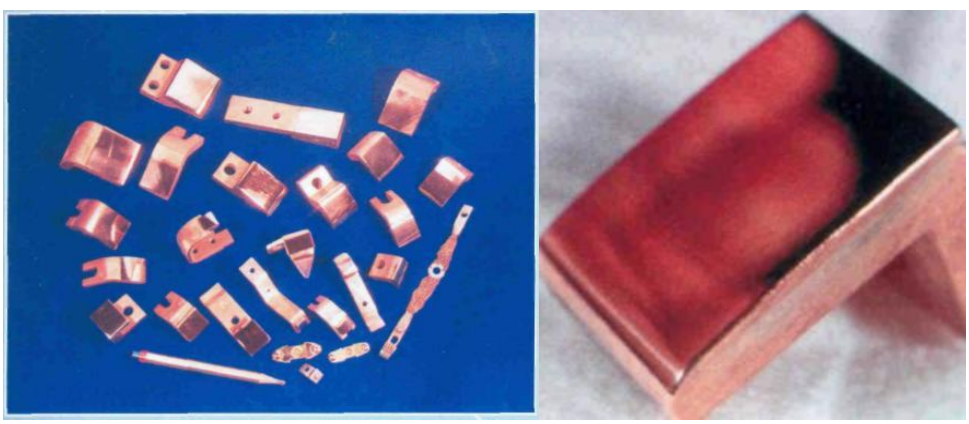

Fig. 3 – Types of electrical contacts

The condensed CM from the vapor phase of Cu-Zr-Y-Mo and Cu-Cr-Zr-Y-Mo systems found the largest industrial applications for discontinuous electrical contacts [4]. Materials, which received the name of MDK, are certified and manufactured in accordance with the technical specifications TCU 20113410.001-98, ISO-2009. Patents of Ukraine and the Russian Federation [4–7] protect the technology of their manufacture. These materials are characterized by a sufficiently high electrical conductivity, hardness, strength and satisfactory ductility (Table 1).

Table 1 – Physical, chemical and mechanical properties of CM on the base of Cu-Zr-Y-Mo

chemical composition, % mass.	density, γ, kg/m^3	electrical resistivity, ρ, μOm*m	Micro-hardness HV	Mechanical properties					
				Before annealing			After annealing, 300°C, 1h		
				$\sigma_{0,2}$, МПа	$\sigma_в$, МПа	δ,%	$\sigma_{0,2}$, МПа	$\sigma_в$, МПа	δ,%
Cu-Zr-Y 3-5% Mo	8980-9000	0,021-0,022	1000-1500	210-370	300-430	10,3-7,3	200-360	295-420	17,6-9,5
Cu-Zr-Y 5,1-8% Mo	9000-9050	0,022-0,024	1500-1650	380-530	440-630	7,25-3,4	365-510	425-600	9,45-4,9
Cu-Zr-Y 8,1-12% Mo	9050-9100	0,024-0,028	1650-1800	550-750	635-785	3,25-1,8	520-695	605-730	4,85-3,9
Cu-Cr- Zr-Y 8,1-12% Mo	9050-9100	0,026-0,030	1650-1800	560-760	641-792	3,21-1-7	531-699	618-742	4,70-3,6

A number of specialized electron beam devices for metals and alloys smelting and refining are known [1, 8], deposition of protective coatings [9–11], obtaining of massive composite materials separated from the substrate [12].

The design and manufacture of specialized electron beam installations is not always economically viable, since only a certain scientific and technological problem can be solved on this type of equipment (for example, the development of new types of protective coatings).

Conclusions

The creation of universal equipment that allows, after a small adjustment, to solve a number of applied research tasks is more promising. A distinctive feature of such equipment is the possibility of implementation, on one installation, the majority of typical technological processes, which are currently being implemented with the help of various special-purpose electron beam systems. Cleaning of the installation with the ion-cleaning device and the process gas inlet system also expands the technological capabilities of the equipment for carrying out experimental work to improve the technologies for obtaining protective coatings.

The developed contact materials based on copper and molybdenum as silver substitutes (containing no noble metals) (TCU 31.2-20113410-003-2002) passed successful industrial tests at more than 200 enterprises in Ukraine, Russia, Poland, Romania, Georgia, etc. Contact areas made of these materials (MDK-3, TCU 24.4-33966101-001: 2014) are successfully operated with alternating voltage and currents from 1 to 1000 A.

The technological problem of foundations developing for high-speed evaporation of copper through a zirconium-yttrium intermediary bath was solved in the process

of this work implementation, so that the evaporation rate of the steam flow increased to 60 μm/min and specified materials have become competitive with similar compositions obtained by powder metallurgy techniques.

REFERENCES

1. Electron beam melting in foundry / Edited by S.V. Ladohin – K.: Publishing house "Steel", 2007 – 626 p.
2. Movchan B.A. Inorganic materials deposited from the vapor phase in vacuum // Modern Materials Science in the 21st Century. – K.: Naukova dumka, 1998. – P. 318–332.
3. Grechanuyk N.I., Kycherenko P.P., Grechanuyk I.N. The new electron-beam equipment and technologies for modern materials and coatings obtaining. Automatic welding №5 (649), may 2007. – P. 36–41.
4. Patent of Ukraine № 74155. A method of a microspherical heat-resistant material obtaining / N. I. Grechanuyk: 15.11.2005, Bul. № 11.
5. Patent of Ukraine № 34875. Composite materials for electrical contacts and method of its production / N.I. Grechanuyk, V.O. Osokin, I.B. Afanasiev, I.N. Grechanuyk: 16.12.2002, Bul № 12.
6. Patent of Ukraine № 86434. Composite material for electrical contacts and electrodes and method of its production / N.I. Grechanuyk, I.N. Grechanuyk, V.A. Denisenko, V.G. Grechanuyk: 27.04.2009
7. Positive decision on application № 4317/3A/13 from18.02.2013. Composite materials for electrical contacts and methodof its production / N.I. Grechanuyk, V.G. Grechanuyk, R.V. Minakova, ets.
8. Movchan B.A., Tihonovskiy A.L., Kyrakov U.A. Electron beammelting and refining of metals and alloys. – Kiev: Naukova dumka, 1973. – 239 p.
9. Pap P.A., Malashenko I.S., Ivanov A.M. Laboratory installation for the production of protective coatings for various purposes by electron beam condensation in a vacuum. Special electrometallurgy. – 1975. – 27, P. 98–104.
10. Movchan B.A., Malashenko I.S. Heat-resistant coatings, precipitated in vacuum. Kiev: Naukova dumka. 1983. – 230 c.
11. Movchan B.A., Yakovchuk K.U. Electron-beam devices for evaporation and deposition of inorganic materials and coatings. Modern electrometallurgy. – 2004. – № 2. P. 10–15.
12. Scherbitskiy V.V., Grechanuyk N.I., Kycherenko P.P. Electron-beam installation for obtaining multilayer materials. Problems of special electrometallurgy. 1982. – 16, P. 51–53.

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ЗАСТОСУВАННЯ ЕКОЛОГІЧНО ЧИСТОГО МЕТОДУ ВИПАРОВУВАННЯ-КОНДЕНСАЦІЇ ДЛЯ ОТРИМАННЯ КОМПОЗИЦІЙНИХ МАТЕРІАЛІВ НА ОСНОВІ МІДІ ДЛЯ ЕЛЕКТРИЧНИХ КОНТАКТІВ

Анотація. В роботі розглянута електронно-променева технологія зі створення нових матеріалів, в тому числі на основі міді та її сплавів, як один з найбільш перспективних напрямків сучасної електрометалургії. Процес формування конденсованих композиційних матеріалів (ККП) за цією технологією є абсолютно екологічно чистим, оскільки відбувається у вакуумі, крім того, подібні матеріали отримують за один технологічний цикл, що економічно вигідно.

Показано, що даний метод вперше використаний для отримання конструкційних композиційних матеріалів Cu-Mo, Cu-W, Cu-Cr (масивних листових конденсатів вагою до 30 кг, відокремлених від підкладки), які було застосовано для електричних контактів і електродів. Найбільше промислове застосування знайшли конденсовані з парової фази КМ системи Cu-Zr-Y-Mo і Cu-Cr-Zr-Y-Mo для розривних електричних контактів.

Досліджено механічні властивості матеріалів системи Cu-Zr-Y-Mo і показано, що зазначені матеріали відрізняються досить високою електропровідністю, твердістю, міцністю і задовільною пластичністю, що дозволяє в значній мірі відмовитися від використання контактів, що містять срібло, так як зазначені матеріали не поступаються, а в деяких випадках перевершують їх за своєю експлуатаційною надійністю.

Ключові слова: метод; випаровування-конденсація; мідь; композиційні матеріали; електричні контакти.

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ECOLOGICAL SAFETY OF TERRITORIES AT INTRODUCTION OF MODERN TECHNOLOGIES OF PROCESSING OF VEGETABLE WASTES

Annotation. *Work is devoted to the decision of research and practice task from the ground of changes of the state of ecological safety of territories at introduction of modern technologies of processing of vegetable wastes. The worked out practical recommendations are in relation to reduction of negative influence on the environment of vegetable wastes that is passed for introduction in further activity in relation to providing of ecological safety of territories.*
Key words: *ecological safety of territory; vegetable wastes; treatment vegetable wastes.*

Introduction

Providing ecologically and technically safe terms of vital functions of society attributed to priority national interests, because a present ecological situation in Ukraine is characterize as difficult.

The feature of the ecological state in Ukraine is that ecologically sharp local situations become complicate by regional crises with her protracted medico-biological, economic, ecological and social consequences. Relations in relation to providing of ecological safety closely constrained with the rational and effective use of natural resources, with the use of ecologically dangerous territories and objects that stipulates the complexity of maintenance of concept of ecological safety. That includes for itself, the guard of natural environment: a) the certain state of natural object (safety of nature) and b) system of guarantees of the state to the citizens on providing of normal vital functions of human.

The decision of problem of providing of ecological safety of territory at introduction of modern technologies of processing of vegetable wastes is in the first turn related to the choice of general conception of further development of the state.

Analysis of previous researches and publications

Analyzing the modern state of ecological safety of territories and handling wastes of production and consumption it is possible to assert that: design of changes of the state of ecological safety, what would take into account quality of environment and condition of residence, their influence on mean time of life is not would prove to practical application. Such Ukrainian and foreign scientists and practices did a ponderable contribution to research of problems of ecological safety of the inhabited territories: Adamenko O.M., Bilyavskiy G.O., Babyak O.S., Iliin O.J., Drawn M.C., Safronov T.A., Ushakov E.P.

Basic part

Existent procedures of evaluation of the state of ecosystem of any region of settlement at building or reconstruction of industrial enterprises are took to verification of the possible exceeding maximum of possible concentrations of toxic substances in up casts and extras of enterprise.

The ecological constituent of steady development of countries is estimated by means of the known index of ESI (Environmental Sustainability Index is an index of ecological constancy, first presented in 2001 in Davos), offered by Center on an eco-law and politics of Yale University (USA). It is form from a 21 ecological indicator that in turn settled accounts based on the use 76 sets of ecological data:

- about the state of natural resources in a country,
- levels of contamination of environment in the past and today,
- efforts of country in relation to a management,
- possibility of country to improve ecological descriptions and others like that, the ecological state [1].

System of ecology of management has fully certain differences from the system of ecology of production. Under an ecology, managements understand the process of steady and successive introduction of the systems of technological, administrative and other decisions that allow to promote efficiency of the use of natural resources and terms equally with an improvement or even maintenance of quality of natural environment (or in general vital environment) on local, regional and global levels.

Under the system, a management understands element of organizational structure in that the systems of financing, planning, and control are included after producing of products, account, grant of services and others like that. A main problem in organization of control system consists in the exposure of measure of accordance of existent factors of the systems of strategy of development of object, with those that is set.

At conducting a ranking of methods of utilization and processing of wastes of phytogenous on results there in flounce on a natural environment, mark results (table 1).

Table 1 – Results of ranging of methods of processing of vegetable wastes are on results influence on an environment

№	Name of method of processing of vegetable wastes	Consequences of influence of method of processing of vegetable wastes are on ecological safety of territory
1	2	3
1	Sorting of organic wastes of phytogenous	Harmful effect on a natural environment on the whole and on a health man in particular minimized during a simultaneous exception potentially of dangerous and harmful components
2	Destruction of vegetable wastes is in a catalytic environment	The extras of hazardous substances considerably below than maximum possible concentrations
3	Anaerobic fermentation is with a receipt and utilization of biogas	Harmful effect of biogas on the environment and human health depends on his concentration in atmospheric air and sentinel period of breathing in this product

Table 1 continuation

1	2	3
4	Punching	Contamination of objects of hydrosphere and fertile epiphaseofsial hazard – to soil, incomplete taking into account of properties, composition and state headstock
5	Method of heat treatment of vegetable wastes to incinerations	Contamination of atmosphere hazard with high probability of further contamination of objects of hydrosphere and soil, exceeding maximum of possible norms of extras of carcinogenic dioxins and furan. Elimination of valuable components, high exit of ash and slags, incomplete taking into account of properties, composition and state of feedstock, decline of immunity of population and animals that live in a radius 30–50 kilometers, high maintenance of dioxin in pectoral milk of mothers; complication of stabilizing of process of incineration.

The results of the conducted procedure of ranking witnessed that most dangerous for a natural environment on the whole and for the health of population of territory there is a method of heat treatment of vegetable wastes by means of incineration. The friendliest to the environment and health of population are two methods. Method of sorting of wastes with a simultaneous exception as potentially dangerous so valuable components and method of destruction of organic wastes of phytogenous in a catalytic environment [2].

For realization of effective management of territory ecological safety the map-chart of distribution of areas of Ukraine is use after ecological strength security (fig. 1).

One of dangerous for an environment and health of humanity of problems there is an accumulation of various wastes in the process of vital functions and productive activity of man that in the whole world grows rates that pass a head their processing, disinfestation and utilization.

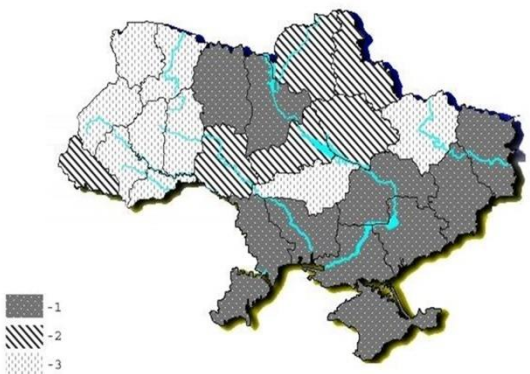

Fig. 1 – Map chart of distribution of territories of Ukraine after administrative distribution for to ecological strength of territories securities in obedience to the conducted calculations for 2015: 1 – crisis, 2 – передкризовий, 3 – normal

Thus, to provide acceptable to quality life of society and steady development of territories ecological strength security and to decrease negative in fluency of wastes on a natural environment overall and on the state of health of population in particular,

it is necessary to develop new technologies in industry of handling wastes or to perfect already existing.

Wastes of consumption or hard domestic wastes have various morphological composition. In composition contained on the average 30 organic wastes of phytogenous [3].

Results of conducted ranking of methods of processing of vegetable wastes, witnessed that the most favorable in ecological sense methods of processing and utilization of vegetable wastes are two methods. Sorting with the simultaneous exception of components, that can threaten to both the health of population and environment on the whole and destruction of organic wastes of phytogenous in a catalytic environment. Leaning on the results of conducted ranking of methods of processing of vegetable wastes after the degree of their influence on a natural environment, offered recommendations in relation to reduction of negative influence of vegetable wastes on ecological safety of territories of compact residence of population.

Based on undertaken scientific studies research and practice recommendations are work out in relation to the evaluation of changes of the state of ecological safety of territories at introduction of modern technologies of processing of vegetable wastes.

At prognostication of indexes of ecological safety of the inhabited territory, it is needed to apply the procedure, based on Bayes' theorem taking into account the complex of indexes that characterize the state of ecological situation and totality of parameters of natural environment.

During realization of the activity related to handling organic wastes of phytogenous, it is expedient to apply reasonable methodology of ranking of the pre-arranged methods of utilization of wastes on the indexes of negative influence on a natural environment overall and on a health population that lives on concrete territory.

The worked out technological analysis of organic wastes of phytogenous taking into account factious composition of plant it is expedient to use for determination of method of processing of concrete part of plant and application of finish good domain from her.

To promote ecological strength of territory of compact residence of population security during handling vegetable wastes it is necessary by means of combination of method of sorting of wastes with a simultaneous exception from them both ecologically dangerous and valuable components, destructions of these wastes in a catalytic environment and also method of their processing on one territory.

Conclusions

For prognostication of indexes of ecological safety of territory at handling vegetable wastes, the modified procedure based on the use of Bayes' theorem is involved. Authentication of dynamics of changes of her indexes is take to the analysis of supervisions and comparison of results.

The distribution of areas of Ukraine evidently represented on a map-chart on three groups after ecological strength security is use for realization of effective management of the inhabited territories ecological safety at handling wastes of phytogenous.

REFERENCES

1. Ecology of Gusyatin district. Monograph / V.M. Trysnuk // Ternopil, Ternograph, 2004. 219.
2. Ecological safety of techno-natural geosystems of region / V.M. Trysnuk, O.M. Trofimchuk, T.V. Trysnuk // Announcer Vinnytsya polytechnic institute. – Vinnytsya, 2015 – №5 (122). 30–34.
3. Monitoring of places of formation, storage and moving away of wastes is for the design of changes of the state of ecological safety of city. M.M. Lebedev, K.E. Muhina – 2008, № 3–4. 54–56.

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В.М. Триснюк

ЕКОЛОГІЧНА БЕЗПЕКА ТЕРИТОРІЙ ПРИ ВПРОВАДЖЕННІ СУЧАСНИХ ТЕХНОЛОГІЙ ПЕРЕРОБКИ РОСЛИННИХ ВІДХОДІВ

Анотація. Робота присвячена вирішенню науково-практичної задачі на підставі змін стану екологічної безпеки територій при впровадженні сучасних технологій переробки рослинних відходів. Розроблені практичні рекомендації стосовно зменшення негативного впливу на навколишнє середовище рослинних відходів, що передаються для впровадження у подальшу діяльність щодо забезпечення екологічної безпеки територій.

Ключові слова: екологічна безпека території; рослинні відходи; обробка рослинних відходів.

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VIBRODINAMIC MONITORING OF PILE FOUNDATION ENGINEERING ON LANDSLIDE HAZARDOUS SITE IN DENSE URBAN DEVELOPMENT CONDITIONS

Abstract. *An example of the application of modern regulatory requirements for the scientific and technical support of construction and monitoring of building structures for the safe arrangement of the pile foundation on a landslide hazardous building site in conditions of dense urban development in Kyiv during the installation of a Ø820 mm bored pile according to the plan of the pile field has been considered. Experimentally registered levels of vibration acceleration on the foundation wall of the building in the vertical and horizontal directions do not exceed 0.015 m/s², which is significantly lower than the minimum permissible values of vibration acceleration for the foundations of buildings with brick bearing walls 0,15 m/s². The research also evaluated the presence of visible damage to the building in the available places and their possible development before and after piles placement. The condition of the plaster screed on a vertical crack in the wall of the house on the 8th floor, which was installed before the start of construction work, after pile foundation installation has not changed – it remained undamaged.*
Key words: *safety; monitoring; pile; technical condition; sensor; vibroacceleration.*

Introduction

The general condition of the construction sites in Ukraine does not ensure safe living conditions for citizens and society due to the increased risk of emergencies [1]. The increase in the buildings and constructions height, break with symmetric forms, constant increase in the technogenic load on the site during construction in conditions of dense urban development enhance the likelihood of disasters conditions. First of all, it regards Kyiv where there are numerous examples of such violations:

1. In the center of Kyiv there have been another construction scandal regarding construction of "Elegant" residential development in dense urban development conditions on 118, Zhilyanskaya street [2]. At the beginning of construction process the neighboring five-storey house cracked during the pile driving, the tenants had to be resettled. As a result, an old five-story mansion and a one-storey building next to it on 120-V Zhilianskaya street was broken down and a huge trench was dug on this site. Residents of nearby houses are afraid that the walls of their houses will collapse – the cracks have already appeared on the upper floors [3].

2. Residents of houses number 3, 5, 5a, 7 on Lesya Ukrainka bvld. and three more houses along Mechnikov Street were united by one problem – the construction in their yard. Houses are built on a landslide slope. Delicate balance can be disrupted by any intervention of construction equipment. Houses on Lesya Ukrainka bvld. will simply slide down to Mechnikov Street [4].

3. On 7, Marjanenko lane crack opening in the house walls coincides with the beginning of excavation for a residential complex on 9 and 11 Mechnikova street. The state of the house was affected immediately by two construction sites – 9a and 11 Mechnikov street and 12a Klovskiy uzviz street as well

The above examples are just the tip of the iceberg of constantly increasing number of ground displacements and catastrophes across Ukraine both in terms of their number and in terms of economic losses scale. There is an acute need for monitoring and scientific and technical support for new constructions taking into account the fulfillment of the requirements of new regulatory documents for soil accidents prevention in future [5].

Over the past 10 years State Enterprise "State Research Institute of Building Constructions" gave much attention to both the regulatory and methodological support and to construction monitoring systems implementation. During this time, a number of regulatory documents considering building structures monitoring issues have been developed:

1. State Construction Standard DBN B.1.2-5: 2007 "The scientific and technical support of construction sites" [6].

2. DBN B.1.2-12-2008 "Construction in conditions of dense urban development. Safety requirements" [7].

3. DBN B.1.2-14-2009 "General principles of reliability and buildings, structures and foundations structural safety ensuring" [8].

All of the above documents were a basis for new final document National Standards of Ukraine DSTU-B B.1.2-17: 2016 "Guidance on scientific and technical monitoring of buildings and constructions" [9], which was developed under scientific supervision of prof. Yu.I. Kaliukh as well as complex of standards for buildings and constructions technical diagnostics systems [10]. Construction standards [9] include all the main methodological instructions and developments on

the scientific and methodological basis, design and experimental development of construction monitoring systems [6–8, 10–11] that were put into effect on 01.04.2017. Guidance [9] was developed in harmonic accordance with international building standards fib [12]. In [9], as in the document fib [12], the classification of construction monitoring systems is the same (see Figure 1 [12]).

Theoretical and methodological issues of the design and organization of monitoring research are analyzed in the works of modern foreign scientists Sassa K., Casagli N., Catani F., Lu P., Mikoš M., Željko A. and others [13–18]. Among the Ukrainian scientists, one should note the researches by associate member of NAS of Ukraine, prof. O. Trofimchuk and prof. I. Kaliukh on theoretical and methodological background of monitoring systems concept, their design and experimental development in practice in construction and geotechnics [19–23], as well as studies in this direction of their students: Kaliukh T. [24], Polevets'kyi V. [25], Klymenkov O. [26], Khavkin K. [27], Berchun Ya. [28], et al.

Main points

Let's consider an example of modern regulatory requirements application for scientific and technical support for building structures construction and monitoring [6–11] for safe arrangement of the pile foundation on a landslide hazardous construction site in conditions of dense urban development at the address 14, Pimonenka street in Kyiv during the installation of a bored pile № 87 Ø820 mm in accordance with the pile field plan. The work area with a well for the bored pile is at a distance of 18–20 m from the nine-storey residential brick building. The area of the construction site is below the level of adjacent to the building area, on the boundary of which there is a retaining wall made of concrete blocks in height ≈ 5 m. The mutual location of the building, the retaining wall and the construction site is presented in Fig. 1

Fig. 1 – Investigated building and retaining wall view

Fig. 2 – Chalky screed state after pile installation

According to the present DBN [6–11] the inspection of technical condition of the building structures of the nine-storey building was performed in advance, prior to conducting drilling works, (Fig. 1). During the study of the technical condition of building constructions, the presence of visible damage in the places available for this site and their possible development before the works beginning, during and after the installation of the piles were assessed. The monitoring of the impact on building of drilling operations was monitored not only instrumentally, but also visually, by periodic observations during the arrangement of the bored pile № 87 Ø820 mm taking into account the integrity of the chalky screed on a vertical crack in the bearing brick wall of the house on the 8th floor. The screed was installed in advance, prior to drilling operations beginning (see Fig. 2).

Well drilling was performed by the BAUER 40 BG drilling rig (Fig. 3). In the photo (Fig. 4) there is a view of the investigated building, including the retaining wall on the side of the construction site. During the research period, one drilling rig BAUER 40 BG (Fig. 3) worked on the site.

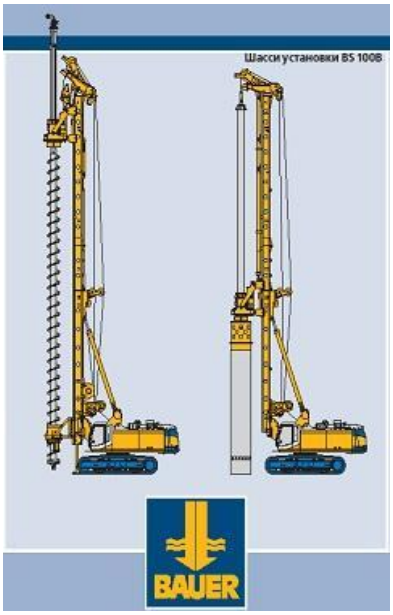

Fig. 3 – Rotary drilling rig BG 40

Fig. 4 – Construction site location near the building toe 14, Pimonenko street (view from the flat on the 9th floor)

The vibration sensors were located on the foundation part of the building (3 vibration sensors), fixed oriented towards X, Z and Y directions (Fig. 5); two vibration sensors that were located on the floor of the 9th floor of the house were oriented towards X, Z or Y, Z directions (Fig. 6). The change in the orientation of the vibration sensors for the measurement of vibration acceleration was conducted in concert with the moment of their registration.

Fig. 5 – Vibration sensors № 1, № 2, № 3 for foundation oscillations registration towards X, Z and Y directions

Fig. 6 – Vibration sensors № 4 and № 5 for registration of oscillations of the top 9th floor of the building towards X, Z or Y, Z directions

Results

With the help of "Seismic monitoring" software [29] the initial experimental results were processed, that are represented in the table.

Table – The values of vibration acceleration (typical and peak) of the building foundation part (sensors № 1, № 2 and № 3) and the upper 9th floor of the building (sensors № 4 and № 5)

№	Monitoring time	Grade, soil	Max values of vibration accelerations	Drilling practice
1	2	3	4	5
1	10.44	0 m; Clay	№ 1 - 0.0005, 0,002-0.004 (X)	Silence regime record
			№ 2 - 0.0005, 0,002-0.004 (Z)	
			№ 3 - 0.0002, 0,002-0.004 (Y)	
			№ 4 - 0.0001, 0,002-0.003 (X)	
			№ 5 - 0.0005, 0,002-0.004 (Z)	
2	10.59	0 m; Clay	№ 1 - 0,002-0,004 (X)	Drilling start Well drilling
			№ 2 - 0,001-0,005 (Z)	
			№ 3 - 0,001-0,002 (Y)	
			№ 4 - 0,001-0,005 (X)	
			№ 5 - 0,001-0,002 (Z)	
			№ 2 - 0,001-0,003 (Y)	
			№ 3 - 0,001-0,002 (Z)	
			№ 4 - 0,001-0,002 (X)	
			№ 5 - 0,0005-0,001 (Z)	
3	11:18	4-5 m; Clay	№ 1 - 0,001-0,003 (X)	Well drilling
			№ 2 - 0,001-0,003 (Z)	
			№ 3 - 0,001-0,002 (Y)	
			№ 4 - 0,001-0,002 (X)	
			№ 5 - 0,0005 (Z)	

Table continuation

1	2	3	4	5
4	11:20	6-7 m; Clay	№ 1 - 0,001-0,003 (X)	Well drilling
			№ 2 - 0,001-0,006 (Z)	
			№ 3 - 0,001-0,002 (Y)	
			№ 4 -0,002-0,0025 (X)	
			№ 5 -0,0005-0.001 (Z)	
5	11:22	8 m; Clay	№ 1 - 0,001-0,002 (X)	Microseismic background. Tube timbering lengthening
			№ 2 - 0,001-0,003 (Z)	
			№ 3 - 0,001-0,002 (Y)	
			№ 4 - 0,001-0,002 (X)	
			№ 5 - 0,0005-0,001 (Z)	
6	11:28	8 m; Clay	№ 1 - 0,002-0,001 (X)	Motion of a drilling rig with tube timbering
			№ 2 - 0,001-0.0035 (Z)	
			№ 3 - 0,001-0,002 (Y)	
			№ 4 - 0,0015-0,001 (X)	
			№ 5 - 0,0005 (Z)	
7	11:40	9-10 m, Clay	№ 1 - 0,0015-0,004 (X)	Tube timbering spudding with further drilling
			№ 2 - 0,001-0,005 (Z)	
			№ 3 - 0,002-0,003 (Y)	
			№ 4 - 0,001-0,005 (X)	
			№ 5 - 0,002-0,0005 (Z)	
8	11:56	14-16 m, Clayed sand	№ 1 - 0,001-0,002; 0,006 (X)	Well drilling
			№ 2 - 0,001-0,002; 0,006 (Z)	
			№ 3 - 0,001-0,002 (Y)	
			№ 4 - 0,001-0,0015 (X)	
			№ 5 - 0,0003 (Z)	
9	12:05	16 m, Clayed sand	№ 1 - 0,001-0,0015 (X)	Microseismic background. Tube timbering lengthening
			№ 2 - 0,0005; 0,002 (Z)	
			№ 3 - 0,0005 (Y)	
			№ 4 - 0,0005; 0,003 (X)	
			№ 5 - 0,0005 (Y)	
10	12.50	17-18 m, Clayed sand	№ 1 - 0,006-0,008 (X)	Well drilling
			№ 2 - 0,004; 0,001-0,003 (Z)	
			№ 3 - 0,001-0,003; 0,015 (Y)	
			№ 4 - 0,0035 (X)	
			№ 5 - 0,0005; 0,0015 (Z)	
11	12:54	18-19 m, Clayed sand	№ 1 - 0,006 (X)	Well drilling
			№ 2 - 0,001-0,003; 0,004 (Z)	
			№ 3 - 0,0025-0,0015; 0,005 (Y)	
			№ 4 - 0,002-0,004 (X)	
			№ 5 - 0,0005; 0.003 (Z)	
12	12:56	19-20 m, Clayed sand	№ 1 - 0,006 (X)	Well drilling
			№ 2 - 0,002-0,005 (Z)	
			№ 3 - 0,0025-0,003; 0.006 (Y)	
			№ 4 - 0,0025 (X)	
			№ 5 - 0,0025 (Z)	

Table continuation

1	2	3	4	5
13	13:22	22 m, Watered clayed sand	№ 1 - 0,001-0,003 (X)	Well drilling
			№ 2 - 0,001-0,006 (Z)	
			№ 3 - 0,001-0,002 (Y)	
			№ 4 - 0,001-0,0025 (X)	
			№ 5 - 0,0005-0,003 (Z)	
14	13:36	24-25 m, Watered clayed sand, Red clay	№ 1 - 0,001-0,0015 (X)	Well drilling
			№2 - 0,0005; 0,002 (Z)	
			№ 3 - 0.0008 (Y)	
			№ 4 - 0,0005-0,002 (X)	
			№ 5 - 0,004; 0,0005 (Z)	
15	14:04	28-30 m, Hard marl	№ 1 - 0,001-0,002 (X)	Well drilling
			№ 2 - 0,001-0,002 (Z)	
			№ 3 - 0,001-0,002 (Y)	
			№ 4 - 0,0025-0,001 (X)	
			№ 5 - 0,0003 (Z)	
16	14:32	32-33 m, Waterlogged marl, Hard clay	№ 1 - 0,001-0,004 (X)	Well drilling
			№ 2 - 0,0005-0,003 (Z)	
			№ 3 - 0,001-0,002 (Y)	
			№ 4 - 0,0025-0,001 (X)	
			№ 5 - 0,0005 (Z)	
17	14:43	35-36 m, Compacted marl	0,0008-0,0015 (X)	Well drilling
			0,001-0,002 (Z)	
			0,001 (Y)	
			0,001; 0,002 (X)	
			0,0005 (Z)	
18	15:13	37-38 m, Marl	0,001-0,002; 0,004 (X)	Well drilling
			0,001-0,0015; 0,005 (Z)	
			0,001-0,0015; 0,003 (Y)	
			0,001; 0,002 (X)	
			0,0035 (Z)	
19	15:26	38-39,5 m, Marl	0,001-0,002 (X)	Well drilling
			0,001-0,002 (Z)	
			0,001-0,0015 (Y)	
			0,001; 0,002 (X)	
			0,0025; 0,0005 (Z)	
20	17.25	39.5-35 m	№ 1 - 0,001-0,002 (X)	Well filling with concrete at the point of 39.5–35 m
			№ 2 - 0,001-0,004; 0,006 (Z)	
			№ 3 - 0,001-0,0015 (Y)	
			№ 4 - 0,0015; 0,003 (X)	
			№ 5 - 0,0005 (Z)	
21	17.35	39,5 m	№ 1 - 0,0005-0,001 (X)	Lifting of tube timbering from the well in 39,5 m depth
			№ 2 - 0,0005 (Z)	
			№ 3 - 0,0005-0,0008 (Y)	
			№ 4 - 0,0015; 0,0005 (X)	
			№ 5 - 0,0005 (Z)	

Table continuation

1	2	3	4	5
22	17.41	31-23 m	№ 1 - 0,0015-0,001 (X)	Well filling with concrete at the point of 31–23 m
			№ 2 - 0,0012-0,0003 (Z)	
			№ 3 - 0,0015-0,0003 (Y)	
			№ 4 - 0,0025-0,0008 (X)	
			№ 5 - 0,0003 (Z)	
23	17.56	31,5 m	№ 1 - 0,001-0,0018 (X)	Lifting of tube timbering from the well in 31,5 m depth
			№ 2 - 0,001-0,0003 (Z)	
			№ 3 - 0,001-0,0002; 0,006 (Y)	
			№ 4 - 0,001-0,002 (X)	
			№ 5 - 0,0003 (Z)	

Conclusions

An example of use of modern regulatory requirements for the scientific and technical support of construction and building structures monitoring [6–11] is considered for safe installation of the pile foundation on a landslide hazardous building site under conditions of dense urban development at the address 14, Pymonenka street in Kiev during the installation of a bored pile № 87 Ø820 mm in accordance with the plan of the pile field. Continuous monitoring of the piling process was conducted from 10.44 (time of works start) to 17.56 (time of works end). *The materials obtained from experiments have shown:*

1. The registered vibration acceleration levels on the foundation wall of the building in the vertical and horizontal directions do not exceed 0.015 m/s², which is considerably less than the minimum permissible values of vibration acceleration for the foundations of buildings with brick bearing walls 0,15 m/s² according to Table 2 in [30].

2. The registered levels of vibration acceleration at the level of the 9th floor slab of the building in the vertical and horizontal directions do not exceed 0.004 m/s², which is significantly lower than the permissible values of vibration acceleration for high-rise buildings of 0.08 m/s² in according with paragraph 7.2 [31].

3. In the studies, the presence of visible damags to the building in the available places and possible development before and after pile installation was also assessed. Their development was evaluated according to a plaster screed on a vertical crack in the wall of the house. The condition of the chalky screed was established prior to the beginning of vibration dynamical tests on 02/15/2017 on the vertical crack in the building on the 8th floor, on the date of research on 02/21/2017 and after the installation of the concrete pile and further entire pile foundation has not changed. It remained undamaged. This is shown in the photo (Fig. 2).

4. Based on the above mentioned, it is permissible to carry out work on pile foundation implementation with the observance of the necessary technological procedures during the operation of the BAUER 40 BG drilling rig (see Fig. 3–4).

5. For the control of pile concreting quality, modern theoretical-numerical developments and technical means of the SE “SRIBC” [32-34] can be used.

REFERENCES

1. Accidents on buildings and structures and their prevention. Proceedings of the Second scientific and technical conference. – K. – 1999.

2. Don’t construct any more, but sell. Top-10 illegal housing estates in Kyiv. Available at http://eveningkiev.com/article/33946

3. Property developers destroy old historical buildings in Kyiv Centre. Available at: https://censor.net.ua/photo_news/254614/v_tsentre_kieva_zastroyischiki_rushat_starinnye_doma_foto
4. Pechersk. New housing estate on hazardous slope: authority, greed, batts and landslides. Available at: https://censor.net.ua/resonance/166/pechersk_novostroyi_na_opasnom_sklone_vlast_jadnost_bity_i_opolzni_viktoriya_vladina_dlyatsenzornet
5. Cracked buildings in Kyiv can count just on installation of “indicators”. Available at: http://eveningkiev.com/article/36152
6. DBN V.1.2-5:2007 «Scientific and technical support of construction facilities” – K.: Ukrbudarchinform, 2007. – 14 c.
7. DBN V.1.2-12-2008 «Construction in dense urban development conditions. Safety requirements» – K.: Ukrbudarchinform, 2007. – 34 p.
8. DBN V.1.2-14-2009 «Common principles of buildings, construction structures and foundations reliability and safety provision» – K.: Ukrbudarchinform 007. – 14 p.
9. Guidance as for scientific and technical monitoring of buildings and structures: DSTU-N B V.1.2-17:2016 / I. Kaliukh, O. Trofymchuk, Y. Berchun et al. // [In effect since 01 April 2017]. – K. : Minregionbud, 2017. – 42 p.
10. DSTU B V.2.6 – 25 – 2003. «Automated systems for technical diagnostics of building structures. General technical requirements» – K.: State Committee for Construction and Architecture of Ukraine, 2003. – 25 c.
11. Buildings and structures. Design of high rise housing estates and public buildings. DBN V.2.2-24:2009. Kyiv. Minenergobud, 2009.
12. Monitoring and safety evaluation of existing concrete structures. State of art report by Task Group 5.1. -International Federation for Structural Concrete (fib), 2003 - 300 p.
13. Sassa K. (2005) Landslides: Risk analysis and sustainable disaster management [Online], http://www.ebook3000.com/Kyoji-Sassa-Landslides-Risk-Analysis-and-Sustainable-Disaster-Management-147509.html.
14. Casagli N., Catani F., Del Ventisette C., Luzi G. (2010) Monitoring, prediction, and early warning using ground-based radar interferometry. Landslides 7(3):291–301
15. Pieraccini M., Casagli N., Luzi G., Tarchi D., Mecatti D., Noferini L., Atzeni C. (2003) Landslide monitoring by ground-based radar interferometry: a field test in Valdarno (Italy). Int J Remote Sens 24(6):1385–1391.
16. Casagli N., Tofani V., Ciampalini A., Raspini F., Lu P., Morelli S. (2018) TXT-tool 2.039-3.1: Satellite Remote Sensing Techniques for Landslides Detection and Mapping. In: Sassa K. et al. (eds) Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools. Springer, Cham. P. 235–254.
17. Hübl J., Mikoš M. (2018) TXT-tool 2.386-1.2: Practice Guidelines on Monitoring and Warning Technology for Debris Flows. In: Sassa K. et al. (eds) Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools. Springer, Cham
18. Mihalic S, Mihalić A, Željko A, Martin K (2013) TXT-tool 2.385-1.2 A comprehensive landslide monitoring system: The Kostanjek landslide, Croatia [Online], https://scholar.google.fr/citations?view_op=view_citation&hl=ru&user=7eoSoYYAAAAJ&citation_for_view=7eoSoYYAAAAJ:D03iK_w7-QYC
19. Mitigation of landslide hazards in Ukraine under the guidance of ICL: 2009–2016 (IPL 153&191) / O. Trofymchuk. I. Kaliukh, K. Silchenko, V. Berchun, T. Kaliukh, Y. Berchun // 4th World Landslide Forum, Ljubljana Slovenia EU, 29 May-2 June, 2017. – [s.l.: s.n.], 2017. – P. 381 – 388.
20. Trofymchuk, O., Kaliukh, I., Berchun V. (2017) Landslide stabilization in building practice: methodology and case study from autonomic Republic of Crimea. 4th World Landslide Forum, Ljubljana Slovenia EU, 29 May – 2 June, 2017. – [s.l.: s.n.], 2017. Workshop on World Landslide Forum. Springer, Cham: 587-595.
21. Modern information and analytical decision making support systems for areas sustainable development provision / [I. Kaliukh, O. Dudarenko, T. Kaliukh et al.] // Scientific and methodological reference guide. Kyiv: Tov. “Znannya”, 2000 – 32 p.

22. Kaliukh I., Kadilnikova T. Reference book on development and design of monitoring systems for complex technical systems and construction facilities. – K.: NIISK, 2004. – 46 p.
23. Trofymchuk O., Kaliukh I., Silchenko K., Polevetskiy V., Berchun V., Kalyukh T. (2015) Use Accelerogram of Real Earthquakes in the Evaluation of the Stress-Strain State of Landslide Slopes in Seismically Active Regions of Ukraine. In: Lollino G. et al. (eds) Engineering Geology for Society and Territory – Volume 2. Springer, Cham. – pp. 1343–1346.
24. Kaliukh T. Assessment of stress condition of landslide hazardous slopes in seismic loads conditions: thesis for Technical degree by specialty 05.15.09 – "Geotechnical and mining mechanical engineering". / T. Kaliukh. – K, 2011. – 173 p.
25. Polevetskiy V. Regional features of landslide protect structures and landslide hazardous slopes in Chernivtsi oblast: thesis for Technical degree by specialty 05.23.02 – Foundamentals and foundations / V. Polevetskiy – K.: SRIBK, 2010. – 204 p.
26. Klimenkov O. Theoretical and methodological and practical aspects of buildings and landslide hazardous areas monitoring / O. Klymenkov, Y. Berchun // 15 International scientific and practical conference "Modern information technologies of environmental safety management, nature management, emergency actions", Kyiv, Pushcha-Voditsa, 3–6.10.16: thesis. – K .: ITHIP NASU, 2016. – P. 152–154.
27. Khavkin K. Landslide hazard and stress-strain state of landslide protection structures in seismically hazardous regions of Ukraine (for example, Bukovina): thesis for Technical degree by specialty 05.23.02 - "Fundamentals and foundations" / K. Khavkin – K. : SRIBK, 2015. – 188 p.
28. Kaliukh I. Monitoring of the Livadia Palace with changes in the physical and mechanical characteristics of the soils of the central Livadia shear equilibrium system / I. Kalyukh, O. Klymenkov, Y. Berchun // Ecological safety. – 2016. – No. 1 – 2 (21). – P. 69–82.
29. National Technical University of Ukraine "Kyiv Polytechnic Institute". Scientific and technical center "NPP technical equipment diagnostics". Management program. “Seismomonitoring” multichannel measuring system, version 1.0. Operator's Guide. Kiev, 2009.20. DSTU GOST 12.1.012: 2008. Vibrational security. General requirements. M. – 1990.
30. Rate making of structures vibration in the USSR and abroad. Issue 1. M. – 1990.
31. DSTU 12.1.012-2008. SSBT. Vibrational security. – M. – 1990.
32. Experimental and theoretical diagnostics of ferroconcrete piles base on reflection of longitudinal and transverse waves) / G. Farenyuk, I. Kaliukh, E. Farenyuk, T. Kaliukh, Y. Berchun, V. Berchun / International fib symposium “High tech concrete: Where technology and engineering meet!”, Maastricht, The Netherlands, 12–14 June, 2017. – [s.l. : s.n.], 2017. – P. 1307–1317.
33. Kaliukh I., Senatorov V., Marienkov N., Trofymchuk O., Silchenko K., Kalyukh T. Arrangement of deep foundation pit in restricted conditions of city build-up in landslide territory with considering of seismic loads of 8 points. In: Proceedings XVI ECSMGE, 13-17 Sept 2015, Edinburgh, Great Britain, pp. 535–540 (2015).
34. Technoecology: textbook for students of institutes of higher education / V.M. Udod, V.V. Trofimovich, O.S. Voloshkina, O.M. Trofimchuk; KNUBA, ITGIP NANU. – K., 2007 – 195 p.

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ВІБРОДИНАМІЧНИЙ МОНІТОРИНГ УЛАШТУВАННЯ ПАЛЬОВОГО ФУНДАМЕНТУ НА ЗСУВОНЕБЕЗПЕЧНІЙ ДІЛЯНЦІ В УМОВАХ УЩІЛЬНЕНОЇ МІСЬКОЇ ЗАБУДОВИ

Анотація. Розглянуто приклад застосування сучасних нормативних вимог щодо науково-технічного супроводу будівництва та моніторингу будівельних конструкцій для безпечного улаштування пальового фундаменту на зсувонебезпечній будівельній ділянці в умовах ущільненої міської забудови в м. Києві під час влаштування

буронабивної палі Ø820 мм згідно з планом пальового поля. Експериментально зареєстровані рівні віброприскорень на фундаментній стіні будівлі в вертикальному та горизонтальному напрямках не перевищують 0,015 м/с², що значно менше мінімально допустимих значень віброприскорень для фундаментів будівель з цегляними несучими стінами 0,15 м/с². При дослідженнях оцінювалась також наявність видимих ушкоджень в будівлі в доступних для цього місцях та їх можливий розвиток до і після влаштування палі. Стан гіпсового маяка на вертикальній тріщині в стіні будинку на 8-му поверсі, який був встановлений до початку будівельних робіт, після влаштування пальового фундаменту не змінився – він залишився неушкодженим.

Ключові слова: безпека; моніторинг; паля; технічний стан; датчик; вібродинаміка.

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CALCULATIONS AND PROGNOSIS OF THE INFLUENCE OF THE EXPLOITATION OF THE "HOTYSLAVSKE" QUARRY ON THE HYDRODINAMICS OF THE GROUND AND UNDERGROUND WATERS OF THE WESTERN POLISSYA

Abstract. *The problems of the influence of the exploitation of the deposit of the sand and chalk "Khotislavske" on the hydrodynamics of ground and underground waters of Western Polissya are considered. At this the analytical methods of calculation of geophiltration processes and methods of mathematical modeling were used. The analysis of the validity of forecast calculations and modeling of the influence of a quarry on the territory of Ukraine carried out by the Belarusian side and the comparison of data are carried out.*
Key words: *filtration area; infiltration recharge; water inflow; hydrogeological conditions; overdraining; technogenic conditions.*

Introduction

The development of the deposit of building materials "Hotislavske" on the territory of the Republic of Belarus for many years has been the subject of discussions on its possible impact on the adjoining territory of Ukraine.

This problem was particularly acute when known specialists and specialists came to the conclusion that is the real possible negative impact of the quarry development on the territory of Western Polissya including the territory of the Shatsk National Park.

Taking into account the aforementioned, the problem of quantitative assessment of the transboundary impact on the territory of Ukraine on the development of this field for the long-term period of its exploitation was raised.

Analysis of recent researches and publications

In the process of the investigations the hydrogeological conditions of the territory of Western Polissya and the conditions of the formation of water resources of the zone of active water exchange the hydrological conditions, the state of surface water courses including the reclamation facilities and the modern water and ecological status of a certain territory were analyzed and determined.

In addition on the base of the analysis of the hydrodynamic conditions of the main aquifers and the filtration schemes of the ground and underground waters interactions in the given area have been developed which allowed to create a conceptual model for water exchange of surface and groundwaters.

When creating the model the results of the modeling of the impact assessment on the environment of the Khotilaslavske field development which are presented in the

corresponding Report of the Belarusian side [13] and monographs [2, 14], were used and analyzed. It was shown that the results of the impact can be considered approximate in connection of with the insufficient reliability of the used data by the Belarusian specialists.

The purpose of the research is to evaluate the impact of the development of the sand and chalk deposit "Khotilslavske" (Republic of Belarus) on the hydrogeological and hydroecological conditions of the territory of Ukraine within the Western Polissya, including the territory of the Shatsk National Park.

In this case the analytical methods of calculation of processes of geophylration and methods of mathematical modeling were used. In addition the analysis of the validity of the projected calculations and modeling the impact of a quarry on the territory of Ukraine performed by the Belarusian side and the comparison of data has been carried out.

Research results

The research area is characterized by complex hydro-geological conditions and is not well understood especially in the north-western part where the Kopayevsk drainage system is located [14, 2].

Absence of reliable data on the separate areas of the determined territory predetermines the approximate approach to the calculations and forecasting of the impact of the operation of the quarry on the hydrodynamics of the ground and underground waters of Western Polissya within its possible influence (Figure 1), which is also noted in the Report of the Belarusian side [13].

Water intake to the quarry is formed at the expense of natural resources of the main aquifers and atmospheric precipitates and at the hydrodynamic schematization it can be considered as a radial flow to a well with a large diameter in an unbounded area of filtration with the assignment on the contour of the quarry the corresponding boundary conditions (values of water intake or constant drawdown on the contour of the quarry).

Proceeding from the foregoing one can consider the problem of water inflow to a large diameter well in a three-layer aquifer unbounded in plane with the absence of flowing from below aquifer and with infiltration recharge [6, 12].

In the assumption of a rigid regime of filtration in a weakly permeable distribution layer of the colmatation zone of the marl-chalk layer and the failure to take into account the infiltration feed of the ground stream the process of transient filtration can be described by the following system of differential equations in partial derivatives [12]:

$$\begin{aligned} a_1\left(\frac{\partial^2 S_1}{\partial r^2}+\frac{1}{r}\cdot\frac{\partial S_1}{\partial r}\right)-b_1\left(S_1-S_2\right)&=\frac{\partial S_1}{\partial t}\\ a_1\left(\frac{\partial^2 S_2}{\partial r^2}+\frac{1}{r}\cdot\frac{\partial S_2}{\partial r}\right)+b_1\left(S_1-S_2\right)&=\frac{\partial S_2}{\partial t}\end{aligned} \qquad (1)$$

where $a_1 = T_1/\mu_1$, $a_2 = T_3/\mu_2$, $b_1 = K_2/\mu_1 m_2$, $b_2 = K_2/\mu_2 m_2$;
$S_1(r,t) = H_{oi} - H_i(r,t)$ – the drawdowns of levels and heads in aquifers with water

permeabilities $T_1 = k_1 m_1$, $T_3 = k_3 m_3$; H_{oi} and $H_i(r,t)$ – levels and heads before and during the water uptake process $(i = 1,2)$; μ_1 and μ_2 – coefficients of storativity of water-bearing horizons.

The system of equations (1) is solved under the following boundary conditions:

$$\begin{aligned} &t = 0,\ S_1 = S_2 = 0 \\ &t > 0,\ r \to 0,\ 2\pi T_1 \frac{\partial S_1}{\partial r} \to -Q,\ \frac{\partial S_2}{\partial r} = 0 \\ &t > 0,\ r \to \infty,\ S_1 \to 0,\ S_2 \to 0 \end{aligned} \qquad (2)$$

where t – hour, day; r – coordinates in space and Q – constant water uptake from the well.

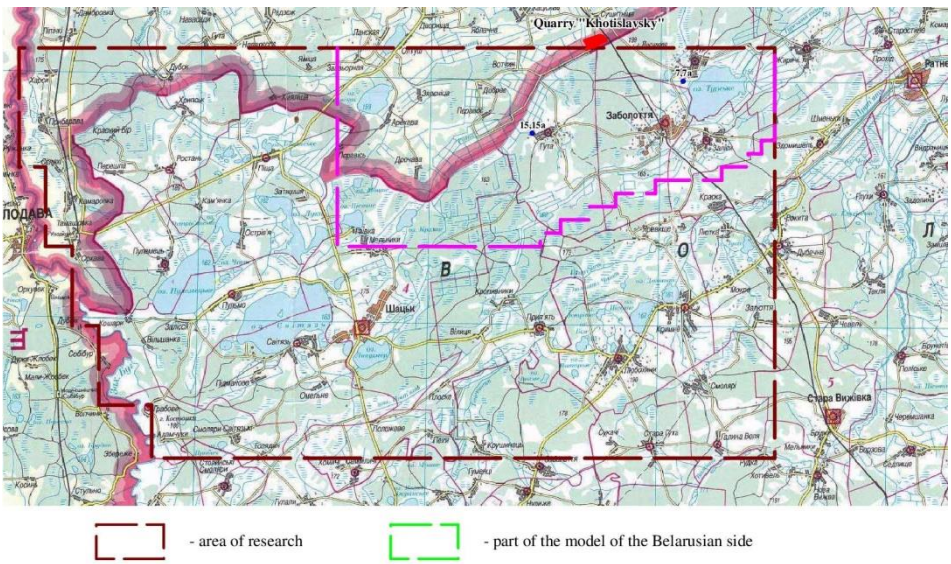

Fig. 1 – Selected area of research within the territory of Western Polissya. Scale 1:200 000.
Note. Within the research area a part of the model of the Belarusian side is demonstrated

The general analytical solution of this problem was received with a help of integral transformations which has the following form with respect to the drawdowns $S_1(r,t)$ and $S_2(r,t)$ [12]:

$$S_i(r,t) = \int_0^\infty p j_0(pr) S_i \cdot (p,t) dt \qquad (3)$$

Equation (3) is a complex analytic expression which can only be realized in a numerical way. To do this an appropriate software package was developed and special tables of filtration resistances for multilayer filtration schemes were designed which greatly simplify the calculations and simulation of the problems of the given class [7, 12].

It is known that in practical calculations the process of interconnection of aquifers through weakly permeable layers during water uptake from one of the horizons can be divided into several stages, namely [6, 7, 12]:

1. small times when the magnitude of the drawdown in the adjacent horizon is insignificant and mainly in the horizon from which the water uptake takes place one can consider the filtration according to the scheme of the isolated water-bearing layer; 2. intermediate times when the flow from the adjacent horizon begins; 3. intermediate large times when there is an uneven drawdown in levels and heads in both horizons; 4. The time when the magnitude of the drawdown can be calculated according to the scheme of a single-layer formation with integral parameters of the whole water-bearing thick:

$$S_1(r,t) = S_2(r,t) = \frac{Q}{4\pi T} w(u) \tag{4}$$

where $T = T_1 + T_3$, $\mu = \mu_1 + \mu_2$, $a = T/\mu$, $w(u)$ – function, $u = r^2/4at$.

For small times the expression for calculating the time criterion of the well operation in the scheme of a single-layer formation has the following form [7]:

$$t_1 \le 0.01\mu_1 m_2 / K_2 \tag{5}$$

Substituting the data on the aquifer of the quaternary deposits in the area of the quarry $\mu_1 = 0.2$, $m_2 = 10.0$ m, $K_2 = 5 \cdot 10^{-3}$ m/day, we find that $t_1 \le 4$ days that is the water uptake from the quarry is provided of only from the horizon of groundwater during 4 days after which the interaction with the lower horizon in the marl-cretaceous strata begin because of the flow from the bottom to the top.

Since according to project decisions [13] the production of chalk and sand from a quarry is planned until 2040 that is for 30 years starting in 2009 when the development of the first stage of the deposit began it is interesting to calculate the time criterion after which the water uptake from quarry can be modeled according to the scheme of a single-layer formation with integral parameters of the entire aquifer. For this case the following dependence is recommended [7]:

$$t_1 \ge 20\, B^2/a_2, \quad r/B \ge 5 \tag{6}$$

where B – flowing parameter, м; a_2 – piezotransmission coefficient, m^2/day.

Substituting the data for the quarry area taken from the model of the Belarusian side we obtain that $B = 419$ m. At $a_2 = 1.3 \cdot 10^4$ m^2/day, $t_2 \ge 270$ days that is after 270 days the system of aquifers can be considered as the only one aquifer with integral parameters of the whole water-bearing thick.

As a rule at calculations of quarry drainage one operates the concepts of working out of depth of a quarry with the corresponding drawdowns of the levels of ground water in it. Forecasting relative to drawdowns is more reasonable than the designation of drainage design values in a quarry as in the development of deposits the determination of drainage values is more approximate in comparing with the

calculations of the distribution cone of depression with a constant drawdown in the career contour.

Taking into account the accepted schematization of hydrogeological conditions in cross section of the research area the following dependence was used to determine the impact of the development of a quarry on the level regime of groundwater [1, 9]:

$$S(r,t) = S_0 \cdot A(\tau, \rho) \quad (7)$$

where $S(r,t)$ – the magnitude of the drawdown at the time *t* at a distance *r* from the quarry; r_0 – radius of a "big well" that is a career, m; S_0 – the design value of drawdown of the level of groundwater at a water uptake, m; $A(\tau, \rho)$ – special tabulated function; $\tau = at/r_0^2$; $\rho = r/r_0$.

The advantage of using this model is that the calculation of drawdowns is taken from existing levels of ground water in which the infiltration takes into account and for long-term forecasts this assumption is justified [9].

Since in the modeling results of the Belarusian side the values of the design drawdowns of 12.0 m are appeared in the development of the first stage of the deposit and 45.0 m with its further development by 2040 a simulation of the distribution of changes in groundwater levels for the project period from the beginning of the development (2009) until 2040 at S_0 = 12.0 and S_0 = 45.0 m based on the dependence (7) was performed.

Data of numerical simulation at different distances from a quarry at S_0 = 12.0 m are given in Table 1.

Table 1 – The magnitude of the drawdowns of the groundwater levels in the research area based on the results of numerical simulation at S_0 = 12.0 m

№ n/a	Distance from the career, km	S_0 = 12.0 m	
		2016 – 2025 y.y., *t* = 10 years	2016 – 2040 y.y., *t* = 25 years
1.	lake Svyate, 6.0	2.02 m	3.08 m
2.	village of Guta, 7.0	1.62 m	2.6 m
3.	settlement of urban type Zabolotya,7.0	1.62 m	2.6 m
4.	lake Velikhovo, 7.2	1.48 m	2.55 m
5.	reservoir Turske, 7.6	1.35 m	2.38 m
6.	village Zalisy, 10.0	0.73 m	0.99 m
7.	village Yarevishche, 14.4	0.23 m	0.85 m
8.	Pripyat River, 16.4	0.115 m	0.60 m
9.	lake Krymno, 17.2	–	0.5 m
10.	settlement of urban type Ratne, 23.4	–	0.17 m
11.	lake Liutsymer, 25.6	–	0.1 m

Based on the results of the simulation the graphs of groundwater levels drawdowns in dependence of the distance from the quarry to the area of possible influence on the given periods of time were building (Figures 2–3).

As can be seen from Table 1 and from the corresponding graphs of the drawdowns the potential impact reaches the Pripyat river by 2025 where a drawdown of S = 0.115 m is forecasted. The radius of influence will be more than 16 km. The zone of influence will include lakes Svyate, Velychovo, Tursk reservoir and a significant number of settlements of the border with the territory of Belarus.

The levels of water in the lakes of Svyate and Velickovo will decrease respectively by 2.02 and 1.62 m at the existing depth of the lake Svyate 15.0 m that is the depth of the lake can be reduced by about 2 m. As for the reservoir of Tursky at its depth of 2.0 m a decrease of 1.35 m will practically change its hydrological regime [14, 5]. In addition the drawdowns of ground water levels in the impact zone by 0.5–1.5 m will worsen the water supply conditions of the population living in this area.

A more difficult situation may arise as of 2040. The impact of quarry development will be of a regional level. The radius of influence will be more than 29 km reaching the territory of Shatsky lakes (Fig. 1). So the water level in the lake Lutzumer is projected to be 0.1 m below the current one that is all lakes of Shatsk National Park will fall into the zone of influence.

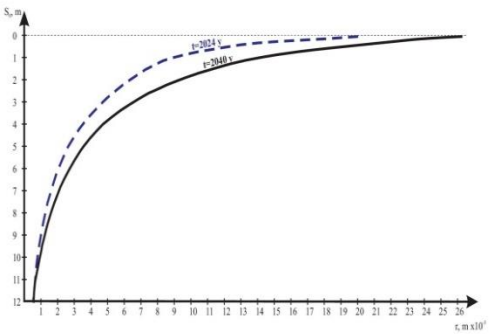

Fig. 2 – Charts of the dependence of the ground water level drawdown from distance to quarry with constant level on its contour S_0 = 12.0 m by 2024 and for 2040 years of working out of a quarry

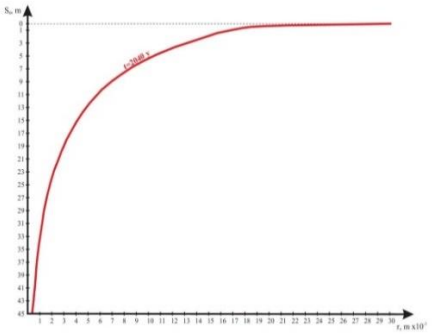

Fig. 3 – Chart of the dependence of the ground water level drawdown rom distance to a quarry with a constant level on its contour S_0 = 45.0 m by 2040y quarry development

For the purpose of the comparison with the Belarusian side's forecast solutions for 2040 at S_0 = 12.0 m a schematic map of the influence of the development of a quarry on the level regime of groundwater on a scale of 1: 200 000 was constructed (Fig. 4). As can be seen from the map the magnitudes of the drawdowns differ significantly among themselves and the distribution of the impact zone according to the modeling of the Belarusian side by 2040 to some extent coincides with the data of the calculations performed at S_0 = 12.0 m on 2025 taking into account and without compensatory measures to decrease the zone of influence on the territory of Ukraine. Thus even with the development of only the upper part of the quarry cross section the projected impact will cover a significant territory of Ukraine.

The next stage in the assessment of the impact of the exploitation of the quarry was the simulation of the drawdowns of groundwater levels by 2040 with the designation on the quarry contour a constant value of drawdown S_0 = 45.0 m for a

period of 15 years from 2025 to 2040 according to design decisions for the development of this deposit [3, 13].

The choice of the modeling period from 2025 to 2040 at S_0 = 45.0 m is due to the assumption that by 2025 the second queue of the quarry will start working as there are no exact dates for the introduction of the second stage in the reporting materials of the Belarusian side. At all forecasting maps for 2014, 2019, 2024 and 2040 the isolines of drawdowns are given at S_0 = 12.0 m (Fig. 4), only one of the maps shows the plane propagation of groundwater levels drawdowns at S_0 = 45.0 m but on state of 2014 year. These data of the drawdowns of the groundwaters are not trustworthy since according to the monitoring data of the Belarusian side in 2014 only the upper part of the cross section of the quaternary sediments was developed with drainage of 1500 m^3/day in 2009, 1200 m^3/day in 2013, 7176 m^3/day in 2015 and 8836 m^3/day in 2016 [10, 11].

For specify of the obtained data we have carried out calculations of groundwater level drawdowns in the territory adjacent to the quarry by the end of 2009, 2013, 2015 and 2016 according to the data of the Belarusian side on the drainage using on the dependence (4). Thus for 2009 at Q = 1500 m^3/day the drawdown on the contour of the quarry was about 1.8 m and about rs. Tursk (observation wells 7 and 7a, Fig. 1) the influence is absent, S < 0.1 m). As of 2013 at Q = 1200 m^3/day the drawdown on the contour of the quarry was about 1.95 m and in the vicinity of observation wells 7 and 7a – about 0.1 m; as of 2015 at Q = 7176 m^3/day the drawdown was 12.4 m while near the Turske reservoir was 1.2 m; as of 2016 at Q = 8354.7 m^3/day the drawdown is calculated S = 14.8 m and in the area of the reservoir Tursk – about 1.4 m.

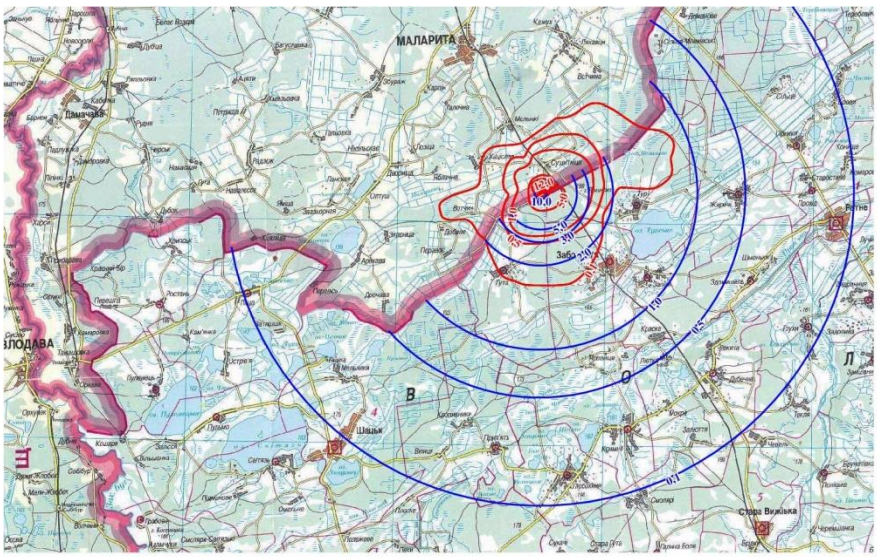

Fig. 4 – The map of forecasted ground water levels drawdowns on the research area by 2040 with a constant drawdown on the quarry contour S_0 = 12.0 m

Similar calculations were carried out at a distance of 7.0 km (Huta village) where observation wells 15 and 15a (Fig. 1) are located.

The analysis of the calculation data and the data of the observation wells indicates that there is a sufficient agreement between the data of calculations and regime observations as both regime data and estimated data show almost the same drawdowns in groundwater levels at a distance of 7.0–7.6 km from the quarry on 2016 year.

The comparative characteristic of the obtained data allows us to assert that for the accepted schematization of the technogenic conditions in the zone of possible influence of the operation of the quarry the indicated calculation models are reasonably reflect the process of changes in water exchange on the territories adjacent to the quarry.

In order to assess the possible impact of the development of a quarry with the full development of its on 2040 year with a design drawdown of S_0 = 45.0 m an appropriate numerical modeling of the distribution of influence on the basis of dependence (7) was conducted. Data model calculations are given in Table 2.

Table 2 – Data on groundwater level drawdowns in the research area by numerical simulation results at S_0 = 45.0 m

№ n/a	Distance from the career, km	S_0 = 45.0 m, t = 2040 year
1.	lake Svyate, 6.0	10.37 m
2.	village of Guta, 7.0	8.86 m
3.	settlement of urban type Zabolotya, 7.0	8.86 m
4.	lake Velikhov, 7.2	8.46 m
5.	reservoir Turske, 7.6	7.96 m
6.	village Zalisy, 10.0	2.97 m
7.	village Yarevishche, 14.4	2.48 m
8.	Pripyat River, 16.4	1.5 m
9.	lake Krymno, 17.2	1.43 m
10.	settlement of urban type Ratne, 23.4	0.39 m
11.	lake Liutsymer, 25.6	0.2 m
12.	lake Svityaz, 25.8	0.19 m
13.	village Khripsk, 29.0	0.09 m

According to this simulation a map of the depression distribution was constructed in the definite area of research for the forecast period of 2040 (Fig. 5).

The obtained data indicate that the zone of possible influence with full development of a quarry practically covers the entire study area within a radius of 29.0 km. The influence will extend also and in the eastern direction beyond the investigated filtration area on the same distance (Fig. 1, 5).

As can be seen from Table 2 the influence of a quarry reaches in the 2040 year the group of Shatsky lakes. On the territory of Shatsk National Park the groundwater levels will decrease from 0.1 to 0.2 m on average.

If you compare the estimated values of the drawdowns with the depths of individual lakes then it is predicted that, for example, the depth of the lake Svyate will decrease by 10.0 m relatively the present depth of 15.0 m, the depth of the lake Liutsymer will decrease by 0.2 m at the present 11.2 m, the depth of the lake Krymno will decrease by 1.43 m with the existing 6.0 m, lake Luky at 0.7 m with existing 3.5 m, lake Svityaz with 0.2 at existing 58.4 m. As all lakes are hydraulically connected their hydraulic regime will change significantly and the lakes with small

depths located in the zone of the influence where the forecast drawdowns will be of the order of 3–10 m will be practically on the verge of drying out.

A similar picture should be expected regarding the river network. Taking into account the fact that almost all watercourses in the territory are characterized by insignificant depths, for example, the depth of the Pripyat River near village Ritchitsya is 2.73 m and higher along the channel the depth is yet smaller, the depth of the Vyzhivka River near the village Vyzhivka is 0.97 m it is possible that there will be drying out of all rivers. Gradually instead of the drainage function the river system will turn into a groundwater recharge area whose drawdowns of the levels will result in an increasing of the thickness of the aeration zone and the drying of the main aquifer.

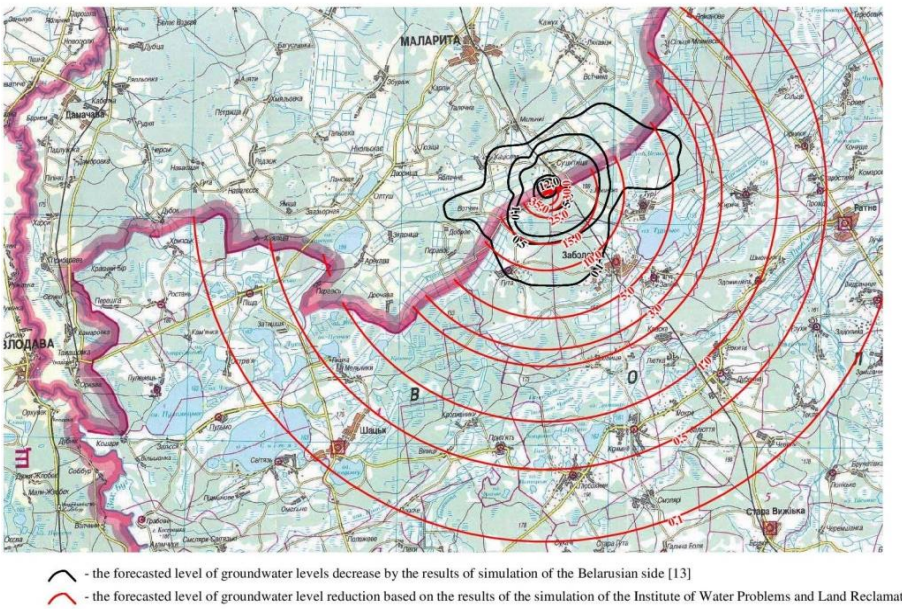

Fig. 5 – Mapping of forecasted drawdowns of the groundwater levels in the research area by 2040 with a constant drawdown on the contour of the quarry S_0 = 45.0 m

Khotyslavsky quarry with hydrodynamic schematization can be considered as a separate field which drains aquifer complex of ground and underground waters. In the conditions of the steady filtration in the unbounded water aquifer in the plan the water inflow to the quarry by 2040 can be calculated according to the following dependences [9, 12]:

$$Q = \frac{2\pi T S_0}{\ln\left(\frac{R}{r_0}\right)} \tag{8}$$

where T – coefficient of the permeability of the complex, T = 420 m^2/day;
S_0 = 45.0 m;
R – radius of influence in the field of filtration, R = 29.0 km;
r_0 – quarry radius, r_0 = 400.0 m [14].

Substituting the given data into (8) we obtain that Q = 27732 m^3/day that is for the conditions of ensuring of the lateral recharge of the complex the designed drainage from the quarry is almost equal to the quantity of the water inflow. Taking into account the fact that the recharge of the aquifer system will decrease due to precipitation and in order to ensure water inflow to the quarry the area of the impact of its will be expanded changing the water balance within the entire area of distribution of the aquifer complex [2, 15, 16].

It should be noted that in the forecast period the water withdrawal from the aquifer system will also increase for water supply of the population with drinking water. In total it is planned to increase the water withdrawal to 50 thousand m^3/day and in general taking into account the drainage from the quarry the water uptake will increase to 70–75 thousand m^3/day [13].

Thus the carried out numerical-analytic calculations and simulations have shown that the development of the Khotsyslavske sand and chalk deposit for the projected period of operation by 2040 will significantly change the hydrodynamic conditions in the territory of Western Polissya and in general will aggravate the hydrogeological and ecological situation in the defined territory.

Conclusion

According to the results of numerical simulation for the 1st stage of quarry development at S_0 = 12.0 m it follows that by 2025 the potential impact will reach the Pripyat River where the decreasing of the groundwater levels is expected to be S = 0.115 m. The radius of influence will be more than 16 km. The zone of influence will include the lakes Svyate, Velychovo, Tursk reservoir and a significant number of settlements within of the border with the territory of Belarus.

A more difficult situation may arise in the development of the second stage with a drawdown of 45 m (S_0 = 45.0 m) by 2040. The impact of a quarry development will be of a regional character. The radius of influence will be more than 29 km reaching the territory of Shatsky lakes. The influence will spread and in the eastern direction beyond the investigated filtration area.

In addition the conclusions of the Belarussian specialists that the development of the stated quarry will not influence on the territory of the Shatsky lakes are doubtfully as in the Belarusian model this area is not included.

On the whole the comparative characteristics of the obtained data allows to suggest that for the schematized technogenic conditions in the zone of possible influence of the exploitation of the quarry the indicated calculation models are reasonably reflect the processes of the changes in the water exchange on the adjacent to the quarry territories.

REFERENCES

1. Bochever F. M., Garmonov I.V., Lebedev D. V., Shestakov V. M. Fundamentals of hydrogeological calculations. Moscow: Nedra, 1965. 250 p.
2. Zaleskiy I.I., Zuzuk F.V., Melnychuk V.G., Matejuk V.V. Shatskoe overlake Geological structure and hydrogeological conditions. T.1. Lutsk: Eastern European National University, 2014. 188 p.
3. Statement on the impact on the environment of the planned economic activity "Development of a chalk deposit " Hotislavskoe "(Phase II) in the Malorita district of the

Brest region". Minsk: Kvartstelprom, RUE TsNIIKIVR, State Scientific and Production Association "NAS of Belarus on Bioresources", 2009. 12 p.
4. Zuzuk F.V. Probability of influence of development of Khotilaslavskogo deposit of chalk on reserve ecosystems of Volyn. Zb sciences Works "Nature of Western Polissya", Lutsk, SNU by name Lesia Ukrainka. 2016. No. 9. P. 3-11.
5. Ilyin L.V. Volyn Lakes: Limnogeographical characteristic. Luck: Nadstyr'ya, 2000. 140 p.
6. Lomakin E.A., Mironenko V.A., Shestakov V.M. Numerical simulation of geophyltration. Moscow: Nedra, 1988. 228 p.
7. Methodical recommendations on calculations of protection of territories from flooding in the irrigation zone. Kiev: Ministry of Water Resources of the USSR, 1986. 392 p.
8. Mokryy V.I. Monitoring, modeling and forecasting of the influence of Khotilaslav's quarry on the hydrogeological and forest-ecological conditions of nature reserves of Western Polissya. Zb sciences Works "Nature of Western Polissya and adjoining territories", Lutsk, SNU them. Lesia Ukrainka. 2012. No. 9. P. 284-288.
9. Norvatov Yu.A. The study and forecast of the technogenic regime of groundwater. Leningrad, Nedra, 1988. 261 p.
10. About monitoring in the area of the Khotilslavskoe field. Letter of the Ministry of Natural Resources of the Republic of Belarus to the Ministry of Ecology and Natural Resources of Ukraine dated July 24, 2017 for No. 3-10 / 36 - imo. Minsk, 2017. 12 p.
11. About monitoring in the area of the deposit of sand and chalk "Hotislavskoe". Letter from the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus. Minsk: No. 13-11 / 3536-v on 27.12.2016. 11 p.
12. Oleinik A. Ya. Filtration calculations of vertical drainage. Kiev: Naukova Dumka, 1978. 202 p.
13. Report on the results of the environmental impact assessment of chalk production at the site of the Hotislavskoye deposit in the Malorita district of the Brest Region. In 2 books. Book. 1. Assessment of the impact of the development of the Chotislavskoye chalk deposit (Stage II) on the hydrological and hydrogeological conditions of the adjacent territory. Ministry of Natural Resources and Environmental Protection of the Republic of Belarus. Republican Unitary Enterprise "Central Scientific Research Institute for the Integrated Use of Water Resources (RUE "TsNIIKIVR"). Minsk, 2009. 142 pp.
14. Nature of Western Polissya adjacent to Khotyslavsky's quarry in Belarus / ed. F.V. Zuzuka, Lutsk: Eastern European National University, 2014. 246 p.
15. Romashchenko M.I., Bakhmachuk Yu.Y. Formation of the natural waters regime of the Shatsk lakes district in modern conditions. Kyiv: Agrarian Science, 2004. 96 p.
16. Shestopalov V.M., Sitnikov A. B., Lyalko V. I., Pashkovsky I. S. Water exchange in hydrogeological structures of Ukraine. Methods of studying water exchange. Kiev: Naukova dumka, 1988. 267 p.

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РОЗРАХУНКИ ТА ПРОГНОЗУВАННЯ ВПЛИВУ РОЗРОБКИ РОДОВИЩА «ХОТИСЛАВСЬКЕ» НА ГІДРОДИНАМІКУ ҐРУНТОВИХ І ПІДЗЕМНИХ ВОД ЗАХІДНОГО ПОЛІССЯ

Анотація. Розглянуто питання впливу розробки родовища піску та крейди «Хотиславське» на гідродинаміку ґрунтових і підземних вод Західного Полісся. Використано аналітичні методи розрахунку процесів геофільтрації та методи математичного моделювання. Проведено аналіз обґрунтованості прогнозних розрахунків та моделювання впливу кар'єру на територію України, виконаних білоруською стороною, та співставлення даних.

Ключові слова: область фільтрації; інфільтраційне живлення; водоприток; гідрогеологічні умови; переосушення; техногенні умови.

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CREATION OF ENERGY EFFICIENT «GREEN STRUCTURES» IN CONDITIONS OF MODERATE CONTINENTAL CLIMATE

Abstract. *The main aspects of creation of energy-efficient «green structures» in urbocenoses of moderate-continental climate are considered. It was established that problems of exploitation of "green roofs" arise in case of violation of the technology of laying roofing layers and in case of incorrect selection of plant assortment. Technical problems in creating "green roofs" arise when the wrong choice of waterproofing. There should also be a single drainage system, which accommodates all other elements. Failure to observe these conditions may lead to rooting and the development of microorganisms. The assortment of plants on an intensive roof is usually limited to low-growing plants: herbs, shrubs and shrubs. Phenological observations carried out on the intensive roof of the Royal Tower residential complex in Kyiv have shown that with the correct selection of plant assortments and their cultivation technology, plant height can be considerably larger: from 4 to 6 m, which significantly expands the ecological and biological capabilities of intensive green roofs moderately-continental climate. The assortment of species of plants with high adaptive potential of various life forms with a wide variation of height is proposed: from low-growing herbs to trees of 6 m in height: Quercus paludosus multicaulus, Quercus rubra multicaulus, Pinus sylvestris, Acer rubrum, Acer rubrum 'Scanlon', Chenomeles Maulei, Arónia melanocárpa, Berberis thunbergii, Betula pumila, Crataegus laevigata, Vitis amurensis, Parthenocíssus tricuspidáta, Cornus alba, Picea abies, Picea canadensis, Picea pungens, Lonicera alpigena, Lonicera caerulea, Salix caprea, Viburnum opulus, Cotoneaster lucidus, Acer tataricum, Acer ginnala, Elaeagnus argentea, Juniperus horizontalis, Juniperus sabina, Sorbus aucuparia, Ribes aureum, Symphoricarpos albus, Pinus mugo, Spiraea arguta, Spiraea japonica, Thuja occidentalis, Philadelphus coronaries, Mālus sibirica, Malus niedzwetzkyana.*
Key words: *«green structures»; «green roofs»; adaptive potential; assortment of plants; «layered» design.*

Introduction

One of the problems of modern cities is the lack of free territories. The expansion of cities horizontally and vertically inevitably leads to the reduction of green zones, the growth of motor transport communications, and the consolidation of development. As a result, landscape modification, sharp decline in biodiversity, pollution of soil, air and water. Environmental tension in the urban environment has a negative impact on the people's health. Unfortunately, due to the densely built up (especially in the central regions), it is impossible to create a full-fledged recreational zone. A way out of the current situation can be the use of «green construction» – «green roofs», «green slopes», vertical landscaping, eco-parking. The advantages of «green constructions» in the possibility of their use in the already built up territories, as they

do not require additional space, but may be located on already created objects: roofs and facades of buildings, built up slopes. At the same time, they fulfill not only aesthetic, but also economic and ecological functions [1, 2].

Analysis of researches and publications

Nowadays, the energy saving of the roof is achieved not only through the use of building and finishing materials, but also with the help of gardening.

All over the world, roofing gardening is given huge importance, raising this area in the category of the most relevant. In Germany, France, Canada, Japan, the United States, Switzerland, roofing landscaping during construction is mandatory. This direction is becoming relevant in Russia and Belarus.

Already, no one doubts the effectiveness of green roofs in megacities. The positive aspects of roofing gardening (effects of conditioning, noise insulation, sanitary and hygienic, aesthetic) almost completely cover the items of expenditure for their creation [3–9].

However, until now, when you build a garden on the roof, a number of problems arise.

The aim of the work is to study and generalize the problems that arise when creating and operating green roofs, as well as finding ways to solve them. We evaluated the general condition of plants after wintering visually on a five-point scale of Tumanov [10]: 5 – the absence of traces of plant death; 4 – slight damage of the tops of the shoots; 3 – 50% of damage, about half of plants die; 2 – 70…80% of damage, death of more than half of plants; 1 – complete destruction, or preservation of individual plants only. In addition, the ability of plants to tolerate unfavorable summer conditions, namely a strong increase in temperature, was determined. The condition of plants in this period was also determined visually on the same scale.

Material, main findings and their analysis

One of the main problems is a high level of humidity. Operated roofs should have increased moisture resistance and as low as possible moisture absorption. This is due to the fact that penetration of water vapor and moisture into the structure of the heater, multiple cycles of "freezing-thawing" ultimately lead to a loss of thermal insulation properties and destruction of the material [11, 12].

The bearing structures of the roof should maintain the weight of the soil layer and the weight of the plants extrapolated in time, other operational loads, usually unevenly distributed over the surface area, and wind loads.

Waterproofing materials can be destroyed under the influence of climatic, chemical and biological factors: temperature changes, aggressive effects of chemicals, microorganisms, destroying effects of the root system of plants. In addition, if in regions with a warm climate, traditional bituminous roofing materials serve long enough, then under conditions of a temperate continental period, the maintenance-free operation of these roofing materials is much shorter. Studies have shown that an ordinary bitumen membrane is able to withstand the roots of plants for no more than six weeks.

To increase the stability of waterproofing, special chemical preparations have been developed – anti root additives, which are introduced into the bitumen-polymer binder in the production process of waterproofing material and evenly distributed

throughout its thickness. They make the membrane completely impermeable to plant roots. Most of the existing bitumen-polymer waterproofing root-resistant materials for green roofs use this method of protection.

There is a variant of roof protection, in which copper foil is applied to the waterproofing membrane. In modern landscaping systems, the waterproofing function is performed by the polymer membrane.

Before installing the landscaping system on the roof of the old building, it is necessary to conduct an examination of the roof. If the roof needs repair, it is necessary to complete it before installing the landscaping system, since, unlike a conventional roof, repairing the multi-layer roofing cake of the green roof, in case of leakage, requires a lot of effort and money.

One of the vulnerabilities of green roofs is the contiguity to vertical surfaces. To avoid leakage in these places, the edge of the waterproofing layer should be raised along the vertical surface. The solution to these problems lies in the strict observance of project requirements. If the requirements are violated, leaks occur, the roof structure is destroyed, the soil and plants rot, and the vegetation layer dries (or freezes).

The problems that arise in the operation of green roofs, in general, come from improper installation or inaccurate calculation of the system load on the rafter and slabs. Some problems may occur if the seeds of trees fly to the roof, so any green roof still needs to be observed and periodically serviced to remove sprouting tree sprouts in their infancy. If seeds of herbaceous plants fall, then the sedum replaces them, because, in fact, it is a weed.

Under the system, the usual roofing cake is completed, which ends with waterproofing. Next comes the root protection film – a special dark film, which prevents the germination of roots in the waterproofing and supporting structures. The quality of the film is checked by the roots of flax. Flax is a plant with the most aggressive roots. In the case of a flat roof, a classic internal drainage system should be provided.

Correct selection of assortment of plants for green roofing is almost 70% of its successful operation. Each type of gardening («intensive» or «extensive») requires a certain range of plants. Plants should not be very heavy, the root system should not be very deep (so as not to damage the waterproofing and other layers of the roof). But the main thing is to take into account the climatic features of the region. Abiotic factors – a powerful load, increasing several times in height. From the correct selection of plants depends on their adaptation and survival.

In the temperate continental climate, when creating an «intensive roof», you can successfully use quince *Chenomeles Maulei*, *Arónia melanocárpa*, *Berberis thunbergii*, *Betula pumila, Crataegus laevigata, Vitis amurensis, Parthenocíssus tricuspidáta, Cornus alba, Picea abies, Picea canadensis, Picea pungens, Lonicera alpigena, Lonicera caerulea, Salix caprea, Viburnum opulus, Cotoneaster lucidus, Acer tataricum, Acer ginnala, Elaeagnus argentea, Juniperus horizontalis, Juniperus sabina, Sorbus aucuparia, Ribes aureum, Symphoricarpos albus, Pinus mugo, Spiraea arguta, Spiraea japonica, Thuja occidentalis, Philadelphus coronaries, Mālus sibirica, Malus niedzwetzkyana* [13].

The creation of gardens on green roofs has a great success. Creating a garden design, you can choose as a traditional geometric scheme, and create something like a flower border, with the inclusion of useful vegetable plants in it. Geometric schemes are simple, but very effective. The classical variant is a composition in a circle or in a square divided into sectors. It can be deployed both on the plane and in

elevated beds. On such beds the soil warms up faster and moisture does not stagnate. To ensure that the beds do not lose shape, they are framed with walls of various materials – wood, metal or brick. Many vegetable cultures are really beautiful. Leaf salads, beets, onions, effectively look and neatly tied tomato bushes look great. In its own way, powerful plants of squash and pumpkin are attractive, the main thing is to place all this correctly on the site. The design of the garden will be especially impressive if you select plants that are contrasting in color, shape and texture. For example, you can create a beautiful pattern, alternating the bushes of green and reddish salad or beets. As a soloist usually take large expressive plants, for example, ornamental cabbage. Her elegant, with a pink middle of a head, decorate any garden, and their coloring will become brighter every day until the late autumn.

We have studied the adaptation of plant species in a multi-storey residential building.

a

b

Fig. a, b – Intensive green roof of the residential complex Royal Tower, Kiev, 2016

Table – The observation of plant phenotype in Kiev

№ in order	Name	Height, m	Mark	Damage level, %
1	*Quercus paludosus multicaulus*	5	4	slight damage to the tips of shoots with complete restoration
2.	*Quercus rubra multicaulus*	6	4	slight damage to the tips of shoots with complete restoration
3.	*Malus multicaulus*	3	4	slight damage to the tips of shoots with complete restoration
4.	*Carpinus*	3,5	4	slight damage to the tips of shoots with complete restoration
5.	*Pinus sylvestris*	6,0	4	slight damage to the tips of shoots with complete restoration
6.	*Amelanchier lamarckii*	3,5	4	slight damage to the tips of shoots with complete restoration
7.	*Amelanchier lamarckii*	4,0	4	slight damage to the tips of shoots with complete restoration
8.	*Ácer platanoides 'Globosum'*	4,5	4	slight damage to the tips of shoots with complete restoration
9.	*Acer rubrum*	5,0	4	slight damage to the tips of shoots with complete restoration
10.	*Acer rubrum 'Scanlon'.*	6,0	4	slight damage to the tips of shoots with complete restoration
11.	*Ligustrum vulgare'Globosum'*	1,10	4	slight damage to the tips of shoots with complete restoration
12.	*Thuja occidentalis 'Smaragd'*	3,0	4	slight damage to the tips of shoots with complete restoration
13.	*Thuja occidentalis Brabant*	2,5	4	slight damage to the tips of shoots with complete restoration
14.	*Spiraea japonica Golden Princess*	0,40	4	slight damage to the tips of shoots with complete restoration
15.	*Spiraea japonica Goldflame*	0,40	4	slight damage to the tips of shoots with complete restoration
16.	*Spiraea japonica 'Little Princess'*	0,30	4	slight damage to the tips of shoots with complete restoration
17.	*Berberis thunbergii*	0,25	4	slight damage to the tips of shoots with complete restoration
18.	*Berberis thunbergii*	0,60	4	slight damage to the tips of shoots with complete restoration
19.	*Euónymus alátus*	1,50	4	slight damage to the tips of shoots with complete restoration
20.	*Hydrangea arborescens 'Annabelle'*	0,80	4	slight damage to the tips of shoots with complete restoration
21.	*Pinus mugo 'Pumilio'*	1,0	4	slight damage to the tips of shoots with complete restoration
22.	*Pinus mugo 'Pumilio'*	0,8	4	slight damage to the tips of shoots with complete restoration
23.	*Azalea rubra*	0,5	4	slight damage to the tips of shoots with complete restoration
24.	*Thuja occidentalis 'Danica'*	0,6	4	slight damage to the tips of shoots with complete restoration
25.	*Hydrangea anomala 'Petiolaris'*	1,5	4	slight damage to the tips of shoots with complete restoration
26.	*Parthenocíssus tricuspidáta*	1,0	4	slight damage to the tips of shoots with complete restoration
27.	*Physocarpus opulifolius 'Luteus'*	0,8	4	slight damage to the tips of shoots with complete restoration

Conclusions

Analysis of roofing gardening technology has shown that the success of the operation of the entire roofing structure depends on the quality of the waterproofing, the drainage layer and the proper laying of all layers. Difficulties with the operation of the "green roof" are associated with a violation of the technology of laying layers and improper selection of the range of plants.

The analysis of the phenological observations of the state of plants in the conditions of the temperate continental climate of Ukraine showed that all types of life forms of plants can flourish in multi-storey buildings: grasses, shrubs, semishrubs, trees. In this case trees with a height of 4 to 6 m showed a high adaptive potential. All plants came from the winter period with an index of 4 points, which indicates the preservation of decorativeness and vitality. The analyzed range of plants can be considered as promising for roofing gardening in the conditions of the temperate continental climate of Ukraine.

REFERENCES (TRANSLATED AND TRANSLITERATED)

1. Tehnoekologija: navch.posib. dlja vyshh. navch. zakl. / V.M. Udod, V.V. Trofimovich, O.S. Voloshkina, O.M. Trofymchuk. – Kyi'v: KNUBA, ITGIP NANU, 2007. – 195 s. (in Ukrainian)
2. Landshaftna ekologija: navch. posibnyk / A.Je. Kuskov, T.M. Tkachenko. – Makii'vka, Donec'k: vyd-vo Noulidzh, 2009. – 165 s. (in Ukrainian)
3. Tkachenko T.N. Vozmozhnost' sozdanija jenergojeffektivnyh jekologicheski chistyh zelenyh tehnologij v uslovijah Ukrainy // Stroitel'stvo, materialovedenie, mashinostroenie: sb. nauchn. trudov. Serija: «Sozdanie vysokotehnologicheskih jekokompleksov v Ukraine na osnove koncepcii sbalansirovannogo (ustojchivogo) razvitija, Vyp.81, GVUZ «Pridneprovskaja gosudarstvennaja akademija stroitel'stva i arhitektury». – Dnepropetrovsk, 2015. – S. 256–260. (in Russian)
4. Grant, G., L. Engleback, B. Nicholson, D. Gedge, M. Frith, and P. Harvey. 2003. (in English)
5. Brenneisen, S. 2003. The Benefits of Biodiversity from Green Roofs Key Design Consequences. In Proc. Greening Rooftops for Sustainable Communities: Chicago 2003.
6. Sutton R.K. Green Roof Ecosystems. – Cham: Springer, 2015. – 447 p.
7. Izumi C. Mori. Biomarkers of green roof vegetation: anthocyanin and chlorophyll as stress marker pigments for plant stresses of roof environments / C. Mori Izumi, S. Utsugi, S. Tanakamaru, A. Tani, T. Enomoto, M. Katsuhara // J. Environ. Eng. Manage., 19(1), 21-27 (2009)
8. Peck Steven W. Report on benefits, barriers and opportunities for green roof and vertical garden technology diffusion / Steven W. Peck, Callaghan C., M. E. Kuhn, B. Bass – Canada Mortgage and Housing Corporation, 1999. – 77 p.
9. Minke whales, G. und Witter, G.; Haeuser mit Gruenem Pelz, Ein Handbuch zur Hausbegruenung; Verlag Dieter Fricke GmbH, Frankfurt, 1982.
10. Metody opredelenija morozostojkosti rastenij. / Pod red. Tumanova I.I. – M.: «Nauka», 1967. – 88 s. (in Russian)
11. Nojferta P., Nefa L. Proektirovanie i stroitel's'vo. Dom, kvartira, sad. – M.: Arhitektura-S, 2005. – 255 s. (in Russian)
12. Ljusev V.K. Posobie po ozeleneniju i blagoustrojstvu jekspluatiruemyh krysh zhilyh i obshhestvennyh zdanij, podzemnyh i polupodzemnyh garazhej, ob#ektov grazhdanskoj oborony i drugih sooruzhenij. – M.: Strojizdat, 2008. – 110 s. (in Russian)

13. Tkachenko T.N. Al'ternativnye vidy promyshlennogo ozelenenija / Tkachenko T.N., Savenkova S.V. // Naukovo-tehnichne ta organizacijno-ekonomichne spryjattja reform u budivnyctvi i zhytlovo-komunal'nomu gospodarstvi: tez. III mizhnar. konf. (12.04-13.04.2012) / Makii'vka, Donbas'ka nacional'na akademija budivnyctva i arhitektury. – 2012. – Ch.I. – S. 211–214. (in Ukrainian)

REFERENCES

1. Техноекологія: навч.посіб. для вищ. навч. закл. / В.М. Удод, В.В. Трофімовіч, О.С. Волошкіна, О.М. Трофимчук. – Київ: КНУБА, ІТГІП НАНУ, 2007. – 195 с.
2. Ландшафтна екологія: навч. посібник / А.Є. Кусков, Т.М. Ткаченко. – Макіївка, Донецьк: вид-во Ноулідж, 2009. – 165 с.
3. Ткаченко Т.Н. Возможность создания энергоэффективных экологически чистых зеленых технологий в условиях Украины // Строительство, материаловедение, машиностроение: сб. научн. трудов. Серия: «Создание высокотехнологических экокомплексов в Украине на основе концепции сбалансированного (устойчивого) развития, Вып.81, ГВУЗ «Приднепровская государственная академия строительства и архитектуры». – Днепропетровск, 2015. – С. 256–260.
4. Grant, G., L. Engleback, B. Nicholson, D. Gedge, M. Frith, and P. Harvey. 2003.
5. Brenneisen, S. 2003. The Benefits of Biodiversity from Green Roofs Key Design Consequences. In Proc. Greening Rooftops for Sustainable Communities: Chicago 2003.
6. Sutton R.K. Green Roof Ecosystems. – Cham: Springer, 2015. – 447 p.
7. Izumi C. Mori. Biomarkers of green roof vegetation: anthocyanin and chlorophyll as stress marker pigments for plant stresses of roof environments / C. Mori Izumi, S. Utsugi, S. Tanakamaru, A. Tani, T. Enomoto, M. Katsuhara // J. Environ. Eng. Manage., 19(1), 21-27 (2009)
8. Peck Steven W. Report on benefits, barriers and opportunities for green roof and vertical garden technology diffusion / Steven W. Peck, Callaghan C., M. E. Kuhn, B. Bass – Canada Mortgage and Housing Corporation, 1999. – 77 p.
9. Minke whales, G. und Witter, G.; Haeuser mit Gruenem Pelz, Ein Handbuch zur Hausbegruenung; Verlag Dieter Fricke GmbH, Frankfurt, 1982.
10. Методы определения морозостойкости растений. / Под ред. Туманова И.И. – М.: «Наука», 1967. – 88 с.
11. Нойферта П., Нефа Л. Проектирование и строительсьво. Дом, квартира, сад. – М.: Архитектура-С, 2005. – 255 с.
12. Люсев В.К. Пособие по озеленению и благоустройству эксплуатируемых крыш жилых и общественных зданий, подземных и полуподземных гаражей, объектов гражданской обороны и других сооружений. – М.: Стройиздат, 2008. – 110 с.
13. Ткаченко Т.Н. Альтернативные виды промышленного озеленения / Ткаченко Т.Н., Савенкова С.В. // Науково-технічне та організаційно-економічне сприяття реформ у будівництві і житлово-комунальному господарстві: тез. ІІІ міжнар. конф. (12.04-13.04.2012) / Макіївка, Донбаська національна академія будівництва і архітектури. – 2012. – Ч.І. – С. 211–214.

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Т.М. Ткаченко

СТВОРЕННЯ ЕНЕРГОЕФЕКТИВНИХ «ЗЕЛЕНИХ КОНСТРУКЦІЙ» В УМОВАХ ПОМІРНО-КОНТИНЕНТАЛЬНОГО КЛІМАТУ

Анотація. Розглянуто основні аспекти створення енергоефективних «зелених конструкцій» в урбоценозах помірно-континентального клімату. Встановлено, що проблеми експлуатації «зелених покрівель» виникають при порушенні технології укладання покрівельних шарів і при неправильному підборі асортименту рослин. Технічні проблеми у створенні «зелених покрівель» виникають при неправильному

виборі гідроізоляції. Також повинна бути єдина дренажна система, на якій розміщуються всі інші елементи. При недотриманні даних умов можливе протікання покрівлі та розвиток мікроорганізмів. Асортимент рослин на інтенсивній покрівлі зазвичай обмежується низькорослими рослинами: травами, напівчагарниками і чагарниками. Фенологічні спостереження, проведені на інтенсивній покрівлі житлового комплексу Royal Tower у Києві, показали, що при правильному підборі асортименту рослин і технології їх вирощування висота рослин може бути значно більшою: від 4 до 6 м, що істотно розширює еколого-біологічні можливості інтенсивних зелених покрівель помірно-континентального клімату. Запропоновано асортимент видів рослин з високим адаптаційним потенціалом різних життєвих форм з широкою висотою варіювання: від низькорослих трав до дерев 6 м висотою: *Quercus paludosus multicaulus, Quercus rubra multicaulus, Pinus sylvestris, Acer rubrum, Acer rubrum 'Scanlon', Chenomeles Maulei, Arónia melanocárpa, Berberis thunbergii, Betula pumila, Crataegus laevigata, Vitis amurensis, Parthenocíssus tricuspidáta, Cornus alba, Picea abies, Picea canadensis, Picea pungens, Lonicera alpigena, Lonicera caerulea, Salix caprea, Viburnum opulus, Cotoneaster lucidus, Acer tataricum, Acer ginnala, Elaeagnus argentea, Juniperus horizontalis, Juniperus sabina, Sorbus aucuparia, Ribes aureum, Symphoricarpos albus, Pinus mugo, Spiraea arguta, Spiraea japonica, Thuja occidentalis, Philadelphus coronaries, Mālus sibirica, Malus niedzwetzkyana.*

Ключові слова: «зелені конструкції»; «зелені покрівлі»; адаптаційний потенціал; асортимент рослин; «пошарова» конструкція.

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ONTOLOGICAL APPROACH TO THE DESCRIPTION OF THE RESERVOIR'S PASSPORT

Summary: *In this paper, an ontologized description of the ecological passport of reservoirs is proposed that allows grouping and combining all necessary data in one document for solving various ecological problems, in particular for planning environmental measures.*
Key words: *ontologized description; forecasting; ontograph; ecological passport; monitoring of surface reservoirs.*

Introduction

Today, society is increasingly using in its activities information on the state of the environment. This information is needed in everyday life of people, when running an economy, in extraordinary circumstances, etc. An important role in human life plays water. It is necessary to keep hydraulic engineering facilities in proper technical condition and ensure their reliable operation, in particular when passing spring and rain floods.

The objective of monitoring the reservoir (as well as other objects) is to obtain objective information on the state and development of measures to improve the environmental situation. Important is the issue of certification of water objects. With the help of certification you can evaluate the technical condition and to develop plans for the prevention of emergencies, recommendations for necessary precautions, etc. [1].

From the point of view of the world-wide practice, the passport is a comprehensive registration document, which contains information on the main parameters (area, volume, width, length, the presence of a dam, etc.), a unified set of basic data on water regime, physical and geographical features, use natural resources and the ecological state, as well as the development of recommendations for improving the sustainability of the ecological system [2].

The indicated information provides for the presence of a considerable amount of various data, for the systematization and structuring of which should be developed by the corresponding mathematical and methodical apparatus. At the same time, the scientific literature describes models that allow mathematically to describe certain components of the reservoir environment, but there are no complex tools that allow for the formalization of the description [3, 4].

The main part

Passport of Protected Object of Nature is a document in which the basic information about a particular object is recorded. In order to assess the ecological status of the river basin and to develop measures for the rational use and protection of water and the reproduction of water resources, the passport shall be developed in accordance with the procedure established by the Cabinet of Ministers of Ukraine.

Individualization of water objects is carried out the by means of passport. This is a set of state measures aimed at streamlining the use of water objects, protecting them from pollution, clogging and exhaustion, prevention of harmful effects on water and elimination of their consequences, improvement of the state of water objects.

The passport of the water object is developed in accordance with the Order of the Ministry of Ecology and Natural Resources of Ukraine "On Approval of the Procedure for the Development of the Passport of a Water Object" dated March 18, 2013, No. 99, and does not provide for a formalized description for computer.

The purpose of the work is to consider approaches to formalizing the description of the ecological passport of the reservoir on the basis of ontology, which allows to systematize and structure all necessary data for solving various problems, in particular for planning environmental measures.

Ontologized description of the reservoir passport

Passports that are developed by individual organizations are often subjective.

Single space of digital knowledge is not provided. Knowledge base describing environmental passports should include environmental concepts and their links. One of the effective approaches to describing such models is an ontological one, where in the knowledge base in the formalized form the knowledge of the subject field is presented. In ontological Knowledge base, the following requirements are taken into account [5]:

1. Computer ontology provides efficient machine processing of knowledge.
2. In contrast to the usual subjective approach to the design of knowledge base, the ontological approach involves rigid structuring of terms and concepts.
3. It is necessary to use means of support the automated construction of ontology.

The ontological aspects of the description of the reservoir passport include a range of issues: from the structuring of information and characteristics to the to communications of characteristics and measures to improve the ecological status of the reservoir.

The passport of the reservoir should include the following blocks: general information, hydrotechnical characteristics of the reservoir, information on the use of reservoirs for fish farming purposes:

General Information:

1. Name of the reservoir, year of creation.
2. Purpose of the reservoir (fish breeding, fishing, irrigation, water supply, etc.).
3. Filling of the reservoir (filled, deflated on a time, is withered, the dam is broken, etc.). From what time without water.
4. Location of the reservoir (among the village, arable land, in the meadow, in the forest, etc.), the catchment ground (black earth, loam, clay, forest, peat).
5. Pollution of the reservoir (wastewater or uncleanness), what types, what is the source of pollution.
6. Distance from the reservoir to agricultural facilities and to the nearest railway station or pier (name) in km.
7. The state of access roads to the reservoir in the spring and autumn.
8. Is there a fish farm in the area and the distance to it in km?

Morphometric and hydraulic engineering characteristics:

9. Form of the reservoir (round, oval, branched, rectangular, etc.).

10. The area of the reservoir, formed by filling water, ha, change in spring, low water.

11. Dimensions of the reservoir (length, width).

12. Depth of reservoirs (largest and medium).

13. The nature of the shores (high, low, steep, flattened, overgrown, swampy, shattered shores, landslides, etc.).

14. Nature of the coastline (equable, winding).

15. Is there an inflow and a runoff or not, permanent, temporary (keys, stream, river, atmospheric waters, etc.).

16. Is reservoir flooded with flood waters and on what time? Is reservoir connected with other reservoirs after the fall of the flood?

17. Is reservoir overgrown with the vegetation, what is exactly, what percentage of the area of overgrown, are there any islands?

18. Soils of the bottom of the reservoir and the degree of silting, the thickness of the layer of mud, the relief of the bottom (even, hollow, etc.).

19. What kind of fish is the usual in the pond (list) that prevails. Fish fattening, fish growth.

20. Is there a predator and garbage fish (pike, perch, etc.) in reservoir and during the flood?

21. Are there crayfish, mollusks in the reservoir?

22. Water quality (fresh, salty, is drinking by people, cattle, no one drinks). Water color. Whether it is noted whether the smell of hydrogen sulfide and to what extent (sharply, weakly).

23. Is there waterfowl in the reservoir and in what quantity?

24. What are the structures in the reservoir: the dam (its length, height, width), water runoff, drainage, pipe, etc. Their design and condition (wooden, stone, brick, working, old, damaged, filtering, etc.).

Information on the use of reservoirs for fish farming purposes:

25. Is it possible catches a fish in reservoir with a seine or other fishing gear, on which part is not catches a fish and for what reasons (pits, driftwood, thickets, etc.).

26. Is there fishing in the reservoir, catching fish, fishing gear and fishing season.

27. Number of fish per year. Specify which breeds are predominant in catches.

28. Is there fish mortality, when and what it is caused. Was it possible to spend the winter in the reservoir: carp, crucian carp.

29. Is it possible to lower a reservoir for fishing, without breaking other economic needs? What needs to be done for descent and how quickly the reservoir is filled after descent and from where.

30. Was the filling with fish with a carp or other fish, when and in what quantity? From which reservoir the fish was taken and what were the results?

Other information.

Accordingly, the part of the ontograph of the passport will look like (Fig. 1).

In addition, ontologized description of the passport of the reservoir contains measures to improve the ecological status of the reservoir.

Methods of wastewater treatment can be divided into mechanical, chemical, physico-chemical and biological, when they are used together, the method of purification and disposal of sewage is called combined [6–15].

The essence of the mechanical method is that mechanical impurities are removed from the sewage by means of settling and filtration. Particles, depending on the size,

are captured by lattices, sieves, sand trap, septic tanks, trap for pus, and surface contamination – oil trap, gasoline trap, sump, etc. Mechanical purification allows to separate from domestic wastewater to 60–75% of insoluble impurities, and from industrial – to 95%, many of which as valuable impurities are used in production.

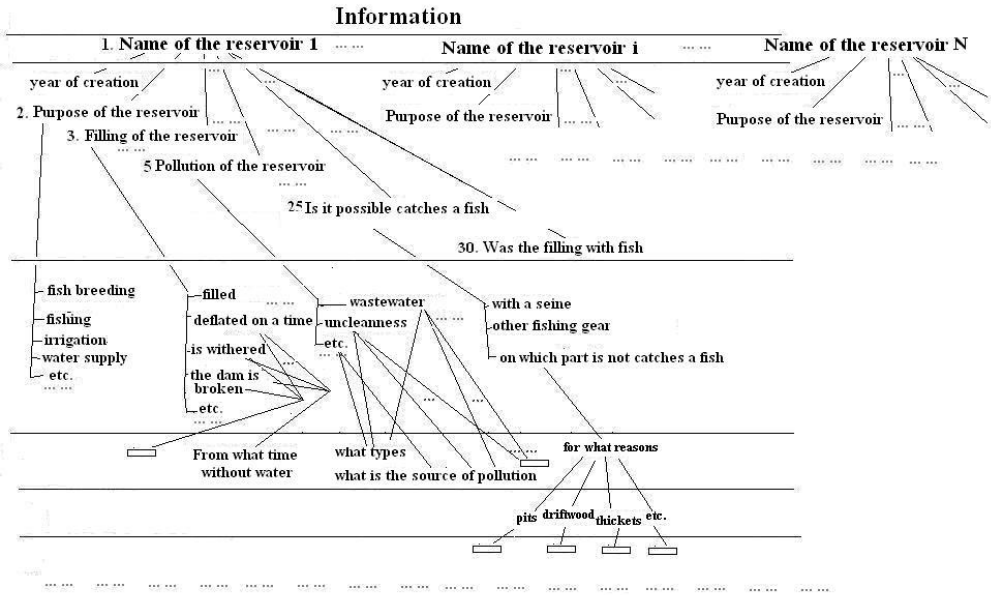

Fig. 1 – Fragment of ontograph "Information"

The chemical method consists in the fact that various chemical reagents are added to the waste water, which react with pollutants and enclose them in the form of insoluble precipitates. Chemical purification reduces insoluble impurities to 95% and soluble – up to 25%.

In the physico-chemical method of treatment from sewage, finely dispersed and dissolved inorganic impurities are removed and organic and badly oxidized substances are destroyed. Often, from physico-chemical methods, coagulation, oxidation, sorption, extraction, and the like are used. Electrolysis is also widely used. It consists in the destruction of organic substances in waste water and the extraction of metals, acids and other inorganic substances. Electrolytic cleaning is carried out in special structures – electrolyzers. The purification of sewage with electrolysis is effective at the lead and copper enterprises, in paintwork and in some other areas of industry.

Contaminated wastewater is also cleaned by ultrasound, ozone, ion-exchange resins and high pressure, good purification by chlorination.

Among the methods of wastewater treatment, an important role is played by the biological method, based on the use of regularities of biochemical and physiological self-purification of rivers and other reservoirs. There are several types of biological devices for sewage treatment: biofilters, biological pond and aero tanks. In aero tanks there is a purification of water by bioorganisms, whose vital activity is supported by the supply of oxygen.

Environmental rehabilitation of reservoirs includes:

– cleaning of the bed of reservoir from contaminated deposits;
– strengthening the bottom;
– accumulation and purification of drainage and storm water, which feed the reservoirs;
– reclamation of catchment areas;
– strengthening the shore;
– rehabilitation and improvement of floodplain territories;
– landscaping of coastal zones.

Environmental rehab consists of several stages:

1. Stages of preparatory work.

The study of hydrogeological characteristics of the reservoir, its morphological parameters (depth, relief of the bottom), sampling of water and sludge deposits for laboratory analysis on the subject of chemical contamination doing.

2. Stages of technical rehabilitation of the reservoir.

Depending on the size of the reservoir, the availability of hydrotechnical structures, hydrogeological characteristics of the area and a number of other circumstances, the need for mechanical cleaning of the reservoir from the sludge is determined.

3. Stage of biological rehabilitation.
4. Creation (restoration) of the coastal ecosystem.

Correctly located and formed coastal areas in many respects determine the qualitative composition of water in the future. Helps to form the natural landscape to provide a forage base of the biota of the reservoir. Restoration in the coastal zone of a certain type of green plantings and various living organisms favorably affects the ecosystem of reservoirs.

5. Complex improvement of the adjoining territory.

Recovery measures include artificial breeding and subsequent release into the habitat of fry, in the first place those species of fish that have suffered the greatest damage and whose populations either have already reached, or are at the border of the amount at which its self-recovery becomes impossible.

The next type of events considered is economic measures, one of which is the rational nature management. The use of nature in any field is based on the following principles:

– principle of system approach;
– principle of optimization of nature use;
– the principle of advancing;
– principle of harmonization of relations of nature and production;
– the principle of integrated use.

Let's briefly consider these principles.

The principle of a systematic approach involves a comprehensive assessment of the impact of production on the environment and its corresponding reactions. For example, rational use of irrigation increases the soil fertility, while at the same time it leads to the depletion of water resources. The discharge of pollutants in the reservoirs is assessed not only by the influence on the biota, but also determine the life cycle of water objects.

The principle of optimization of nature management is to make appropriate decisions on the use of natural resources and natural systems on the basis of simultaneous application of ecological and economic approaches, forecasting the development of various industries and geographical regions.

The principle of outspeeding up the production of raw materials by processing rates is based on reducing the amount of waste in the production process. It envisages the growth of products through more complete use of raw materials, resource conservation and technology improvement.

The principle of harmonization of relations of nature and production is based on the creation and exploitation of natural and man-made ecological and economic systems, representing a set of industries that provide high production rates. At the same time, maintaining an environmentally safe environment is ensured. The production has a management service for timely detection of harmful effects and adjustment of system components. For example, if a deterioration of the environment due to the production activity of the enterprise is detected, the management decides to suspend the process or reduce emissions and discharges. In such systems, prediction of unwanted situations is foreseen by monitoring.

The principle of integrated use of natural resources involves the creation of territorial production complexes based on existing raw materials and energy resources, which allow for a more complete use of these resources, while reducing the technogenic load on the environment. They have a specialization, concentrated in a certain territory, have a single industrial and social structure and jointly promote the protection of the natural environment. However, these complexes can also have a negative impact on the natural environment, but due to the complex use of resources, this effect is significantly reduced.

The measures necessary for improve the ecological status of the reservoir are also described by the relevant part of the ontograph of the passport (Fig. 2).

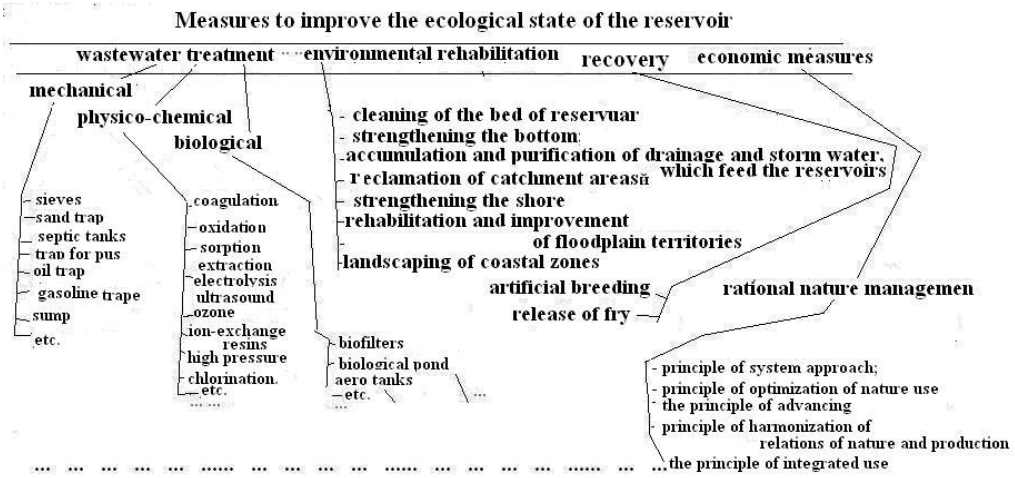

Fig. 2 – Fragment of the ontograph "Measures to improve the ecological state of the reservoir"

Applications of ontologized description of the passport.

Computer ontologies (KO) make it possible to solve a certain range of tasks:

– Analysis of the status of objects in order to develop recommendations for improvement environmental indicators and prevention of emergencies.

– Analysis of static and dynamic information about objects with the purpose of making recommendations for scheduled maintenance and (or) emergency repairs.

– Development of recommendations for optimization of maintenance processes.

The use of an ontological description of environmental problems and measures that are necessary to improve the ecological status allows us to take into account the linkages of problems and corresponding measures, which should increase the effectiveness of the recommendations and plan the measures for improving the ecological state.

An example is the planning of some measures in reservoirs to improve the ecological state. Notions of fragment ontograph "Information" (Fig. 1), which determine the ecological problem associated with those notions of the fragment of the ontograph "Measures to improve the ecological status of the reservoir" (Fig. 2), which can solve this problem (Fig. 3).

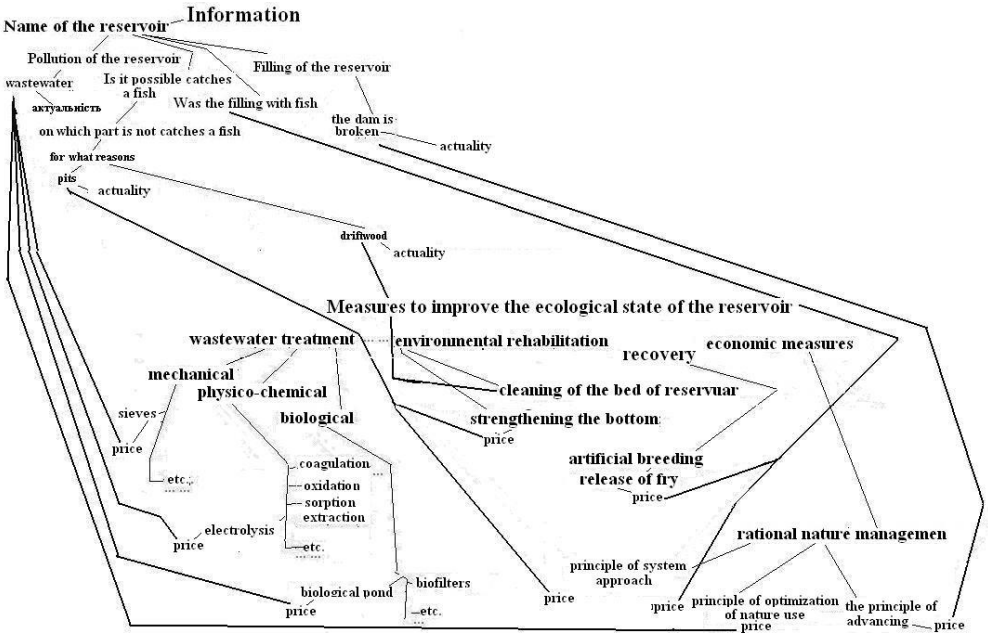

Fig. 3 – Communication concepts and measures

In Figure 3, such connections combine the notions of "waste waters", "pits", "driftwood", "ruptured dam" with the notions of "sieves", "electrolysis", "biological pond", "banding", "fry production", "the principle of integrated use", "the principle of optimizing the use of nature".

The interest of society in solving a specific ecological problem is reflected in the description of the concept of "relevance" which is associated with the concept defining the problem. This indicator corresponds to the degree of "maturity" of the problem (how clearly it is determined, how much it is necessary for society, how much society is ready to pay for it). financing in a certain period or priority can be of the decision of practical implementation of this characteristic. Specific data is contained in the description of ontology (in the description of the concept of "relevance").

For example, the notions of "ruptured dam" ontology with the threat of flooding of housing will be the first priority, as society is very interested in solving this problem. At the same time, the "Nature of the coastline" (the coefficient of winding) is what is unlikely to be a problem for society.

Each notion of the ontograph of measures that respond to environmental problems is a technical, scientific or economic opportunity to address these problems. The price of solving a specific environmental problem is reflected in the description of the concept of "price" which is associated with the notion of measure that solving problem. Consider more detailed planning of measures to reduce the pollution of reservoirs by sewage. Measures to improve the ecological state for this are expensive and time-consuming. Meaningless carry out all measures at the same time. Necessary is plan of development and implementation (ranking by the order of conducting, in particular – which to implement first).

From the computer ontology (ontologized description of the passport) in the automated mode selected notions that denote appropriate measures. The description of the concept of "price", which is connected with the concept "wastewaters" are doing analyzed. The ranking is performed in accordance with the fragment of the algorithm in Fig. 4. Using the graphical interface, an expert adjusts the ranking of events and determines waste waters one to enter first.

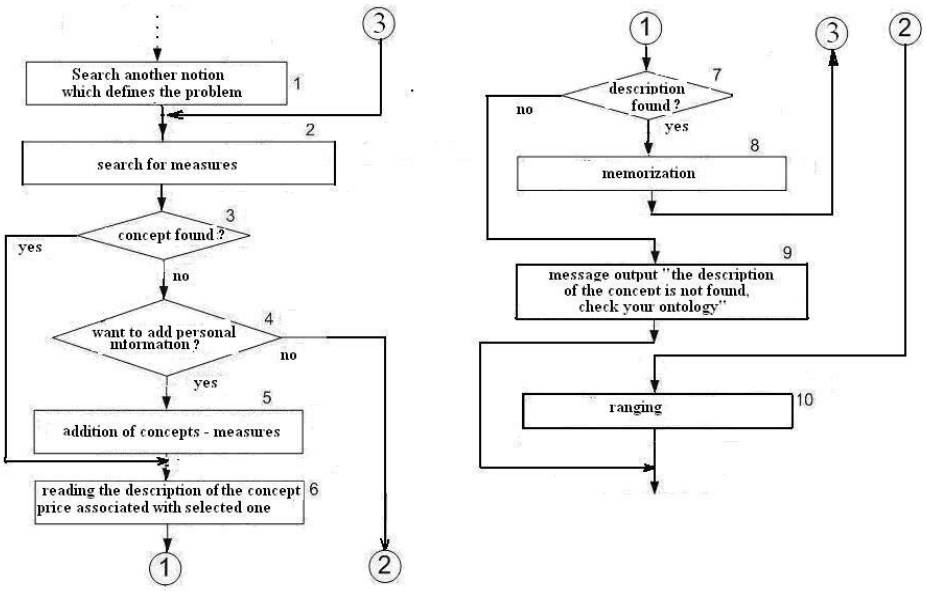

Fig. 4 – Fragment of the algorithm relating to the ranking of measures for a notion that defines an environmental problem

In block 1 in this example, the notion "waste waters" choosed.

In block 2 the following notion is sought – a measure associated with the chosen one.

In block 3 the situation when the notion is not found means that the list of measures for this problem is exhausted.

In blocks 4, 5 a dialogue and a window for introducing additional notion – measures are displayed.

In block 7, the situation when the description is not found requires updating the ontology, is displayed message in block 9.

Block 8 stores the notion – measure and the value of its price for further ranking.

In block 10, the ranking of concepts – measures on the difference "funding from the selected problem" – "price of the event".

Conclusions

An ontological approach to the description of the ecological passport of a reservoir, which uses computer ontologies, provides systematization of concepts, taking into account their interconnection and provides the opportunity to group and combine all necessary data in one document for solving various ecological tasks, in particular for planning of ecological measures. A similar approach can be used for planning in industry and other industries, including in education to plan e-course preparation.

REFERENCES (TRANSLITERATED)

1. Klymenko V.H. Zahalna hidrolohiya: Navchalnyy posibnyk dlya studentiv / Klymenko V.H. – Kharkiv: KHNU, 2008. – 144 c. (in Ukrainian)
2. Vodna Ramkova Dyrektyva 2000/60/ES. Osnovni terminy ta yikh vyznachennya. – K.: RODECOVERSeau, 2006. – 244 s. (in Ukrainian)
3. Mokin V.B. Matematychni modeli ta prohramy: monohrafiya. / V.B. Mokin, B.I. Mokin. – Vinnytsya: UNIVERSUM-Vinnytsya, 2000. – 152 s. (in Ukrainian)
4. Komp'yuteryzovani rehionalni systemy derzhavnoho monitorynhu poverkhnevykh vod: modeli, alhorytmy, prohramy. Monohrafiya / [Mokin V.B., Botsula M.P., Horyachev H.V., Davydenko O.V., Katasonov A.I., Yashcholt A.R.]; pid red. V.B. Mokina. – Vinnytsya: UNIVERSUM-Vinnytsya, 2005. – 310 s. (in Ukrainian)
5. Palahyn A.V. Ontolohycheskye metody y sredstva obrabotky predmetnykh znanyy / A.V. Palahyn, S.L. Kryvyy, N.H. Petrenko. – [monohrafyya] – Luhansk: yzd-vo VNU ym. V. Dalya, 2012. – 323 s. (in Russian)
6. Khilchevskyy V.K. Vodopostachannya i vodovidvedennya: hidroekolohichni aspekty: Pidruchnyk. – K.: VPTS "Kyyivskyy universytet", 1999. – 319 s. (in Ukrainian)
7. Zapolskyy A.K. Vodopostachannya, vodovidvedennya ta yakist vody. – K.: Vyshcha shkola, 2005. – 671 s. (in Ukrainian)
8. Ochyshchennya stichnykh vod pryrodnymy dyspersnymy sorbentamy: [monohrafiya] / M.S. Malovanyy, I.M. Petrushka; M-vo osvity i nauky, molodi ta sportu Ukrayiny, Nats. un-t "Lviv. politekhnika". – L.: Vyd-vo Lviv. politekhniky, 2012. – 180 s.: il. – Bibliohr.: s. 160-174 (171 nazva). – ISBN 978-617-607-306-2(in Ukrainian)
9. Mala hirnycha entsyklopediya: u 3 t. / za red. V.S. Biletskoho. – D.: Skhidnyy vydavnychyy dim, 2004–2013. (in Ukrainian)
10. Vodosnabzhenye y vodootvedenye: Éntsyklopedyya / Otv. red. A.E. Popov. – K.: Lohos, 2002. – 488 s. (in Russian)
11. Brahynskyy L.P. Vsestoronnyy analyz toksycheskoy opasnosty poverkhnostno-aktyvnykh veshchestv dlya hydrobyontov / L.P. Brahynskyy, L.A. Syrenko // Hydrobyol. zhurn. – 2003. – №6. – S. 115–118. (in Russian)
12. Krot Yu.H. Yspolzovanye vysshykh vodnykh rastenyy v byotekhnolohyyakh ochystky poverkhnostnykh y stochnykh vod / Yu.H. Krot // Hydrobyol. zhurn. – 2006. – №1. – S. 47–57.
13. Ostroumov S.A. O byotycheskom ochyshchenyy vody y ékolohycheskoy reparatsyy / S.A. Ostroumov // Syb. ékol. zhurnal. – 2006. – №3. – S. 339–343. (in Russian)
14. Ekolohichna bezpeka hidrosfery rehionu, ochyshchennya stichnykh vod ta utylizatsiya shlamiv vodoochyshchennya / O.M. Adamenko, L.I. Chelyadyn, V.L. Chelyadyn, M.R. Skrobach // Ékotekhnolohyy y resursosberezhenye. – 2007. – No 5. – S. 68–73. (in Ukrainian)
15. Fizyko-khimichni osnovy tekhnolohiyi ochyshchennya stichnykh vod. Pidruchnyk / Pid red. A.K. Zapolskoho. – K.: Libra, 2000 – 552 s. (in Ukrainian)

REFERENCES

1. Клименко В.Г. Загальна гідрологія: Навчальний посібник для студентів / Клименко В.Г. – Харків: ХНУ, 2008. – 144 с.

2. Водна Рамкова Директива 2000/60/ЕС. Основні терміни та їх визначення. – К.: RODECOVERSeau, 2006. – 244 с.
3. Мокін В.Б. Математичні моделі та програми: монографія. / В.Б. Мокін, Б.І. Мокін. – Вінниця: УНІВЕРСУМ-Вінниця, 2000. – 152 с.
4. Комп'ютеризовані регіональні системи державного моніторингу поверхневих вод: моделі, алгоритми, програми. Монографія / [Мокін В.Б., Боцула М.П., Горячев Г.В., Давиденко О.В., Катасонов А.І., Ящолт А.Р.]; під ред. В.Б. Мокіна. – Вінниця: УНІВЕРСУМ-Вінниця, 2005. – 310 с.
5. Палагин А.В. Онтологические методы и средства обработки предметных знаний / А.В. Палагин, С.Л. Кривый, Н.Г. Петренко. – [монография] – Луганск: изд-во ВНУ им. В. Даля, 2012. – 323 с.
6. Хільчевський В.К. Водопостачання і водовідведення: гідроекологічні аспекти: Підручник. – К.: ВПЦ "Київський університет", 1999. – 319 с.
7. Запольський А. К. Водопостачання, водовідведення та якість води. – К.: Вища школа, 2005. – 671 с.
8. Очищення стічних вод природними дисперсними сорбентами : [монографія] / М.С. Мальований, І.М. Петрушка; М-во освіти і науки, молоді та спорту України, Нац. ун-т "Львів. політехніка". – Л. : Вид-во Львів. політехніки, 2012. – 180 с. : іл. – Бібліогр.: с. 160–174 (171 назва). – ISBN 978-617-607-306-2
9. Мала гірнича енциклопедія : у 3 т. / за ред. В.С. Білецького. – Д. : Східний видавничий дім, 2004–2013.
10. Водоснабжение и водоотведение: Энциклопедия / Отв. ред. А. Е. Попов. – К.: Логос, 2002. – 488 с.
11. Брагинский Л.П. Всесторонний анализ токсической опасности поверхностно-активных веществ для гидробионтов / Л.П. Брагинский, Л.А. Сиренко // Гидробиол. журн. – 2003. – №6. – С. 115–118.
12. Крот Ю.Г. Использование высших водных растений в биотехнологиях очистки поверхностных и сточных вод / Ю.Г. Крот // Гидробиол. журн. – 2006. – №1. – С. 47–57.
13. Остроумов С.А. О биотическом очищении воды и экологической репарации / С.А. Остроумов // Сиб. экол. журнал. – 2006. – №3. – С. 339–343.
14. Екологічна безпека гідросфери регіону, очищення стічних вод та утилізація шламів водоочищення / О.М. Адаменко, Л.І. Челядин, В.Л. Челядин, М.Р. Скробач // Экотехнологии и ресурсосбережение. – 2007.– No 5. – С. 68–73.
15. Фізико-хімічні основи технології очищення стічних вод. Підручник / Під ред. А.К. Запольського. – К.: Лібра, 2000 – 552 с.

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Ю.Л. Тихонов

ОНТОЛОГІЧНИЙ ПІДХІД ДО ОПИСУ ПАСПОРТА ВОДОЙМИЩА

Анотація. У даній роботі пропонується онтологізований опис екологічного паспорта водоймищ, що дозволяє згрупувати і об'єднати всі необхідні дані в одному документі для вирішення різних екологічних завдань, зокрема для планування екологічних заходів.

Ключові слова: онтологізований опис; прогнозування; онтограф; екологічний паспорт; моніторинг поверхневих водойм; БЗ.

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РЕФЕРАТИ / ABSTRACTS

ЕКОЛОГІЧНА БЕЗПЕКА
ENVIRONMENTAL SAFETY

UDC 628.35: 651.6: 556.3

The methodic of modeling and alculations of the oxygen regime at the purification of the waste waters in aerotanks with suspended and fixed biocenosis / Airapetian T.S., Telyma S.V., Oliynyk O.Ya. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 5–14.

The methodic of mathematical modeling and calculations of oxygen regime at biological treatment of waste waters from organic contaminants in aerotanks with suspended and fixed biocenosis is given. The peculiarities of the simulation of oxygen supply during purification in aerotanks-mixers and aerotanks-displacers are considered at this.

УДК 628.35: 651.6: 556.3

Методика моделювання і розрахунків кисневого режиму при очистці стічних вод в аеротенках зі зваженим і закріпленим біоценозом / Айрапетян Т.С., Телима С.В., Олійник О.Я. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 5–14.

Наводиться методика математичного моделювання і розрахунків кисневого режиму при біологічній очистці стічних вод від органічних забруднень в аеротенках зі зваженим і закріпленим біоценозом. При цьому розглядаються особливості моделювання подачі кисню при очистці в аеротенках-змішувачах і в аеротенках-витискувачах.

UDC 536.24: 662.994

Expansion of the Range of Wet Air I-d Diagram for Environmental Safe Heat Production / Dziubenko V.H., Mileikovskyi V.O., Sachenko I.A. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 15–22.

The approach to expanding the parameters range of wet air I-d diagram without loss of accuracy for the tasks of condensing boilers is considered, which makes possible simplification of the calculations of heat and mass exchange processes during the development of condensation heat exchangers.

УДК 536.24: 662.994

Розширення діапазону I-d діаграми вологого повітря для екологічно безпечного виробництва теплоти / Дзюбенко В.Г., Мілейковський В.О., Саченко І.А. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 15–22.

Розглянуто підхід до розширення діапазону параметрів I-d діаграми вологого повітря без втрати точності для задач розробки конденсаційних котлоагрегатів, що дозволяє спростити розрахунки тепломасообмінних процесів при розробці конденсаційних теплообмінників.

UDC 504.062+556:528.8

GIS-based assessment of anthropogenic influence in Western Polissya region limnological ecosystems / Zagorodnya S.A., Novokhatska N.A., Okhariev V.O., Popova M.A., Radchuk I.V., Trysnyuk T.V., Shumeiko V.O., Atrasevych O.V. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 23–33.

Results of expeditionary researches of limnological systems in Western Polissya region of hydroacoustic methods complex using and information-analytical technologies are presented. Remote sensing monitoring method for lakes eutrophication processes research is considered. The concept of lake passport information model is proposed.

УДК 504.062+556:528.8

ГІС-оцінка антропогенного впливу в лімнологічних екосистемах Західного Полісся / Загородня С.А., Новохацька Н.А., Охарєв В.О., Попова М.А., Радчук І.В., Триснюк Т.В., Шумейко В.О., Атрасевич О.В. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 23–33.

Наведені результати експедиційних досліджень лімнологічних систем Західного Полісся на основі комплексного використання гідроакустичних методів та інформаційно-аналітичних технологій. Розглянуто методику дистанційного моніторингу евтрофікаційних процесів озер, запропонована концепція інформаційної моделі паспорту озера.

ОСНОВИ ПРИРОДОКОРИСТУВАННЯ
NATURAL RESOURCES

UDC 049.3:574.4:581.526

Analysis of the stability of water bodies to the action of destabilizing factors / Azarov S.I., Zadunaj O.S. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 34–42.

Methodical approaches to the assessment of ecological safety of ecosystems based on the establishment of a comprehensive indicator of the degradation of environmental components have been developed, which will allow us to assess non-additive properties of different-scale aquatic ecosystems. The analysis of methods for assessing the stability of water bodies to change the parameters of natural and anthropogenic regimes is carried out. Investigation of the nature of resistance of water bodies has revealed not only their desire for balance, but also a complex fight against regular and irregular (fluctuations) forces.

УДК 049.3:574.4:581.526

Аналіз стійкості водних об'єктів до дії дестабілізуючих факторів / Азаров С.І., Задунай О.С. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 34–42.

Розроблено методичні підходи до оцінки екологічної безпеки екосистем, які базуються на встановленні комплексного показника деградації компонентів природного середовища, що дозволить оцінювати неадитивні властивості різномасштабних водних екосистем. Проведено аналіз методів оцінки стійкості водойм до зміни параметрів природного і антропогенного режимів. Дослідження природи стійкості водних об'єктів виявило не тільки прагнення їх до рівноваги, а й складну боротьбу регулярних та нерегулярних (флуктуацій) сил.

UDC 669.187.001.2

Ecologically clean evaporation-condensation method application for obtaining of electrical contacts based on copper composite materials / Grechanuyk V.G., Matsenko O.V. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 43–48.

In this paper is considered the electron-beam technology on new materials creation, including copper and its alloys, as one of the most promising directions of modern electrometallurgy. The formation process of condensed composite materials (CCM) using this technology is absolutely environmentally clean, because it occurs in a vacuum, in addition, similar materials are obtained in a single technological cycle, what is economically profitable.

It is shown that this method was used for the first time to obtain structural composite materials Cu-Mo, Cu-W, Cu-Cr (massive sheet condensates weighting up to 30 kg separated from the substrate), which were used for electrical contacts and electrodes. The most industrial applications found the condensed from the vapor phase CM of Cu-Zr-Y-Mo and Cu-Cr-Zr-Y-Mo systems for discontinuous electrical contacts.

The mechanical properties of materials of Cu-Zr-Y-Mo system have been studied and it is shown that these materials are characterized by a sufficiently high electrical conductivity, hardness, strength and satisfactory plasticity, and mostly allows to refuse from silver-containing contacts, since they are not inferior, and in some cases exceed them for their operational reliability.

УДК 669.187.001.2

Застосування екологічно чистого методу випаровування-конденсації для отримання композиційних матеріалів на основі міді для електричних контактів / Гречанюк В.Г., Маценко О.В. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 43–48.

В роботі розглянута електронно-променева технологія зі створення нових матеріалів, в тому числі на основі міді та її сплавів, як один з найбільш перспективних напрямків сучасної електрометалургії. Процес формування конденсованих композиційних матеріалів (ККП) за цією технологією є абсолютно екологічно чистим, оскільки відбувається у вакуумі, крім того, подібні матеріали отримують за один технологічний цикл, що економічно вигідно.

Показано, що даний метод вперше використаний для отримання конструкційних композиційних матеріалів Cu-Mo, Cu-W, Cu-Cr (масивних листових конденсатів вагою до 30 кг, відокремлених від підкладки), які було застосовано для електричних контактів і електродів. Найбільше промислове застосування знайшли конденсовані з парової фази КМ системи Cu-Zr-Y-Mo і Cu-Cr-Zr-Y-Mo для розривних електричних контактів.

Досліджено механічні властивості матеріалів системи Cu-Zr-Y-Mo і показано, що зазначені матеріали відрізняються досить високою електропровідністю, твердістю, міцністю і задовільною пластичністю, що дозволяє в значній мірі відмовитися від використання контактів, що містять срібло, так як зазначені матеріали не поступаються, а в деяких випадках перевершують їх за своєю експлуатаційною надійністю.

UDC 504.349

Ecological safety of territories at introduction of modern technologies of processing of vegetable wastes / Trysnyuk V.M. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 49–53.

Work is devoted to the decision of research and practice task from the ground of changes of the state of ecological safety of territories at introduction of modern technologies of processing of vegetable wastes. The worked out practical recommendations are in relation to reduction of negative influence on the environment of vegetable wastes that is passed for introduction in further activity in relation to providing of ecological safety of territories.

УДК 504.349

Екологічна безпека територій при впровадженні сучасних технологій переробки рослинних відходів / Триснюк В.М. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 49–53.

Робота присвячена вирішенню науково-практичної задачі на підставі змін стану екологічної безпеки територій при впровадженні сучасних технологій переробки рослинних відходів. Розроблені практичні рекомендації стосовно зменшення негативного впливу на навколишнє середовище рослинних відходів, що передаються для впровадження у подальшу діяльність щодо забезпечення екологічної безпеки територій.

ІНФОРМАЦІЙНІ РЕСУРСИ ТА СИСТЕМИ
INFORMATION RESOURCES AND SYSTEMS

UDK 519.7:624.012

Vibrodinamic monitoring of pile foundation engineering on landslide hazardous site in dense urban development conditions / Kaliukh I.I., Lebid O.G., Dunin V.A., Margvelashvili N., Berchun Y.O., Samoilenko S.M. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 54–64.

An example of the application of modern regulatory requirements for the scientific and technical support of construction and monitoring of building structures for the safe arrangement of the pile foundation on a landslide hazardous building site in conditions of dense urban development in Kyiv has been considered.

УДК 519.7:624.012

Вібродинамічний моніторинг улаштування пальового фундаменту на зсувонебезпечній ділянці в умовах ущільненої міської забудови / Калюх Ю.І., Лебідь О.Г., Дунін В.А., Маргвелашвілі Н., Берчун Я.О., Самойленко С.М. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 54–64.

Розглянуто приклад застосування сучасних нормативних вимог щодо науково-технічного супроводу будівництва та моніторингу будівельних конструкцій для безпечного улаштування пальового фундаменту на зсувонебезпечній будівельній ділянці в умовах ущільненої міської забудови в м. Києві.

UDC 532.5:519.86:556.182:556.3:631.621

Calculations and prognosis of the influence of the exploitation of the "Hotyslavske" quarry on the hydrodinamics of the ground and underground waters of the Western Polissya / Diatel O.O. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 65–76.

The problems of the influence of the exploitation of the deposit of the sand and chalk "Khotislavske" on the hydrodynamics of ground and underground waters of Western Polissya are considered. At this the analytical methods of calculation of geophiltration processes and methods of mathematical modeling were used. The analysis of the validity of forecast calculations and modeling of the influence of a quarry on the territory of Ukraine carried out by the Belarusian side and the comparison of data are carried out.

УДК 532.5:519.86:556.182:556.3:631.621

Розрахунки та прогнозування впливу розробки родовища «Хотиславське» на гідродинаміку ґрунтових і підземних вод Західного Полісся / Дятел О.О. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 65–76.

Розглянуто питання впливу розробки родовища піску та крейди «Хотиславське» на гідродинаміку ґрунтових і підземних вод Західного Полісся. Використано аналітичні методи розрахунку процесів геофільтрації та методи математичного моделювання. Проведено аналіз обґрунтованості прогнозних розрахунків та моделювання впливу кар'єру на територію України, виконаних білоруською стороною, та співставлення даних.

UDC 504:712

Creation of energy efficient «green structures» in conditions of moderate continental climate / Tkachenko T.M. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 77–84.

The main aspects of creation of energy-efficient «green structures» in urbocenoses of moderate-continental climate are considered. It was established that problems of exploitation of "green roofs" arise in case of violation of the technology of laying roofing layers and in case of incorrect selection of plant assortment. Technical problems in creating "green roofs" arise when the wrong choice of waterproofing. There should also be a single drainage system, which accommodates all other elements. Failure to observe these conditions may lead to rooting and the development of microorganisms. The assortment of plants on an intensive roof is usually limited to low-growing plants: herbs, shrubs and shrubs. Phenological observations carried out on the intensive roof of the Royal Tower residential complex in Kyiv have shown that with the correct selection of plant assortments and their cultivation technology, plant height can be considerably larger: from 4 to 6 m, which significantly expands the ecological and biological capabilities of intensive green roofs moderately-continental climate. The assortment of species of plants with high adaptive potential of various life forms with a wide variation of height is proposed: from low-growing herbs to trees of 6 m in height: *Quercus paludosus multicaulus, Quercus rubra multicaulus, Pinus sylvestris, Acer rubrum, Acer rubrum 'Scanlon', Chenomeles Maulei, Arónia melanocárpa, Berberis thunbergii, Betula pumila, Crataegus laevigata, Vitis amurensis, Parthenocíssus tricuspidáta, Cornus alba, Picea abies, Picea canadensis, Picea pungens, Lonicera alpigena, Lonicera caerulea, Salix caprea, Viburnum opulus, Cotoneaster lucidus, Acer tataricum, Acer ginnala, Elaeagnus argentea, Juniperus horizontalis, Juniperus sabina, Sorbus aucuparia, Ribes aureum, Symphoricarpos albus, Pinus mugo, Spiraea arguta, Spiraea japonica, Thuja occidentalis, Philadelphus coronaries, Mālus sibirica, Malus niedzwetzkyana.*

УДК 504:712

Створення енергоефективних «зелених конструкцій» в умовах помірно-континентального клімату / Ткаченко Т.М. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 77–84.

Розглянуто основні аспекти створення енергоефективних «зелених конструкцій» в урбоценозах помірно-континентального клімату. Встановлено, що проблеми експлуатації «зелених покрівель» виникають при порушенні технології укладання покрівельних шарів і при неправильному підборі асортименту рослин. Технічні проблеми у створенні «зелених покрівель» виникають при неправильному виборі гідроізоляції. Також повинна бути єдина дренажна система, на якій розміщуються всі інші елементи. При недотриманні даних умов можливе протікання покрівлі та розвиток мікроорганізмів. Асортимент рослин на інтенсивній покрівлі зазвичай обмежується низькорослими рослинами: травами, напівчагарниками і чагарниками. Фенологічні спостереження, проведені на інтенсивній покрівлі житлового комплексу

Royal Tower у Києві, показали, що при правильному підборі асортименту рослин і технології їх вирощування висота рослин може бути значно більшою: від 4 до 6 м, що істотно розширює еколого-біологічні можливості інтенсивних зелених покрівель помірно-континентального клімату. Запропоновано асортимент видів рослин з високим адаптаційним потенціалом різних життєвих форм з широкою висотою варіювання: від низькорослих трав до дерев 6 м висотою: *Quercus paludosus multicaulus, Quercus rubra multicaulus, Pinus sylvestris, Acer rubrum, Acer rubrum 'Scanlon', Chenomeles Maulei, Arónia melanocárpa, Berberis thunbergii, Betula pumila, Crataegus laevigata, Vitis amurensis, Parthenocíssus tricuspidáta, Cornus alba, Picea abies, Picea canadensis, Picea pungens, Lonicera alpigena, Lonicera caerulea, Salix caprea, Viburnum opulus, Cotoneaster lucidus, Acer tataricum, Acer ginnala, Elaeagnus argentea, Juniperus horizontalis, Juniperus sabina, Sorbus aucuparia, Ribes aureum, Symphoricarpos albus, Pinus mugo, Spiraea arguta, Spiraea japonica, Thuja occidentalis, Philadelphus coronaries, Mālus sibirica, Malus niedzwetzkyana.*

UDC 504: 004.6
Ontological approach to the description of the reservoir's passport / Tikhonov Yu.L. // Environmental safety and natural resources. – 2018. – Issue 2 (26). – P. 85–94.
An ontological approach to the description of the ecological passport of reservoirs has been developed, which makes it possible to systematize and structure all the necessary data for solving various ecological problems. A technique is proposed that uses computer ontologies to plan environmental activities.

УДК 504: 004.6
Онтологічний підхід до опису паспорта водосховища / Тихонов Ю.Л. // Екологічна безпека та природокористування. – 2018. – Вип. 2 (26). – С. 85–94.
Розроблено онтологічний підхід до опису екологічного паспорта водойм, що дозволяє систематизувати і структурувати всі необхідні дані для вирішення різних екологічних завдань. Запропоновано методику, яка використовує комп'ютерні онтології для планування екологічних заходів.

ДО УВАГИ АВТОРІВ ЗБІРНИКА

Зміст матеріалів, що направляються до редакції, повинен відповідати профілю та науково-технічному рівню збірника.

Кожна наукова стаття повинна мати вступ, розділи основної частини та висновки, а також анотацію і ключові слова (не менше п’яти) трьома мовами (українською, російською та англійською). Також трьома мовами подаються реферати до статті.

Підготовка статті здійснюється в текстовому редакторі MS WORD for WINDOWS, з використанням шрифту Times New Roman, Cyr, кегль 11, одинарний інтервал, полями 2,0 см з кожного боку, заданим розміром сторінок 17х26 см.

Усі формули мають бути набрані в редакторі MathType.

Ілюстрації повинні обов'язково нумеруватися, мати книжкову орієнтацію і не можуть перевищувати за розміром задану сторінку (параметри сторінки 17х26 см з полями 2,0 см). Перелік літературних джерел оформляється згідно з ГОСТ 7.1-84 і подається загальним списком у кінці статті за чергою посилань у тексті.

Наприкінці статті наводиться коротка довідка про авторів, де вказуються прізвище, повне ім’я та по батькові авторів, науковий ступінь, вчене звання, посада, назва підрозділу (кафедри) та організації, особисті дані кожного з авторів (адреса, місто, країна, контактний телефон, e-mail), ORCID ID.

Обов'язково слід надати електронну версію статті в редакторі Microsoft Word.

Усі представлені в редакцію рукописи проходять ретельне багатоланкове рецензування відповідними фахівцями за профілем статті. Якщо сумарна оцінка рецензентів менша за встановлений поріг, рукописи відхиляються. Автору надсилається відповідне повідомлення. Матеріали, отримані від автора, редакцією не повертаються. Після доопрацювання автор може подати матеріал повторно.

Зміст статті та якість написання або перекладу (українською або англійською мовами) переглядаються коректорами збірника, проте відповідальність за зміст та якість статті несуть автори матеріалу. До статті можуть бути внесені зміни редакційного характеру без згоди автора.

Розділ збірника, до якого буде віднесена стаття, визначається редакцією, узгоджується – головним редактором або його заступником. Остаточний висновок щодо публікації матеріалів схвалює редакційна колегія збірника.

Електронна версія збірника, правила оформлення та вимоги до статей містяться в Інтернеті на сайті http://www.es-journal.in.ua, який систематично оновлюється.

Збірник наукових праць також представлений на сайті Національної бібліотеки України ім. В.І. Вернадського, на сайті Інституту телекомунікацій і глобального інформаційного простору НАН України http://itgip.org/ у розділі «Видавнича діяльність» та на сайті бібліотеки Київського національного університету будівництва і архітектури http://library.knuba.edu.ua/node/883.

Виконавчий редактор – **В.П. Берчун**

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