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MODELING humus
Soil environment agroecosystems

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The simulation of soil humus-based flows and stocks of carbon in soil humus and organic carbon nehumusnoyi nature - organic residues and organic fertilizers.

Humus, carbon ahroekosyctema, autonomy, and productivity.

Problem. The theoretical basis of energy efficiency agroecosystem is maximizing energy law, according to which in competition with other systems survives and one that best promotes the flow of energy and uses it the maximum number of the most effective way. For this purpose the system:

- creates a high energy storage;
- spending of stored energy in the inflow of new energy (through feedback mechanisms);
- provides cycling of matter;
- create regulatory mechanisms that support the stability of the system and its ability to adapt to changing conditions;
- establishing exchange with other systems required to meet the needs of specific types of energy [1, 2, 3].

Analysis of recent research. Agro-ecosystems should be governed by man. Any increase in the productivity of agro-ecosystems requires higher energy costs, including anthropogenic. They go on maintaining energy potential agro-ecosystems or change the conditions for its implementation.

The value of the stream of human energy depends on the goal that puts producer of agricultural products, mainly to maximize revenue by reducing the energy intensity of production. This is achieved by either reducing energy at a fixed level of performance or growth outstripping productivity to increase energy. The first task solved by rational organization of labor and production, replacing energy-intensive operations more energy efficient, second - increasing levels of system performance [5].

The latter is defined bioclimatic potential, soil fertility, socio-economic conditions.

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Easy and effective indicator of increased level of system performance is humus in the soil [6]. If the operation agroecosystem humus content increases, then we can talk about increasing levels of system performance.

If the content of humus in the operation of the agro-ecosystem is not changed, the system does not change its level of performance, and if the humus content decreases, the system operates with reduced levels of performance. Considering the factors determining the humification of manure and plant residues at different wrapping them in soil, concluded that anaerobic humification process [7, 8].

Based on these considerations consumable items humus are:

– use of simple hydrolysis of humus substances (amino acids, amines, amides) plants for their growth and development [9];

– humus mineralization by microorganisms;

– humus loss as a result of erosion.

It should be noted that a significant impact on loss of humus in two recent articles is the cultivation of the soil environment, in terms of conservation of agronomically valuable soil structure [10].

Articles receipt of humus is [9, 11]:

– manure and compost, as a source of nutrients;

– leaving a stubble field, of straw, crop stalks, tops and similar organic residues;

– of mineral nitrogen fertilizers for increasing ratios humification of plant residues (8 ... 10 kg / t stubble);

– root system remaining in the soil after harvest of the main crop;

– syderalnyh crops crops (green manure);

– root selection of organic substances (eskudat);

– microorganisms or soil microfauna (up to 14 t / ha);

– mesofauna soil.

The purpose of research. Modeling humus soil environment during operation of the agro-ecosystem, based on the need to ensure its energy autonomy and a balanced balance of humus.

Results. According to studies [7, 8, 9, 11] modeling humus can be made on the basis of flows and stocks of carbon in soil humus and organic carbon nehumusnoyi nature (organic residues and organic fertilizers) (Fig. 1).

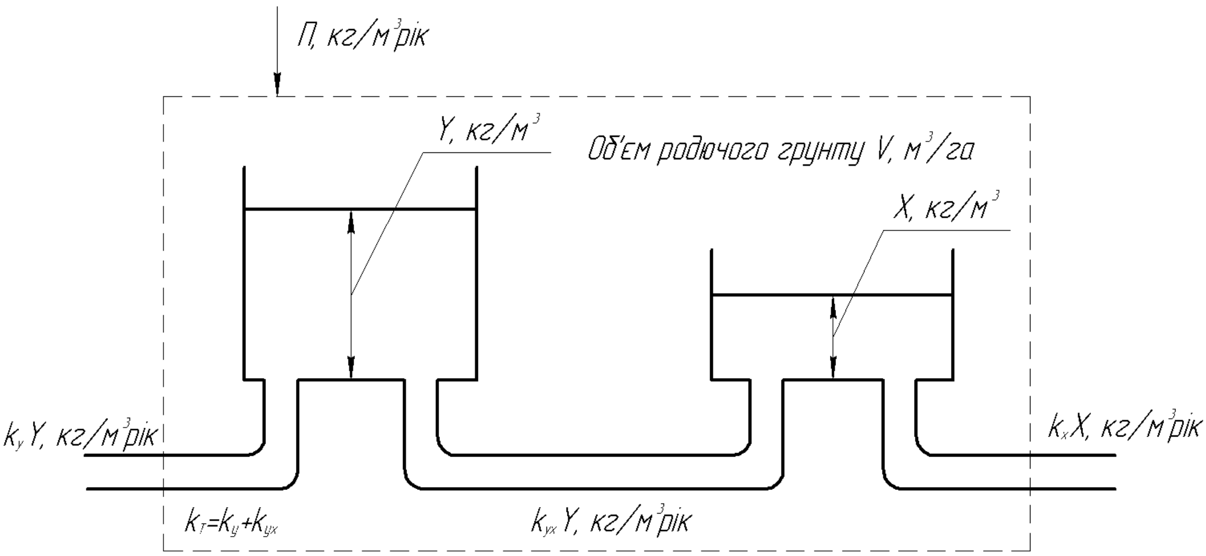

Fig. 1. Calculation of changes in soil carbon content: Π - An annual revenue of carbon in soil nehumusovoyi nature, kg / m3 per year; Y - Carbon content in soil nehumusovoyi nature, kg / m3; X - Carbon content of humus in the soil, kg / m3; V - The amount of topsoil, m3 / ha; k_y - The annual rate of carbon mineralization in soil nehumusovoyi nature, relative. units. / year; k_{yx} - Annual humification coefficient of carbon in soil nehumusovoyi nature, relative. units. / year; k_x - The annual rate of carbon mineralization in soil humus, ratio. units. / year; k_T - The annual rate of transformation of carbon in soil nehumusovoyi nature, relative. units. / year.

Changing the carbon content of humus in the soil can be determined according to the system of equations:

$$\begin{cases} V\dfrac{dY}{dt} = \Pi V - k_y YV - k_{yx}YV = \Pi V - YV\left(k_y + k_{yx}\right) = \Pi V - k_T YV; \\ V\dfrac{dX}{dt} = k_{yx}YV - k_x XV; \end{cases} \quad (1)$$

or

$$\begin{cases} \dfrac{dY}{dt} = \Pi - k_y Y - k_{yx}Y = \Pi - Y\left(k_y + k_{yx}\right) = \Pi - k_T Y; \\ \dfrac{dX}{dt} = k_{yx}Y - k_x X; \end{cases} \quad (2)$$

where Y - Carbon content 22Nature is the humus in the soil, kg / m3; X - Carbon content of humus in the soil, kg / m3; V - The amount of topsoil, m3 / ha; Π - An annual revenue of carbon 22Nature is the humus into the soil, kg / m3 per year; $k_y YV$ - Annual carbon mineralization 22Nature is the humus in the soil, kg / ha per year; $k_{yx}YV$ - Annual carbon humification 23Nature is the humus in the soil, kg / ha per year; $k_x XV$ - Annual carbon mineralization of humus in the soil, kg / ha per year; k_y - The annual rate of carbon mineralization 23Nature is the humus in the soil, ratio. units. / year; k_{yx} - Ratio of annual carbon humification 23Nature is the humus in the soil, ratio. units. / year; k_x - The annual rate of carbon mineralization in soil humus, ratio. units. / year; $k_T = k_y + k_{yx}$ - Ratio of annual carbon transformation 23Nature is the humus in the soil, ratio. units. / year.

From the second equation of:

$$Y = \frac{1}{k_{yx}}\frac{dX}{dt} + \frac{k_x}{k_{yx}}X; \quad \frac{dY}{dt} = \frac{1}{k_{yx}}\frac{d^2X}{dt^2} + \frac{k_x}{k_{yx}}\frac{dX}{dt}. \tag{3}$$

Substituting (3) into equation (1) we obtain:

$$\frac{1}{k_{yx}}\frac{d^2X}{dt^2} + \frac{k_x}{k_{yx}}\frac{dX}{dt} = \Pi - \frac{k_T}{k_{yx}}\frac{dX}{dt} - \frac{k_T k_x}{k_{yx}}X; \tag{4}$$

$$\frac{d^2X}{dt^2} + \left(k_x + k_T\right)\frac{dX}{dt} + k_T k_x X = \Pi k_{yx}. \tag{5}$$

Homogeneous equation will look like:

$$\frac{d^2X}{dt^2} + \left(k_x + k_T\right)\frac{dX}{dt} + k_T k_x X = 0. \tag{6}$$

Characteristic equation and its solution will look like:

$$\lambda^2 + \left(k_x + k_T\right)\lambda + k_T k_x = 0; \tag{7}$$

$$\begin{aligned}\lambda_{1,2} &= -\frac{\left(k_x + k_T\right)}{2} \pm \sqrt{\frac{k_x^2 + 2k_x k_T + k_T^2}{4} - k_x k_T} = \\ &= -\frac{\left(k_x + k_T\right)}{2} \pm \sqrt{\frac{k_x^2 + 2k_x k_T + k_T^2 - 4k_x k_T}{4}} = \\ &= -\frac{\left(k_x + k_T\right)}{2} \pm \sqrt{\frac{\left(k_x - k_T\right)^2}{4}} = -\frac{\left(k_x + k_T\right)}{2} \pm \frac{\left(k_x - k_T\right)}{2};\end{aligned} \tag{8}$$

$$\begin{cases}\lambda_1 = -\frac{\left(k_x + k_T\right)}{2} + \frac{\left(k_x - k_T\right)}{2} = -k_T; \\ \lambda_2 = -\frac{\left(k_x + k_T\right)}{2} - \frac{\left(k_x - k_T\right)}{2} = -k_x.\end{cases} \tag{9}$$

Solution homogeneous equation (6) will look like:

$$X_{ОД} = C_1 \exp\left(-k_T t\right) + C_2 \exp\left(-k_x t\right). \tag{10}$$

One of the solutions (partial solution) would be as follows:

$$X_{ЧР} = \frac{k_{yx}}{k_x k_T}\Pi. \tag{11}$$

The general solution of the differential equation (5) will look like:

$$X = C_1 \exp\left(-k_T t\right) + C_2 \exp\left(-k_x t\right) + \frac{k_{yx}}{k_x k_T}\Pi. \tag{12}$$

For the initial conditions:

$$t = 0 \Rightarrow X = X_0;\ t = 0 \Rightarrow \frac{dX}{dt} = \left(\frac{dX}{dt}\right)_0;$$

where X_0 - Carbon content in the soil at time $t = 0$ Kg / m3; $\left(\frac{dX}{dt}\right)_0$ - The rate of change of humus content in the soil at time $t = 0$ Kg / m3 year, we define the constant differentiation:

$$\frac{dX}{dt} = -k_T C_1 \exp(-k_T t) - k_x C_2 \exp(-k_x t);$$

$$\begin{cases} X_0 = C_1 + C_2 + \dfrac{k_{yx}}{k_x k_T} \Pi; \\ \left(\dfrac{dX}{dt}\right)_0 = -k_T C_1 - k_x C_2 \exp(-k_x t); \end{cases}$$

$$\begin{cases} C_1 + C_2 = X_0 - \dfrac{k_{yx}}{k_x k_T} \Pi; \\ -k_T C_1 - k_x C_2 \exp(-k_x t) = \left(\dfrac{dX}{dt}\right)_0; \end{cases}$$

$$\Delta = \begin{vmatrix} 1 & 1 \\ -k_T & -k_x \end{vmatrix} = k_T - k_x;$$

$$\Delta C_1 = \begin{vmatrix} X_0 - \dfrac{k_{yx}}{k_x k_T} \Pi & 1 \\ \left(\dfrac{dX}{dt}\right)_0 & -k_T \end{vmatrix} = -X_0 k_x + \frac{k_{yx}}{k_x k_T} \Pi - \left(\frac{dX}{dt}\right)_0;$$

$$\Delta C_2 = \begin{vmatrix} 1 & X_0 - \dfrac{k_{yx}}{k_x k_T} \Pi \\ -k_T & \left(\dfrac{dX}{dt}\right)_0 \end{vmatrix} = \left(\frac{dX}{dt}\right)_0 + X_0 k_x - \frac{k_{yx}}{k_x k_T} \Pi;$$

$$C_1 = \frac{\Delta C_1}{\Delta} = \frac{-X_0 k_x + \dfrac{k_{yx}}{k_x k_T} \Pi - \left(\dfrac{dX}{dt}\right)_0}{k_T - k_x};$$

$$C_2 = \frac{\Delta C_2}{\Delta} = \frac{\left(\dfrac{dX}{dt}\right)_0 + X_0 k_x - \dfrac{k_{yx}}{k_x k_T} \Pi}{k_T - k_x}.$$

The general solution of the differential equation (5) will look like:

$$X = \frac{1}{k_T - k_x}\left(-X_0 k_x + \frac{k_{yx}}{k_x k_T} \Pi - \left(\frac{dX}{dt}\right)_0\right)\exp(-k_T t) + \\ + \frac{1}{k_T - k_x}\left(\left(\frac{dX}{dt}\right)_0 + X_0 k_x - \frac{k_{yx}}{k_x k_T} \Pi\right)\exp(-k_x t) + \frac{k_{yx}}{k_x k_T} \Pi. \quad (13)$$

At $t=0$ carbon content of humus is $X_t = X_0$ And at $t=\infty$ humus content is:

$$X_t = \frac{k_{yx}}{k_x k_T} \varPi. \tag{14}$$

To prevent dehumifikatsiyi virgin soil and keep the original humus content, you must annually submit a soil carbon in nature nehumusovoyi number:

$$\varPi = \frac{k_x k_T}{k_{yx}} X_0. \tag{15}$$

In the above mentioned values of coefficients and topsoil thickness of 1 m, must pay 63.4 tons of carbon per hectare per year.

Based on the foregoing, there is reason to believe that the differential equation describing the change in humus can be written as follows:

$$\frac{dX}{dt} = k_{гум} \varPi - k_x X; \tag{16}$$

where X - Humus content in the soil, t / ha; P - annual revenues of organic matter in the soil, t / ha per year; $k_{гум}$ - Coefficient of humification of organic matter entering the soil, ratio. ed .; k_x - The annual rate of mineralization of humus in the soil, ratio. units. / year.

The general solution of the differential equation (16) will look like:

$$\frac{dX}{k_{гум}\varPi - k_x X} = dt; \; -\frac{1}{k_x} \ln \frac{k_{гум}\varPi - k_x X}{k_{гум}\varPi - k_x X_0} = t; \; \frac{k_{гум}\varPi - k_x X}{k_{гум}\varPi - k_x X_0} = \exp\left(-k_x t\right);$$

$$k_{гум}\varPi - k_x X = \left(k_{гум}\varPi - k_x X_0\right)\exp\left(-k_x t\right);$$

$$X = \frac{k_{гум}}{k_x}\varPi + \left(-\frac{k_{гум}}{k_x}\varPi + X_0\right)\exp\left(-k_x t\right);$$

$$X = \frac{k_{гум}}{k_x}\varPi\left[1 - \exp\left(-k_x t\right)\right] + X_0 \exp\left(-k_x t\right).$$

At $t=0$ carbon content of humus is $X_t = X_0$ And at $t=\infty$ humus content is:

$$X_t = \frac{k_{гум}}{k_x} \varPi. \tag{17}$$

The task of biological agriculture to ensure reproduction of soil fertility, which is expressed mathematically by the expression:

$$k_x X_t \le k_{гум} \varPi. \tag{18}$$

This condition can be achieved through rational land use and the use of straw.

Conclusion. Rational use of straw provides the following measures:

– straw left on the field and exposed humification using compensating doses of nitrogen and phosphate fertilizers;

– straw used for bedding in cowhouses and subsequently entered solomystyy manure on fields as organic fertilizer;

– straw used for bedding in piggery and poultry houses and subsequently subjected to composting in vitro for decontamination and inactivation of weed seeds. The resulting compost is brought to the fields as organic fertilizer or used technology vermykompostuvannya.

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A Modeling soil humus STATUS based on flows and stocks of carbon in humus soil of organic carbon and nehumusnoy nature - and of organic ostatkov of organic fertilizers.

Humus, carbon, ahroэkosyctema, autonomy, proyzvodytelnost.

The modeling humus soil based flows and stocks of carbon in soil humus and organic carbon do not humus source - organic residues and organic fertilizers.

Humus, carbon, agroecosystem, autonomy, productiveness.

UDC 681.3

METHOD OF SYNTHESIS OF FUZZY-REGULATORS

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YO Pomasevych, Ph.D.

The description of fuzzy-regulation system. Done base rules for fuzzy-PI controller. The method of fuzzy-controller configuration, which can reduce the requirements for the hardware and software parts and improve performance.

Fuzzy-rotary base rules approximation algorithm Mamdani, term, membership function.

Problem. One of the most common controls used in modern mechatronic systems is unclear or fuzzy-controller [1]. Using fuzzy-controller is justified in cases where there is no mathematical model of the object or regulation when available empirical material (base of expertise) of the regulation system. In any case, the same problem adjusting mechatronic system can

solved using both classical and non-classical controllers (fuzzy-regulators or regulators constructed based on artificial neural networks) [2].

One of the problems facing the developer fuzzy-regulator, is the choice of hardware and software, to which the controller will operate. It is necessary to take into account the requirements for speed digital hardware (microcontroller) and volume of his memory. This follows from the fact that when the calculation of the output fuzzy-controller, microcontroller should perform a significant amount of logic and arithmetic operations. Reducing the number of calculations performed by the microcontroller during the regulatory process, reduces the hardware and software fuzzy-regulator. This reduces the capital costs of developing the controller.