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Analysis of Existing Models in Relation to the Problems of Mass Exchange between Autotransport Complex and the Environment

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ABSTRACT
The main recommendations of this article mainly analyzing the rate of harmful elements the period of exploitation of the automobile implements and its services to develop activity of automobile implements of the exploitation period.

KEYWORDS: *transport, transport problems, the ecological mathematical problems, harmful substance*

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INTRODUCTION

In Uzbekistan, the protection and protection of the environment is considered as the most important state task. The sustainable development of a democratic society is characterized by a complete set of methods of rational use of natural resources in all spheres of the national economy, including in the autotransport complex (ATC), which significantly affect nature.

A mathematical model of the process under study is a system of equations that describes the dependencies of individual factors, as well as the totality of individual factors, as well as the totality of known data necessary for their solutions, such as the values of coefficients, experimental data, the limits of changes in individual parameters, initial and boundary conditions.

Theoretical modeling replaces difficult or expensive experiments in various operating conditions of the object, allows you to optimize the modes of their operation, find optimal technical solutions. With the help of mathematical modeling, the properties and their characteristics of the processes under consideration are determined by solving a system of equations that make up the mathematical model itself.

A model is an imitation of one or another phenomenon of a real ecosystem, taking into account the influence of anthropogenic or technogenic factors on it, which allows making scientific forecasts.

The modeling strategy is that the constructed model must have sufficient similarity to the original so that the results of its study are applicable to the original. Typically, the original is a multi-component system, where the interactions between environmental and technological systems are so complex that they do not lend themselves to a sufficiently satisfactory analysis. At the same time, the laws of functioning of some models can be found through sign-based methods, where studies of the system can be replaced by studies of the model, and then interpret the results in relation to the original.

Ideal sign models are divided into conceptual (verbal, graphic) and mathematical models.

The conceptual model is a more or less formalized version of the traditional description of the system being studied, consisting of text, flowcharts, tables, graphs, and other illustrative material. The disadvantages of such a model are ambiguity of interpretation and static nature.

For example, to assess the sustainable development of the state and identify areas of potential threats and challenges, a National Integrated Environmental Monitoring System (OXMOS) has been developed.

METHODS AND RESEARCH

Mathematical modeling methods are more effective in studying the interconnectedness of various systems in dynamics. Methods of mathematics can be used to conduct a deep theoretical development of models, the inadequacy is known in advance. Usually, a priori models are derived from theoretical assumptions, and a posteriori models are constructed from empirical data.

Descriptions of the functioning of ATCs in ecosystems are usually characterized by uneven knowledge of individual processes. Often, not only is the mathematical form of the dependencies between the individual components not known, but there are no quantitative characteristics of the processes at all.

An attempt to create models that combine physical-dynamic and chemical-biological processes usually leads to the use of differential equations. The advantages of using systems of differential equations as mathematical models of natural-technical complexes include the fundamental possibility of establishing general provisions of the theory of the functioning of various systems.

One of the simplest models of population growth belongs to T. Malthus, who noticed that populations tend to increase exponentially. However, the growth of populations is sufficiently constrained by such factors as the struggle for existence, disease, natural death and destruction by predators. Usually, if a population begins to develop in an environment with a sufficient amount of food and with a relatively small number of predators, then at first its number grows very quickly. Over time, food supplies are depleted, overpopulation leads to conditions less favorable for survival, fertility decreases and mortality increases. Under certain conditions, an equilibrium state is reached and the population size becomes more or less constant.

The first model that takes into account the maximum number that a population can reach in conditions of limited resources was proposed in 1825 by B. Gompertz.

$$N(t) = K\, e^{\left\{ ln \frac{N(O)}{K} e^{-\frac{Mt}{ln K}} \right\}} \quad (1)$$

where K is the capacity of the medium. As you can see, this model describes the "saturation" effect.

The "logistic" model developed by Furhalst, which describes the dynamics of many natural populations of the species quite well:

$$N(t) = \frac{KN(O)}{N(O) + [K - N(O)] \cdot e^{-\mu t}} \quad (2)$$

In 1925, A. Lotka published the book "Elements of physical biology". In his work, he comes to the following system of differential equations describing the dynamics of two interacting biological populations:

$$\begin{aligned} \frac{dN_1}{dt} &= N_1(\xi_1 + r_1 N_2), \\ \frac{dN_2}{dt} &= N_2(\xi_2 + r_2 N_2), \end{aligned} \quad (3)$$

whereii are the coefficients of natural growth or death; ri are the coefficients describing inter-population interactions. Depending on the choice of signs of these coefficients, model (3) describes either the competition of species for one resource, or the relationship of the type "predator-prey" or "parasite-host".

In 1936, A. N. Kolmogorov proposed to consider a much more general model for the "predator-prey" system.

$$\begin{aligned} \frac{dN_1}{dt} &= N_1 K_1(N_1, N_2), \\ \frac{dN_2}{dt} &= N_2 K_2(N_1, N_2). \end{aligned} \quad (4)$$

where K1 (O, O)>0; dK1/ d1N≤0; dK1/dN2≤0, etc.Naturally, this model qualitatively describes almost any real situation, but the excessive generality of this model makes it difficult to quantify it.

The most general view of Voltaire models is as follows:

$$\frac{dZ_t}{dt} = Zt(\varepsilon_t + \frac{1}{b_t}\sum_{p=1}^{2n} a_{tp} Z_p)\ (t = 1, \overline{2n}); \quad (5)$$

$$a_{tp} = -a_{pt}$$

Where $Z_t = \begin{cases} x_i & (i = \overline{1,m}; \quad t = i) \\ y_i & (j = \overline{1,n}; \quad t = j + m) \end{cases}$

- producers with biomass; - consults with concentrations; - the social function of fertility and mortality of producers and consults: - the generalized function of the consumption of the producer, consult and substrate.

This form of recording means that only a certain part of the mass of each substrate goes to the formation of new biomass of the species that consumes it. Everything is determined by the energy and biochemical value of the consumed substrate.

In the general case, differential models are associated with processes that occur frequently in nature, of which the rates of change of variables are significant, dynamic, determined by various quantities that continuously change over time.

Thus, the study of population growth is a vast problem for which many models can be constructed. In the work of J. Murdy considered specifically tasks related to one species and two interacting species, with applications to the problem of pest control. Consideration of the model brings to the fore the problem of identifying the entered parameters with the data obtained from real biological experiments.

Environmental engineering is undergoing a period of intense and profound transformation, encompassing both the empirical and theoretical level of the study of environmental processes. In connection with the assessment of new discoveries in environmental engineering, the formation of theoretical concepts and the expansion of the scope of their practical application, there is a need to put forward and discuss common approaches to describing the processes of information processing in environmental and technical systems.

The complexity of information processing in technological systems is determined, in particular, by their multi-level structures. The application of a multi-level concept to the description of information tasks poses the problem of identifying the basic principles of constructing levels of abstraction and the conditions for their effective interaction.

The basic principles of building a conceptual level are as follows.

- properties of real objects including their relationships to each other, represented by a system of predicates:
- real objects are represented by a set of structured relations, functions, or operations:
- events facts are represented using a set of statements:

- stable, periodic repeatable invariant models of the structure and guidance of real objects are represented by a set of universal statements:

The solution of a conceptual problem is characterized by the fact that it defines the tasks of the lower level and their solutions in general terms, indicating the way to form a set of tasks and the direction of finding their solutions. If the solutions to the lower-level problems cannot be found, the transition to the conceptual level will follow to clarify or replace the formed problem, and also to develop new restrictions on the search for lower-level solutions.

The models developed by Yu. M. Aponintake into account the inhibitory effect of large concentrations of the substrate consumed by the victim on its population.

N. E. Bolshakov and V. A. Radkevich, studying the law of pest migration inside the biotope, determined that the migration rate is low, due to the small diffusion coefficient. Changes in the density of pests will be written in the form

$N = \beta x^2 + N_o$, (6)

where-the distance from the center of the biotope: -the population density in the center of the biotope.

In the work of A. N. Goncharov and E. Ya.Elizarov, a biocenosis consisting of one type of predator and several types of prey is considered. It is noted that starting from a certain level of prey concentration, the predator shows selective activity. Assuming that - the time of the predator's reprisal with one individual of the prey species, and-a constant that characterizes the predator's viewing space when hunting prey species, such that the value where the concentration of the prey species at a time is the frequency of encounters of the predator with the prey species. Then the rate of eating by the predator of the prey species.

$$g_i = \frac{\varepsilon_j \sigma_j p_j}{1 + \sum_{k=1}^{n} \varepsilon_k \sigma_k \tau_k p_k} \qquad (7)$$

The model is described by the following system of differential equations

$$\left. \begin{aligned} x' &= \left(\sum_{k=1}^{n} \zeta_k g_k - \varepsilon\right) x \\ p_j' &= \varepsilon_j p_j - g_j x - \gamma_j p_j^2, \quad j = \overline{1, n} \end{aligned} \right\} \qquad (8)$$

where - the concentration of predators at a time; and-respectively, the coefficients of predator mortality and fertility of the prey species; - a certain coefficient of assimilation, such that the value - is the coefficient of predator growth when feeding only on the prey species; - the coefficient of intra-species competition.

B. G. Kovrov and O. A. Cherepanov studied the factors that change species diversity, since a number of important ecological principles are associated with diversity. They obtained a mathematical model of the community, if we take into account the reproduction of the population-the population is limited by the substrate extracted from the sources, its reproduction rate and the amount of food extracted by one of its individuals from the source are known, has the form:

$$\dot{S} = P - \sum_{i=1}^{n} \min\left\{\gamma_{oi} S, \frac{\mu_{mi}}{\alpha_{io}}\right\} N_i,$$

$$\dot{N}_i = [\min\{\varepsilon_{10} S, \mu_{mi}\} - \beta_i] N_i -$$

$$\sum_{j=1}^{n} \min\left\{\gamma_{ij} N_i, \frac{\hat{\mu}_{mi}}{\alpha_{ij}} \frac{\varepsilon_{ji} N_i}{\sum_{i=1}^{n} \varepsilon_{ji} N_i}\right\} R_j, \qquad (9)$$

$$\dot{R}_j = \left[\min\left\{\sum_{i=1}^{n} \varepsilon_{ji} N_i, \hat{\mu}_{mj}\right\} - \hat{\beta}_j\right] R_j$$

Where the coefficient that characterizes the efficiency of production and use of food Oh population activity population for the extraction of food from th power source; a proportionality factor, the ratio of the second predator on the second food; maximum reproduction rate; population density of victims or the concentration of the substrate; and -takes into account natural death of individuals and waste of mass on respiration; –substrate concentration; the Oh density of the predator population; . Analyzing the obtained model, the authors state: a) the sustainable existence of the entire community is possible if all the predators and at least one of the prey populations is limited by food; b) a stationary state exists in some area of population characteristics change, if the number of predator populations is equal to or less than the number of prey populations per unit.

In the work of A.D. Bazykin, a model of population dynamics is constructed, in which the ability of individuals to reproduce significantly depends on the population density, and a differential equation describing the change in the size of a local population is proposed:

$$\dot{R}_j = \left[\min\left\{\sum_{i=1}^{n} \varepsilon_{ji} N_i, \hat{\mu}_{mj}\right\} - \hat{\beta}_j\right] R_j \qquad (10)$$

Where is the number of populations; the coefficient of intra-species competition; the coefficient of natural mortality; the constant having the dimension of density: the proportionality coefficient of E. Ya.Frisman and Yu. I. Khudoley transformed this model taking into account the migration factor (b) of the population ($n = 2$):

$$\dot{x}_1 = \frac{\tau x_1^2}{\alpha + x_1} - g x_1^2 - (\tau + b) x_1 + b x_2$$

$$\dot{x}_2 = \frac{\tau x_2^2}{\alpha + x_2} - g x_2^2 - (\tau + b) x_2 + b x_1 \qquad (11)$$

According to the authors ' discussion, there are nine stationary points for this system. Of these, two of them are of the greatest interest:

$$1)\ \hat{x}_1 \approx \frac{\alpha b}{ag}; \quad \hat{x}_2 \approx c - \frac{\hat{b}(\alpha + c)}{g(c - a)};$$

$$2)\ \hat{x}_1 \approx c - \frac{b(\alpha + c)}{g(c - a)}; \quad \hat{x}_2 \approx \frac{\hat{b}\alpha}{ag}; \qquad (12)$$

These points are stable if the migration coefficient is less than a certain value .

In the work of N. A. Korneev and V. A. Fedyanin, the dynamics of the formation and structure of fish aggregations are studied. To study the relationship between the individual density rates and the feed biomass density, respectively, we used a slightly modified system of Voltaire equations:

$$\left.\begin{aligned}\frac{dN}{dt} &= N(k\mu - l)\\ \frac{d\mu}{dt} &= \mu - (b + pN)\mu\end{aligned}\right\} \qquad (13)$$

where the rate of reproduction of fish flocks; mortality of individuals; specific rate of decrease in the biomass of the stern, caused for example by lack of oxygen, inhibition of metabolites; the attrition rate of the biomass feed as a result of eating his fish; the growth rate of biomass density of feed for the considered period of time.

The stationary densities are determined:

$$\overline{\mu} = \frac{l}{k}; \qquad \overline{N} = \frac{(\mu k - bl)}{lp} \qquad (14)$$

Given small deviations from the stationary values, a generalized equation for the growth of fish populations is obtained:

$$\frac{d^2 n}{dt^2} + 2\delta\frac{dn}{dt} + \omega_o^2 n = 0, \qquad (15)$$

Where $2\delta = \frac{\mu k}{l}$, $\omega_0^2 = \mu k - bl$, $k = \beta(\varepsilon\tau - c - \gamma\overline{N})$,

where β – the increase in the number of individuals per unit of energy consumed, per unit of biomass density of feed; τ – dimensionless time, part-time, driven in the active state; c-with the energy to maintain life individuals per unit of time; γ – the average interaction energy of a pair of individuals per unit of time multiplied by the given volume of the pack; ε – metaboliziruemah energy received by the individual from food per unit time minus the energy spent on obtaining that food.

There are quite a few approaches to defining the concept of ecosystem stability, stability in the corresponding mathematical models of ecosystems, and comparing ecosystems by this property. However, in the framework of systems of differential equations of community dynamics, the most universal, as before, is the definition of the stability of the equilibrium point of the system. For example, for two subsystems "predator-prey", conditions are found for the parameters of the model, in which migration with different intensities has a stabilizing effect, although it changes the equilibrium values of the numbers. An example of a different type of communication between systems is obtained if the sets of isolated predator-prey pairs are combined by introducing competition at the level of victims or at the level of predators. Fluctuations in the neighborhood of the equilibrium inherent in isolated pairs, and are saved when you die systems, however, the oscillation frequency decreases in the case of low-level concurrency of victims and increase in the case of a low competition level predators.

In modern sources, a mathematical model is considered that expresses the balance of the population size:

$$\frac{dp_n}{dt} = \left[\overline{\lambda}(p_n, M) - \mu(p_n, W, M)\right]p_n, \qquad (16)$$

where p_n – is the population density, i.e., the number of individuals living per unit area of the range: M – the mass of the individual; $\overline{\lambda}(p_n, M)$ – the birth rate: $\mu(p_n, W, M)$ – the mortality rate.

The authors state that the birth rate and mortality are assumed to depend on the mass of the individual or, more precisely, on the deviation of the mass from some normal value for the species under consideration. Therefore, the equation (16) is added to the equation expressing the dynamics of change in the mass of individuals:

$$\frac{d(c_M M)}{dt} = \Delta W \qquad (17)$$

where ΔW energy imbalance individuals; c_M – average specific caloric of the body individuals

$$\Delta W = \Pi C_\Pi - \frac{\Pi\zeta}{\eta_M} - W_0 - W_S \qquad (18)$$

where P-amount of food produced by animals per unit of time; the average caloric content of food; C_Π – the efficiency of skeletal muscle; η_M – the energy ratio of the diet; ζ – it determines the power that must be expended for persons obtaining a unit amount of food per unit time; W_0 – base exchange capacity, W_S – which spends an individual in connection with the various secretions of the substance.

The energy criterion of optimality of at least the basic exchange is selected:

$$W_0 \to \min$$

The peculiarity of equations (17) and (18) is that the energy balance of the population is considered as the main link in the chain of environmental factors. The composition of the main exchange includes, in particular, the power consumed by organs and systems that are part of the oxygen transport system. At the same time, the power consumed by the oxygen transport system is a component of the main exchange.

Currently, when studying complex processes, it is considered appropriate to use the principles of a systematic approach to problems. In a systematic approach, all research methods are integrated into a single process of environmental research, which should be carried out within the framework of an interdisciplinary research project.

For example, in the work of L. A. Akhmetov, E. V. Kornev and T. Z. Sitshaev [13], the entire complex of energy-ecological tasks in road transport is carried out on the basis of a management system for rational energy consumption and environmental protection activities. This system is the main link of the road transport system from the standpoint of environmental priority in relation to the systems of commercial (CEA) and technical (TEA) operation of the car, technical preparation of the car (TPA) and the system: driver

–car-road-environment (VADS) with direct and feedback links.

For the CEA, an indicator of environmental friendliness is introduced:

$$\varepsilon_n = 1 - \frac{2\left(\sum P + \sum M_i^{\tau}\right)}{N + 2\left(\sum P + \sum M_i^{\tau}\right)}, \quad (19)$$

where $\sum P$ *is the total energy loss;* $\sum M_j^{\tau}$ *– total gross vehicle emissions;* $N = \left(\sum Q_Э - \sum P - \sum M_j^{\tau}\right)$ *– hyperbolic dependence of the* ε_n*;* $Q_Э$ *– total energy consumption for road transport work.*

The RAPOD management system (rational energy consumption and environmental protection) operates from the standpoint of rational use of all types of resources:

$$R_i^B = \frac{R_i^B}{\sum_{i=1}^{n} a_i R_i^H} a_i R_i^H, \quad (20)$$

where R_i^B – the resources allocated to the entire system; R_i^H – normative (consumed) resources; a_i – priority assessment of the i – go factor.

The set of PBX systems operates based on the permissible environmental loads

$$(S_2 - S_1 + AP) \le 0$$
$$C_{1год} \le B\,ПДК_{24}, \quad (21)$$

where S_1 – the given costs (transport costs) of transport work with the existing technology of energy consumption; S_2 – the same with energy-saving technology; AP – reduction of environmental damage during environmental protection measures; $C_{1год}$ – annual concentration of harmful substances; B – natural and climatic coefficient; $ПДК_{24}$ – average daily maximum permissible concentrations of harmful substances.

In modern scientific research, the principle of system analysis is successfully applied in solving multicomponent problems. The basis for solving multicomponent problems is oriented graphs, and the basis for modeling them is pulse processes. The essence of the pulse process is that a certain change is set to a certain vertex.

Oriented graphs form the basis for solving multicomponent problems, depending on the values on the arcs, which are placed by experts or determined on the basis of statistical information. Digraphs can be either signed or weighted.

The development of systems on the digraph is modeled using pulse processes. The digraph can have positive or negative feedback loops. The type of feedback determines the stability of the system: absolute or impulse. For the purpose of linking to the time scale, time delays should be indicated on the digraph arcs.

Multi-component tasks allow us to model predator-prey ecosystems. The biological principles of ecosystem sustainability are implemented in models not digraphs. The conceptual representation of the equilibrium points can be demonstrated using the eating and accumulation curves. Large disturbances in the ecosystem and the transition of the system from one equilibrium state to another.

With the help of modeling multicomponent problems on digraphs, it is possible to test the variants of the proposed scientific hypotheses based on logical constructions that are sufficient to create a formalized mathematical model. Ecosystem development is possible through a combination of seven basic development curves.

The United Nations Economic Commission for Europe and the Declaration on Low-Waste and Non-Waste Technology, adopted in 1979 at the Meeting on Pan-European Cooperation in the Field of Environmental Protection, define low-waste and non-waste technology as the practical application of knowledge, methods and tools in order to ensure the most rational use of natural resources and protect the environment within the framework of human needs. It follows that low-waste technology solves a two-pronged problem: the effective use of natural raw materials and products of their processing, on the one hand, and the protection of the environment from various types of pollution and waste, on the other.

The goal of developing low-waste and resource-saving technologies is to create closed technological cycles with full use of incoming raw materials and waste. This is an attempt to reproduce natural cycles, since the biosphere is a closed system, where all the elements are interconnected and cause each other. The modern man-made economy, including the ATC, is an open system, where obtaining a relatively small final product requires huge resources and is accompanied by large waste .

The gradual transformation of traditional technologies into low-waste and resource-saving ones will allow for a gradual transition from open production systems with free input of resources and waste output to semi-open ones with partial use of recoverable materials and waste treatment, and then to closed-type systems with complete processing and disposal of all incoming resources and waste and the cessation of environmental pollution by the latter.

Thus, in natural, natural ecological systems, the acquisition of resources and disposal of waste occur within the cycle of all elements.

In most scientific and technical studies, the PBX is considered as an object that influences the formation of environmental indicators of the ATC. The processes of energy and mass transformations between the PBX and the environment occur the entire lifecycle and are associated with the consumption in the relevant processes fuel, oil, other types of operating materials, energy, accompanied by pollution with harmful substances.

In [3], the total consumption of materials for the operation of the PBX is treated by processing an array of information, which allows us to establish reliable dependencies of the form:

$$M_i = a_0 + a_1 \prod_{ЭУ} + a_2 \prod_{ЭУ}{}^2 \quad (22)$$

where $\prod_{ЭУ}$ – the complex meter is the quality of the power plant; a_0, a_1, a_2 – multiple correlation coefficients.

Mathematical models of fuel consumption can be obtained by synthesizing the equations of motion of the car and the various characteristics and operating modes of the engines.

The authors distinguish several modes of operation of PBX during their operation:

- acceleration and braking mode of the car

$$m = f(\vartheta) + c_i\left(\dot{\vartheta}\right)_+ + c_2\left(\dot{\vartheta}\right)_-, \qquad (23)$$

where $\left(\dot{\vartheta}\right)_+ = \left\{\dot{\vartheta}, \quad \dot{\vartheta} \geq 0; \quad 0, \quad \dot{\vartheta} \prec 0\right\}$

Thus, if the traffic mode $\vartheta = \vartheta(t), t \in [t_1, t_2]$ the PBX is known $(\vartheta \succ 0)$:

$$m = \int_{t_2}^{t_1}\left(f(\vartheta(t)) + c_1\left(\dot{\vartheta}(t)\right)_+ + c_2\left(\dot{\vartheta}(t)\right)_-\right)dt$$

At idle, $\vartheta = 0$:

$$m = \int_{t_1}^{t_2} f(n(t))dt$$

where $n(t)$ is the engine crankshaft speed.

N. Ya.Govorushchenko [12] presents the general form of the fuel consumption equation in the following (l/100 km):

$$Q = \frac{Ai_k + Bi_k^2\vartheta_a + C(G_a\psi + 0.077kF\vartheta_a^2 \pm 0.1\beta G_a\dot{\vartheta}_a)}{\eta_i} \qquad (24)$$

where

$$A = \frac{7.95aV_n i_0}{H_U\rho_T\tau_k}; \quad B = \frac{0.69V_n S_\Pi i_0^2}{H_U\rho_T\tau_k^2}; \quad C = \frac{100}{H_U\rho_T\eta_{TP}} \qquad (25)$$

where $a_k = 45$ kPa and $в = 13$ kPa / cm - for carburetor engines; $a_k = 48$ kPa and $в = 16$ kPa/cm - for diesels; V_n - working volume of the cylinder; S_Π – and consequently the gear ratios of the gearbox and the main gear; H_U – the piston stroke; ρ_T – the net calorific value of fuel, density of fuel; τ_k – the rolling radius of the wheels; η_{TP} – drivetrain efficiency; ϑ_a – the speed of the car; G_a – all car; k – coefficient of air resistance; F – a frontal area of the car.

$$\beta = 1 + a_k i_k^2 \qquad (26)$$

where a_k – is the constant value for this car. η_i – indicated efficiency of the engine, ψ – the coefficient of road resistance.

This coefficient depends on the compression ratio of the engine, the excess air ratio, the power developed and the speed of the engine

$$\eta_i = \frac{Rp_i L_0 T_0}{H_U\eta_V p_0}\alpha \qquad (27)$$

where R – is the universal gas constant; p_i – mean indicated pressure; L_0 – the stoichiometric amount of air in the mixture to 1 kg of fuel; T_0 – ambient temperature; H_U – low specific heat of combustion; η_V – the filling ratio; p_0 – the ambient pressure.

CONCLUSION

The greatest influence on fuel consumption is exerted by the indicator efficiency, which characterizes the efficiency of the actual cycle and is determined by the ratio of the indicator work to the heat spent on obtaining this work. In contrast to the thermal efficiency, the indicator takes into account not only the heat removal to the cold source, but also other losses associated with incompleteness of combustion and dissociations; leakage of the working fluid through non-densities and heat removal with exhaust gases.

Thus, for sufficiently large quantities of non-discrete quantities, despite their simplified properties, deterministic mathematical models, within the limits of some reliability of the results, are in good agreement with the studied ecological processes.

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