



## ANALYSIS OF EXISTING MODELS IN RELATION TO THE PROBLEMS OF MASS EXCHANGE BETWEEN ATC AND THE ENVIRONMENT

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### Abstract

This article provides for the development of methodological recommendations and the application of their results in production in order to improve the environmental safety of motor vehicle traffic.

**Keywords:** Transport, transport problems, ecological mathematical problems, harmful substances.

### Introduction

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

Theoretical modeling replaces difficult or expensive experiments in various operating conditions of the facility, allows you to optimize the modes of their operation, and 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 a particular phenomenon of a real ecosystem, taking into account the influence of anthropogenic or man-made factors on it, which makes it possible to make scientific forecasts.

The modeling strategy is that the constructed model should be sufficiently similar to the original so that the results of its study are applicable to the original. Usually, the original is a multi-component system, where the interactions between ecological and technological systems are so complex that they do not lend themselves to sufficient



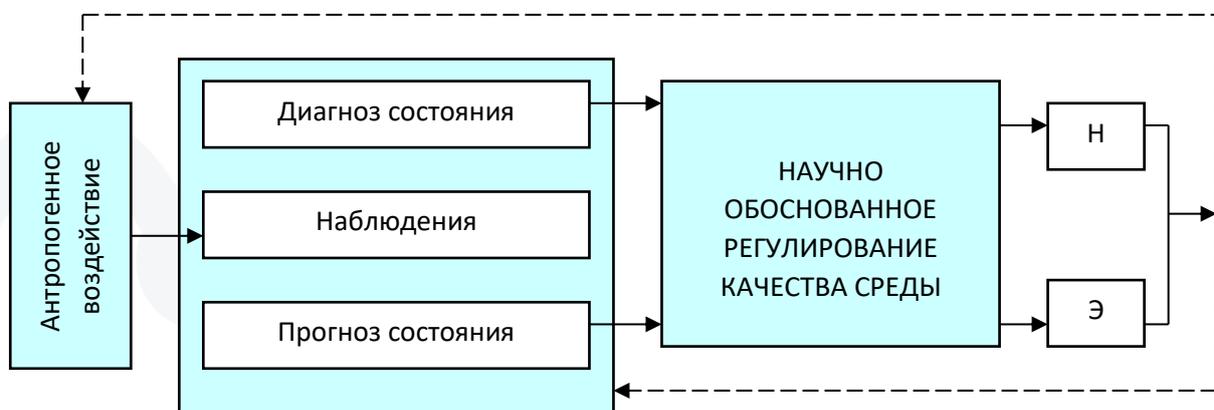


satisfactory analysis. At the same time, the laws of functioning of some models can be found through sign methods, where studies of the system can be replaced by studies of the model, and then the results can be interpreted in relation to the original.

Ideal sign models are made for conceptual (verbal, graphic) and mathematical.

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

For example, the National Integrated Environmental Monitoring System (OKSMOS) has been developed to assess the sustainable development of the state and identify areas of potential threats and challenges. The functional features of the valuable system are presented in the form of separate blocks (Fig. 1).



**Rice. 1. Scheme of construction of the main functions of OKSMOS:**

**Н - scientific and technical solution; E - economic opportunities**

Methods of mathematical modeling are more effective in studying the interconnectedness of various systems in dynamics. Using the methods of mathematics, it is possible to carry out a deep theoretical development of models, the inadequacy is known in advance. Usually, a priori models are derived on the basis of theoretical premises, while a posteriori models are built on empirical data.

Descriptions of the functioning of ATCs as part of ecosystems are usually characterized by uneven knowledge of individual processes. Often not only is the mathematical type of dependencies between individual components unknown, 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 one hundred populations tend to increase exponentially. However, population growth is sufficiently restrained by factors such as the struggle for existence, disease, natural death and destruction by predators. Usually, if a population begins to develop in an environment with enough food and a relatively small number of predators, then at first its number grows very quickly. Over time, food supplies are depleted, overcrowding leads to conditions less conducive to survival, fertility decreases, and mortality increases. Under certain conditions, it reaches an equilibrium state and the population size becomes more or less constant.

The first model, which takes into account the maximum number that a population can achieve under 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. At  $t \rightarrow \infty$ ,  $N(t) \rightarrow K$ . As can be seen, this model describes the effect of "saturation".

The "logistic" model developed by F uhrhalt, which describes the dynamics of many natural populations of a 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 arrives at the following system of differential equations describing the dynamics of two interacting biological populations:

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

where  $\xi_i$  are the coefficients of natural increase or death;  $r_i$  - coefficients describing interpopulation 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 "predator-prey" or "parasite-host" type.

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



$$\frac{dN_1}{dt} = N_1 K_1(N_1, N_2),$$

$$\frac{dN_2}{dt} = N_2 K_2(N_1, N_2).$$

(4)

where  $K_1(0, 0) > 0$ ;  $dK_1/dN_1 \leq 0$ ;  $dK_1/dN_2 \leq 0$ , etc.

The most general view of Voltaire's models is as follows:

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

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

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

$x_i$  - producers with biomass;  $y_j$  - Consumers with concentrations;  $\varepsilon_t$  - social function of fertility and mortality of producers and consumers:  $\frac{a_{tp}}{b_t}$  - generalized function of eating

up producer, consumer and substrate.

This form of notation 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 substrate consumed.

In general, differential models are associated with the topic of processes occurring in nature, of which the rates of change of variables are essential, dynamic, determined by various quantities, continuously changing with 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 specific problems related to one species and two interacting species, with applications to the problem of pest control. Considerations of the model bring to the fore the problem of identifying the entered parameters with the data obtained from real biological experiments.

Engineering ecology is going through a period of intensive and deep transformations, covering both the empirical and theoretical levels of the study of ecological processes. In connection with the assessment of new discoveries in engineering ecology, the formation of theoretical ideas and the expansion of the scope of their practical application, there is a need to put forward and discuss common approaches to the description of information processing processes in ecological and technical systems. The complexity of information processing in technological systems is determined, in particular, by their multi-level structures. The application of the multi-level concept to the description of information tasks poses the problem of identifying the basic



principles of building levels of abstraction and the conditions for their effective interaction.

The basic principles of constructing the conceptual level are as follows.

- properties of real objects, including their relationships with each other, are represented using a system of predicates:

- real objects are represented by a set of structured relations, functions or operations:

- Events facts are represented with the help of a set of statements:

- stable, periodically 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 of forming a set of problems and the direction of searching for their solutions. If solutions to lower-level problems cannot be found, a transition to the conceptual level will follow to clarify or replace the formed problem, as well as to develop new constraints in the process of finding lower-level solutions.

The models developed by Y.M. Aponin take into account the inhibitory effect of large concentrations of the substrate consumed by the prey on its population.

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