MATHEMATICAL MODELS FOR MAKING THE COMPUTERIZED SYSTEMS OF ECOLOGICAL MONITORING

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ABSTRACT

Nowadays ecological problems have become actual. Active assimilation of nature and fast-going development of production of technologies led to growth in welfare of human being, but at the same time assisted to ecological crisis extension. In order to solve the appearance of problems, the balance between ecological safety and economical impact of agricultural complex should be held.

Keywords: ecological monitoring, mathematical modeling of nature, ecosystem, ecological processes, forecasting methods, conceptual models.

INTRODUCTION

In recent years, the scales of anthropogenic and technogenic influence on nature have caused colossal dramatic consequences in ecosystem. Uncontrolled technogenic influence on nature pollutes habitat areas, drinking water and provisions substantively, affects on population's health condition adversely, conducts the appearance of poor ecological risk, increase the level of ecological safety, rational control of ecological situation are going to be the supreme problem.

Science - technological development has an extremely dramatic impact on environment. Different types of environmental pollutions cause an alarm and anxiety between ecology specialists. The problem of environmental protection has become actual for many industrially developed countries. In such kind of situation the wide - ranging and effective control on environment of megalopolises, which are close to ecological dangerous object should be necessary, and this will be the foundation for safety support and stable development.

The knowledge about the condition of the environment is necessary for our daily life, housekeeping, and construction and in extreme situations. Especially, the dramatical change in environmental conditions is not only the result of natural processes, but also the human actions have a negative character. The necessity of the anthropogenic changes forecast in nature is a specific problem.

The observation of climatic changes is made today. They are meteorological, phenological, seismological and other types of environmental monitoring. The range of environmental monitoring is widening as well as the number of measuring parameters, the quantity of monitoring stations is growing, too. The problems of environmental monitoring are becoming more and more complicated.

MATERIALS AND METHODS

Solving the problems of ecological situations analysis, valuation of ecological conditions, and establishmentof computerized ecology monitoring systems and forecast is proper to realize on the base of mathematical modeling, which depict distinctive features of ecological processes in an adequate way and modern methods of mathematical modeling.

Modern ecological system in reality is a complicated one. The complication is recognized in following features:

- wide range of interconnected and associated elements;
- multifactor of purpose;
- association of various under systems;
- control on informational, energetic, substantial streams in the system;
- casual and non- quantitative factor - changing character;
- association with the environment;

In this term, it should be mentioned that ecosystem is a self - regulated complex that tries to reach a stable condition. Having straight, inner and outer reverse connections makes it possible. Self - regulation that is based on negative reverse connections becomes more complicated under secondary reactions and extreme impact on ecological objects.

With help of system’s ecological analysis the probable prediction of characters, scales and forms of interrelations and associations in ecology can be made, as well as the stability and adaptation of different ecological objects. Physical and mathematical modeling, optimization methods, set theory and transformations are usually used as means of system’s ecological analysis.

Nowadays, there are plenty of methods of prediction. They have different quantity and quality nature, safety, precision, mathematical instrument, characteristics of object predicted and other used methods.

As it is known, manufacturing affects on the wide variety of natural components: sounds, vibrations, harmful emissions into sewage and air, a great number of emissions like the result of obtained minerals and others. The system of ecological monitoring that is based on ecological modeling is used to prevent or decrease non - typical, and

emergency situations, which are accompanied with harmful emissions. To get the exact description of ecological situation an adequate model is demanded that could depict the ecological status of an object. The effectiveness of ecological modeling is determined by identification and prediction of an ecological situation that is based on analysis of ecological information. This problem is solved with the usage of the methods of mathematical modeling of ecological safety.

Mathematical modeling of ecological systems and processes is a scientific direction, with means of effective cognition of ecological processes that give a chance to unite the practice of controlling them. It should be mentioned that mathematical modeling and experimental observation are supplements and developments of each side.

The usage of methods of ecological modeling is necessary for observation of the character, forms and scales of ecological interrelations, and analysis of the stability and adaptation of ecological objects. In reality, ecological models are complicated systems. The construction of ecological models is a complex process.

The usage of new manufacturing methods, working out ecologically clean ways ofrubbish utilization, the transition to non-rubbish technologies are the main directions to decrease the negative impact of technogenic complexes on ecological situation. Besides, it is necessary to study its influence on environment and solution the methods of prediction on the base of ecological models and ecological modeling methods. Examining the problems as an object of the image of modeling means solution of the problem of system ecological analysis.

Mathematical modeling methods are used to study the quantitative and dynamics of the ecosystem. The model becomes less more complicated rather than the original but reflects the original’s particular characteristics. In terms of foundation the models are divided in ideal and material.

Material models are used in the projection of large industrial complexes that mean the reconstruction of the nature. These construction models are made in laboratories; processes that are programmed are examined. These models are used in technical purposes, but they are not useful in solving ecological problems. That is why, ideal mathematical, graphic, imitational and conceptual models play a huge role in ecology.

Graphical models are block diagrams representing the dependence of the processes in form of graphics and tables.

Conceptual models are block diagrams imitating association under systems and processes in large systems.

Both conceptual and mathematical modeling play a huge role in ecology.

Conceptual model is the type of more formalized and systemized variant of traditional science – natural model of the considering ecosystem that consists of scientific texts, block diagrams, tables, graphics and other illustrated materials. The goal of the conceptual model is generalized, clear and full image of the determined techniques of scientific conception of the examining system.

Energetic or biochemical conceptual model is a block diagram of substance flow, trophic connections in ecological system that are explained with texts, tables, graphics showing the composition, structure and particular ecosystem's function aspects.

The privileges of the conceptual models are universality, flexibility, diversity of manners and etc., owing to that they can be used in different systems, but at the same time they have disadvantages: high level of ambiguity interpretation, static character that make it difficult to describe the processes in dynamical systems.

In ecological modeling there are three groups of mathematical means – set and transformation theory, matrix algebra, differential equation. Set and transformation theory can be used for models with variety of characteristics.

The study and classification of ecosystems on its base creates various models of changing conditions that point at the quality condition that are probable for ecosystems, transformation rules that determine the following status for any given condition. Statistic and probability models are used to be the most adequate toward to reality of ecosystems and reflect the influence at accidental factors on ecological situation.

The first type is created on the base of fundamental laws of the material world (conservation of energy, mass, quantity of movement, transformation and etc.). The research selection of the most significant laws for the particular objects is done; formalized recording is done; equations are solved and interpretation of the solutions are produced; model verification is done.

These models carry the information that is held in the structure of the mathematical model itself (differential, integral, balanced types of equations), and the information that is held in model's parameters from experiences. It should be took in account, that absence of the observation data about the coefficients in examining ofmathematical equation solutions gives an opportunity to obtain more qualified results. It should be mentioned, that the models received this way could stand more complicated because of the sophistication, multifactor, variety ofboundary and initial conditions, particularity of environment and other factors.

The trouble in method is that it cannot be the same as the realistic mode and also in complexibilty of the resperesentation the mode of the model with a number of parameters.

The result of overcoming these difficulties is the second type of models that is based on ecosystem's functional pattern by the revealing of the interrelations in given systems. The method of statistic analysis for model construction, projection of the process of receiving the control on data, compilation the data of given ecologic systems, constructing process of the algorithm and computer calculation of statistic corresponding. The diversification rule of ecological situation's formulation demands repeated described process, but in another quality.

The statistic determination of the mathematical model is in the selection of the model's type and parameters. In terms of this, the initial function could not be solely one - factor but also multifactorial. The selection of the model is informal problem because the same dependence is described with the same error with different regressive equations. An appropriate selection of model's type is based on the following criteria: compactness, interpretation means and etc. The calculation of the parameters of the chosen model type is typically formal problem that is easily solved by computer resources.

When the statistic hypothesis of a particular ecologic system is formed, it can be too expanded. In order to get more realistic image of the system the unrealistic information should be separated, in other words the type and number of the data should be decreased. The factor analysis is one the ecological information shortening methods. The data reduction is made with the help ofleast squares method, with the main component used with the cluster analysis. It also should be mentioned, that the initial ecological information has the following specialities: sophisticated data, nonlinearity, polisemantity in system's connections, calculation faults, unexpected factor's influence, spatio - temporal dynamics. The mathematical models that include the factors above give the opportunity to describe the ecological processes in a more exact way.

To solve the ecological problems it is quite reasonable to use non - linear mathematical models, because the majority of ecological laws is not enough explored. As a result, attention is paid on the sophistication of the modeling connections and non - linearity.

In statistical modeling the usage of the prior data that is fixed in solution of the various pattern process is important, as well as their probable number decrease.

The revelation of the models' parameters is calculated by least squares method and main component method, and by their derivative.

The necessity of long - lasting prediction of complicated ecosystems with the usage of computers gave an opportunity to create the new model type - imitational

model that includes the first and the foundation of the second types. The essence of imitational modeling is in study of complex mathematical model by computer experiments and result handling. The computer imitation gives a chance to recreate casual and consistent interrelations between ecological processes, and it helps to study the manner of complex ecosystems eithertheoretically and by studying different strategies of ecological situation.

Today's one of the most effective methods of construction of the ecological systems models is the method based on the usage of fuzzy set theory. Models based on this type of sets give an opportunity to take into consideration the uncertainty of the modeling object's initial ecological information. Models based on uncertain logics, taking in account the object's hierarchy allow simplifying the ecological model, and supporting its adequateness in uncertainty conditions. The construction of models takes into consideration that do not submit the formal description because the particular part of parameters are uncertain or qualified given quantities. The traditional methods are not suitable for solutions of these kinds of problems because they are not able to describe the appearing uncertainty. The usage of uncertain logics allows gaining knowledge data and expert systems of the new generation that gives a chance to keep and examine the incorrect information about ecological object. Systems based on uncertain logics can be used to evaluate the degree of negative factors while the information about the ecological object is uncertain. Uncertain models can describe ecological processes with initial uncertain information in a more adequate and fulfilled way, and also decrease the probability of mistaken solutions in terms of ecological monitoring and prediction.

Once constructing mathematical models for ecological computer monitoring it is necessary to take into consideration the territorial and distributional character of the modelling object. From this point of view, all the objects can be separated into four groups.

The worldwide level objects group. These models should take in an account the problems and features of ecological processes related to a number of countries. For instance, air pools, world oceans, trans-boarded rivers, outer space, migration of birds and etc.

The state level objects group. The models of this group should consider vast territories, big economical potential, basic factories and resources. The country's techno genic complexes provide independence and safety of the country. Ecological safety of these complexes is equalized to ecological safety of the country and stable development of the field and state, probably in rational and organized agricultural area.

Local level objects. These type of models should evaluate the natural resources with orientation on science and high technological branches, resource - saving technologies, complex extraction of precise components, utilization of technogenic and secondary stuff, the reduction part of the stuff and the increase of the final competitive product, and also the other resources of pressure decrease of the ecological situation on nature and population.

Inhabit level objects. These models should characterize the organization of areal and industrial elements of production with poor and polluting impact on ecology, outer negative influence on nature and manufacture.

CONCLUSION

Rationally chosen mathematical models with purpose of the construction of the system of ecological monitoring and prediction with the usage of modern informational technologies that allow collecting, process and keeping the information about functional process of the ecological object, and allowing control on the ecological situation in an effective direction.

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