Man In India, 97 (3) : 163-173

ANALYSIS AND ESTIMATION OF THE ECOLOGICAL RISK RESULTING FROM NEGATIVE MAN-MADE ACTIVITIES BY MEANS OF END-TO-END MODELING

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This article contains the results of the research into the development and improvement of methodological approaches to ensuring ecological safety. There is stated the author's position on taking into account ecological risks when substantiating and making investment decisions. It shows the algorithm of risk estimation. The topicality of the research is stipulated by the author's approach to the analysis and estimation of environmental damage while substantiating and making investment decisions. The targets of the article are:- substantiation of technologies for studying ecological risk arising from man-made activities by means of scientific research;- determination of correlation between separate emergencies resulting in destruction of natural-technological systems;- analysis and estimation of the ecological risk for making decisions on handling the situation. The principal method of the study of the problem is the scientific-methodological researches revealing causes of possible dangers when taking decisions for dealing with the situation. The structure of the article contains the results of the analysis and estimation of ecological risks resulting from man-made activities when prognosing the development of the social-economic situation in the region of the Russian Donbass with its unprofitable coal mines and its subsequent rehabilitation. On this basis there was worked out a prognostication complex for informational support for taking decisions.

Keywords: planning decisions, environmental damage, risk management, complex of models, end-to-end modeling.

INTRODUCTION

The influence of man-made activities on human beings and the environment (ENV) has been extending gradually since manufacturing capacity has considerably increased in its intensity and scale. In the circumstances it is of utmost importance to introduce the latest achievements of today's science into everyday life of people (Zakirova & Shilova, 2016). They will make it possible to come to well-grounded decisions from the ecological point of view at the stages of both planning and exploiting industrial and infrastructural units. One of the decisions is the analysis and estimation of the man-made risks. Today's science interprets technological safety as a probabalistic measure for foreseeing man-made or natural phenomena accompanied by appearance, formation and effect of dangers and the social, economic, ecological and other sorts of damage and losses caused thereby. Man-made influence on the environment is manifested in the changes of the

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global climate, namely in: water and air pollution with harmfull substances, and the contamination of soil with production wastes as well as changed chemical composition of air and contamination of biosphere by power production (Molev *et al.*, 2006; Molev *et al.*, 2012a; Molev *et al.*, 2012b; Molev *et al.*, 2012b; Molev *et al.*, 2012d; Molev *et al.*, 2012e; Molev *et al.*, 2012f; Molev, Zanina & Stuzhenko, 2015; Kayumova & Zakirova, 2016; Masalimova & Benin, 2016; Khuziakhmetov & Sytina, 2016; Vlasova, Simonova & Soleymani, 2016). The ecological risk is estimation of the probability of negative changes in ENV, resulting from building or exploiting industrial or infrastructural units. As the basis for takinf decisions on planning activity, the risk analysis includes the following kinds of technical and economic calculations:

– estimation of all risks in the aggregate caused by the activity of the investment units;
– analysis of expenditures on the realization of projects;
– analysis of the long-term profit and benefits arising from the decision taken (Akarisktiev, 2005; Molev, Merkulov& Merkulova, 2010; Zakirova & Purik, 2016; Vlasova, Masalimova & Alamanov, 2016).

Ensuring technological safety of the Russian Federation is on the priority list of the leaders of the state.The importance of the problem is emphasized by the corresponding state laws, i.e. "Ecological doctrine of the Russian Federation" and a number of other legal acts. In Russia the years of 2017 has been proclaimed the year of ecology and from that year on all higher medical schools of Russia will start teaching their students a new profession "bachelor of school medicine". It will bring changes into school health service and at the same time it will improve the level of vital activity of schoolchildren (Denisenkova, *et al.*, 2014; Molev *et al.*, 2013; Molev *et al.*, 2014; Takho-Godi *et al.*, 2012; Kalimullin & Islamova, 2016).

RESEARCH METHODOLOGY

In the process of the research the following methods were used

– effective method of liquidation measures;
– method of universal symbiosis of physical and physical-mathematical models;
– methods of engineering, modeling, expert, sociological, of complex analysis (stage by stage) along with methods of prognosis, classifying, end-to-end modeling, hypotheses and dimentional discontinual monitoring.

Experimental base of the research

Research and experimental base of the research comprises a number of the Russian Donbass territories, they are: Shakhtinskiy, Gukovskiy, Krasnosulinskiy, Zverevskiy and some other regions in the process of liquidation of unprofitable coal mines and the rehabilitation the region that followed.

Stages of the research

There were several stages in the research:

The starting ("technological") stage of the analysis was the process of danger identification and estimation of risk for certain people or groups of people, objects of the environment and other objects under review. At the second stage there was made up the algorithm of the risk analysis with consecutive compulsory stages in compliance with the requirements of legal acts. At the third stage there were classified hazards of applying criteria of acceptable risk in order to find out the unacceptable risk which will become the basis for working out recommendations and measures for lessening the dangers. At the same time both the criteria and the results can be expressed qualitatively as well as quantatively.

At the fourth stage there were analyzed ecological effects and factors of probable negative influence, there were estimated levels of influence of harmful emanations, extent of their spreading considering weather conditions, periods of time and according to their criticality category.

At the fifth stage there was worked out an instrument for forecasting the condition of the environment with the help of modeling all the stages of the process.

Based on the complex analysis and research carried out stage by stage there was made up a universal symbiosis of physical and physical-mathematical models for working out an efficient technique of measures for liquidation.

RESULTS

The analysis at the technical stage resulted in discovering the process of risk identification and the estimation of risk for certain people or groups of people, natural objects of the environment and other objects under review. The specific feature of the analysis lies in the fact that at the stage there were studied possible negative consequences which may result from failure of technical systems, technological processes, omissions of the staff as well as ejection of harmful and hazardous substances and sewage pollution. The risk analysis gave answers to three main questions:

1. What negative event can take place?
2. How often can they happen?
3. What consequences can there be?

The main element of the risk analysis is identification of hazards and dangers which can bring about negative consequences. The algorithm of the risk analysis has a number of compulsory consecutive stages:

- planning of work for identification of the emergencies;
- detecting the dangers;
- preliminary estimation of the character of dangers;
- analysis of the frequency, consequences and uncertainties;
- working out recommendations for managing the risks.

In order to enter the process of handling the risk the risk analysis is carried out in compliance with the requirements of legal acts. The analysis of danger has to comply with the complexity of the processes under review, presence of the necessary data and appropriately qualified professionals carrying out the analysis. In doing so simpler and clearer methods of the analysis should be preferred to more complicated ones. At the first stage it is necessary:

- to plan and organize the works;
- to indicate the causes and problems which made the analysis necessary;
- to define the aims and criteria of the analysis of the acceptable risk for ENV;
- to describe the analyzed system;
- to form a team of experts.

At the stage of danger identification the main task is to find out and describe distinctly all the dangers inherent in the technical system. The dangers must be classified using the criteria of acceptable risk aiming at finding out the unacceptable risk danger, which will become the basis for working out recommendations and measures for decreasing the dangers. The criteria and the results of of the estimation can be expressed both qualitatively and quantatively.

The preliminary estimation of dangers for deciding on the further steps includes:

- giving up analyzing because of the insignificance of the dangers;
- carrying out a more detailed risk analysis;
- working out recommendations for decreasing the dangers.

There are analyzed ecological effects and factors of possible negative influences, there are also estimated the degree of the influence of harmful substances and emissions, the range of spreading considering the weather conditions and periods of their action. The classification is performed in compliance with the so-called “criticality categories”:

- limitation and “negligible” effects;
- critical situations;
- disastrous consequences.

The analysis can already stop at the stage of identification of dangers. If necessary, the stage of risk estimation is passed on to. And the final stage of the risk analysis is working out recommendations for decreasing the degree of risk (handling the risk). The system of making decisions based on the risk analysis can have three basic types of vagueness:

- vagueness of the parameters, when it is impossible to predict numerical values of the basic parameters of influence;
- vagueness of the ecological models, when all the variables, influencing the process, and their functional correlation are not clear.

The social acceptability of the degree of risk depends on the number of people exposed to the danger as the economic losses of the state can be absolutely huge. The greater the number of people exposed to the danger is, the more society cares about safety and takes measures for decreasing the degree of the individual risk. Society is ready to put up with voluntary risk by 1000 fold more than with the forced one. Often smaller degrees of risk connected with new, not fully known fields of activity (for example, consequences of irradiation of small doses) are disregarded.

Acceptable risk should correspond to the minimum of the total losses and expenditures of the society and the environment aimed at the achievement of the goal set by mankind. the minima are defined empirically, by trial and error, which brings about considerable costs, blunders and miscalculations, all those have a negative influence on the lives of most people and become apparent in case of ecological risk defined as average probability of the negative consequences befalling. At the same time strochastics of intensity, duration and specific features of the influence are recognized. . In particular cases, the negative consequences imply human death. Today's practice has four different methods for estimating risk: engineering, modeling, expert and sociological. The engineering approach is based of the probability analysis of safety (making up and calculating of so-called trees of events and trees of refusals). The modeling method is creating models of harmful factors influence on human beings and the environment. The models help to describe and analyze the consequences of everyday functioning of enterprises and losses resulting from accidents at them. When turning to the expert approach, the probability of various negative events, their correlation and the consequences of the accidents are not defined with the help of calculations, but by interrogating experts. In the context of the topic it is necessary to make the following remark concerning vagueness of the solution of the problem. There exists the principle of incomplete information (discrepancy between the technical base and the informational abilities of humans when it comes to estimating the consequences of remaking ENV), according to the principle it is recommended to realize that the information at hand is never sufficient for all-around estimation of probable negative consequences arising from remaking the environment. The existence of the principle is objectively connected with extreme complexity of natural systems, their uniqueness, unpredictability of natural chain reactions, whose direction, scale and character are difficult to predict. There are quite a few uncertainties connected with estimation of risk. The system of taking decisions based on the analyses of risks has three main types of vagueness:

- vague parameters, when it is impossible to predict the numerical values of the influence basic parameters;
- vague ecological models, when all the variables effecting the process and their functional correlation are not clear;
- vague rules for making decisions.

In order to interpret the levels of risk it is necessary to understand the uncertainties and their causes. The analysis of the uncertainties present is transfer of the vague initial parameters and suggestion used in risk estimation into vague results. If possible, the sources of vagueness must be identified. At present the most efficient way of developing prognosis of the environment condition is modeling all the stages of the process. The ”end-to-end” modeling within the limits of general logic algorithm for solving the prognostic problem ensures the objective estimation of the results at each and every stage and planning of further operations in the proper strategic direction. At the stage of choosing the modeling method the researcher has to select several preferable variants. As a rule, an experienced systems analyst instantly sees families of possible solutions to specific problems. On the whole, the most general analytical solution is required, which will make it possible to use the results of studying analogous problems and the corresponding mathematical operations. Each specific problem can be solved in more than one way. It is recommended to work out several alternative solutions and stop at the one which suits the problem best.

After the alternative statistic models have undergone due analysis, it is necessary to go on to modeling dynamic correlations and interactions among different elements and factors of mining technological complex, for example: mining work, hollows in the rocks, water content of the deposit, mineralization and so on. We should remember that the modeled process as well as the mechanisms of feedback are prone to inner vagueness, and that can make both understanding and manageability of the system far more difficult. In the process of modeling it is necessary to take into account a number of rules which have to be obeyed when the decision on the appropriate strategy is being taken. For example, let us consider the hypothesis that the more complex model is also more precise from the point of view of vagueness, typical of model prognoses. Systematic shift, arising when the system is split into several subsystems, is associated with the complexity of the model of inverse relationship, but along with that there is an increase in the vagueness due to errors in selection of certain parameters of the model. The new parameters that are entered in the model must be defined quantatively in field and laboratory experiments, and there are always some mistakes in them. when undergoing imitation the mistakes in measurements add to the vagueness of the obtained prognoses. These all are reasons why it is advisable to cut down on the number of parameters in review in any model. It is necessary to note that the process of modeling includes:

- consideration of representing volume of the ecosystem parameters;
- simulation of the variety of phenomena of different physical nature;
- awareness that majority of the model coefficients have physical sense.

Basing on the analysis of the research performed, I believe that for working out an efficient methods of liqudation measures it is necessary to work out a universal symbiosis of physical and phisycal-mathematical models:

- integral model of the technosphere within range of the territory under review;
- particular natural-technical models;
- models of the mountain mass, air and water ecomodels;
- models of geomechanical, hydrogeological, hydrophysical and other technological processes;
- formalized procedure models describing the order and content of handling activities;
- informational models;
- standard models of ecologically satisfactory condition of the natural units and systems;
- basic interpretational models;
- economic-mathematical models used in evaluation of the efficiency of measures for environmental proyection;
- mathematical models (balance equation).

The purpose of the above models is to show that in the course of expert comparison of model and factual data on the condition of the objects or parameters of the process in the analytical and prognostic subsystems there are considered ecological risks of implementing certain organizational and technical measures and structural materials.For estimation of the risk it is necessary to employ a complex of calculation models including the following types:

- exponent leveling models;
- model for excerption of maximal similarity;
- Markov model;
- model based on unclear logic.

When deciding on the model for estimation of risk it is vital to take into account a number of conditions. In order to ensure high reliability of the prognoses it is necessary to be in line with the basic principles and rules stipulating the process of constructing of the above models:

– well-grounded technical and economic compromise between the expected accuracy of the modeling results and the complexity of the model;
– precision balance (determining the admissible error);
– sufficient variety of the model elements;
– clearness of the model for the researcher; model
– presentation of the model in blocks;
– specification of the models (feasibility of relatively small conditional submodels aimed at analyzing a unit, a system or a process within a narrow range of conditions).

While working out the models there are also used procedures of checking the correspondence of the model and the description of the actual unit, and consecutive simplification and complication of the formed models. Preference should be given to the descriptive models which describe the characteristics of the modelled units and explain the laws of changing of their parameters verbally and by means of pictures and some symbols. These models are the most suitable ones for answering questions like: "What is a technological risk?"; "How does its value depend on the probability and gravity of accidents in the technosphere?"; "How will the basic parameters change in time?" Among other characteristics of the models there are those known as "adequacy" and the degree of their complexity and predictability (or probability). If the results of employing some model achieve the aim, i.e. they are suitable for prognoses of behaviour and characteristic features of the original, then the model is considered to be adequate to the reality. However, taking into consideration the inherent incompleteness of the model from the very beginning, it is rightful to maintain that, in principle, there is no way a model that is perfectly adequate to a complex unit can exist. As for the complexity (or simplicity) of the model, it is appropriate to say the following: of the two models aimed at the achievement the desired goal the simpler one should be preferred. The adequacy and simplicity of a model are not always contradictory requirements. Consequently, for any complex unit there can be created a great number of models differing in their completeness, adequacy and complexity. Practice of risk evaluation shows that at the present stage of the development of science and technology the most suitable means of obtaining information is the system of three-dimentional discontinual monitoring which takes into account all the above-mentioned requirements. The offered monitoring system solves the problems connected with different aspects of the project realization:

– forming the informational base and selection of methods and means for observation;
– making up models of the units and processes taking place in the area;
– deciding on the informational techniques of collecting, studying and interpreting the information;
– creating an efficient technique for making up reliable prognoses and outlooks;
– forming an optimum executive body in charge of the prognostication complex.

DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

The main target of all methodological approaches to the analysis of probable hazards is finding out causal connection of separate nasty accidents resulting in disasters in the natural-technical systems. Basing on the results of the complex analysis, a prospective prediction for the further existence of the system "human being-environment" is made and a range of measures for prevention of probable negative consequences is offered. Practice of risk evaluation shows that at the present stage of science and technology development the most suitable means of obtaining information is the system of three-dimentional discontinual monitoring which takes into account all the above-mentioned requirements.

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All the above elements of the system were tested in the course of observations and working out prognoses for the development of social-economic situation in the region of Ruysdian Donbass, namely: Shakhtinskiy, Gukovskiy, Krasnosulinskiy, Nonoshakhtinkiy, Zverevskiy and some other in the process of liquidation of the unprofitable coal mines and the following rehabilitation of the region. The analysis of the prognostic and factual data revealed high ecological-economic efficiency of the methodological research and of the prognostic complex based on it. The obtained results made it possible to use this prognostic system for the informational support of the management's decision-making in the field of control over the ecological-economic situation in the coal mining region.

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