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APPLICATION OF RISK-ASSESSMENT METHODS IN ENVIRONMENTAL PROBLEMS

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Events associated with environmental processes frequently depend on numerous stochastic factors [1]. These events can be conveniently interpreted as the corresponding random outcomes occurring in some stochastic experiments. The latter means that inherent uncertainty of environmental phenomena can be expressed and measured in terms of random events and their probabilities.

In some cases, an experimenter can influence a set of possible events and their probabilities by performing certain actions. A set of actions supposedly leading to the goal of an experimenter is called the decision policy or decision rule. If one can measure quantitatively the consequences of these actions, then it is possible to look for the best policy (in a certain a priori prescribed meaning).

Risk-assessment methods usually evaluate probable undesirable consequences of some decisions in the terms of risk. An informal definition of risk can be expressed by the following verbal formula:

$$Risk = (effect) \times (Probability\,of\;Occurrence).$$

Soil contamination by petroleum products, for example, can be defined as the excess over the maximum allowable level of concentrating of total petroleum hydrocarbon products (TPH) at the point of interest. Thus, event E equivalent to this effect can be expressed as

$$E = \{C(TPH) > L\},$$

where$C(TPH)$ is the concentration of TPH in the soil and L is the maximum allowable level of this concentration. Preference is given to the decision policy that minimizes the risk.

Now, it is possible to formulate a general scheme of decision making based on the concept of mean risk. LetA_j^i, $j = 1, \dots, n_i, i = 1, \dots, m$, represents a complete set of events, with the probabilities of occurrence $P(A_j^i)$ associated with the decision policy *i*. Let R_j^i represent the loss (possibly monetary) associated with the occurrence of event A_j^i. Then, mean risk MR_i associated with decision *i* is define by the following formula:

$$MR_i = \sum_j R_j^i \times P(A_j^i). \qquad (1)$$

Remark 1. Equation (1), which determines the mean risk associated with decision *i*, actually shows the expected losses associated with decision *i*. This term is used almost as frequently as mean risk.

The minimum mean risk decision rule selects the policy with index 0 among *m* alternatives for which

$$MR_0 = min_i\{MR_i\}, i = 1, \dots, m.$$

Example.Wastewater treatment.A chemical plant discharges wastewater after appropriate treatment into a nearby river. As compensation to the local authorities, the company pays an average of S 1 for each cubic meter of discharge. Current payment Z depends on quality characteristic X of the wastewater and is defined of the following way:

$$Z(X) = 1 \text{if} 9 \le X \le 11, Z(X) = 0{,}5 \text{ if } X \le 9, Z(X) = 2 \text{ if } 11 \le X.$$

The probabilities of events of interest are

$$P(9 \le X \le 11) = 0{,}6;\ P(X \le 9) = 0{,}3; P(11 \le X) = 0{,}1.$$

A new process of wastewater treatment is proposed for which random characteristic X after the process implementation, will become normally distributed with parameters $\mu = 10$ and $\sigma = 1$

The following question arises:to proceed with the new treatment system in the future or to continue using the old one?To answer this question, we must compare the mean risk values for the old and new treatment systems.

Let MR_1,MR_2 be mean risks for the old system and for the new system respectively. Then $MR_1 = 1 \cdot 0{,}6 + 0{,}5 \cdot 0{,}3 + 2 \cdot 0{,}1 = 0{,}85$,

On the other hand, using the probability integral Ф of the normal distribution, we obtain [2, 3]:

$$MR_2 = 1 \cdot \left(\Phi(1) - \Phi(-1)\right) + 0{,}5 \cdot \Phi(-1) + 2 \cdot \left(1 - \Phi(1)\right) \cong 1{,}08.$$

Therefore, the new system should not be accepted.

Remark 2. In the above discussed example, the wastewater was approximately equal to the mean risk defined by the mathematical expectation of the cost. This cinclusion is based on the law of large numbers.

References

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