Information modernization of the general theory of environmental safety ensuring

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Abstract. A brief analysis of the content of the concept “information” in ecology is given. The purpose of this work is to analyze the features of the information component of the second and third principles of the ensuring environmental safety general theory. It is noted that information interactions in ecological systems play a key role in terms of the possibility of maintaining a balance in them to ensure environmental safety. It is argued that the information components of ecological systems of the environment have a physicochemical meaning, which consists in the reflection of material-energy changes in the form of an information environment (information field) of all subsystems. Information processing can be viewed as a kind of partial modification of self-organization. In open systems (pumped) that give off entropy, information can be acquired. It is the entropy and, of course, the uncertainty of the position of the system that can only increase, i.e. information itself can be nothing more than lost. Thus, the indicated problem seems to be important, essential for the currently achieved level of development of the general theory of ensuring environmental safety and information theory.

1. Introduction

According to the second principle of the general theory of environmental safety (GTES) in any system, quantitative and qualitative aggregates of substances, energy and information are inextricably linked, being in continuous change caused by a change in the characteristics of environmental factors (N.F. Reimers., Yu.N. Kurazhkovsky, L.V. Bobukh, K.A. Bobukh, L.P. Mileshko) [1].

Information here is characterized by an energetically weak effect, a coded message perceived by an organism about the possibility of much more powerful influences on it from other organisms or environmental circumstances and prompting it to respond [2].

In accordance with the third principle of GTES, the energy consumption for information interactions is insignificant and does not lead to imbalance in ecological systems but leads to the coordinated behaviour of subsystems (self-organization), as a result of which the degree of ordering of the system increases, i.e. entropy decreases (L.P. Mileshko, V.V. Kotenko) [3].

The development of GTES from the standpoint of information substantiation of its principles is an important task that is essential for its further improvement.
The purpose of this work is to analyze the features of the information component of the second and third principles of the general theory of ensuring environmental safety.

2. Materials and method

According to N. F. Reimers, according to the law of internal dynamic equilibrium (ISDR) - “matter, energy, information and dynamic qualities of individual natural systems and their hierarchy are so interconnected that any change in one of these indicators causes concomitant functional and structural quantitative and qualitative changes that preserve the total sum of material-energy, informational and dynamic qualities of the systems where these changes take place, or in their hierarchy”[2].

In the interpretation of the ISDR N. F. Reimers refers to other laws, principles and rules that can be used as an algorithm for studying the laws of ecology. For example, the concept of information in environmental management, natural chain reactions, the Le Chatelier-Brown principle, the law of irreversibility of evolution, the law of reducing the energy efficiency of environmental management, the rules of one and ten percent, etc.

The ecological meaning of the bit(s) of N.F. Reimers explains as follows. As you know, a bit(s) of information is a unit of the amount of information that is obtained during the implementation of one of two equally probable events (i.e. a binary unit of information). For example, the information that within the range of a dandelion it grew in this place (it could or may not have grown) contains information in 1 bit.

However, unlike technology, in nature, single events occur very rarely (say, the appearance or not the appearance of a species outside its range). In the case of the dandelion, the chain of events is actually not exhausted by the alternative “grown - not grown”, as in the case of a coin toss - “heads - tails”. In the coin variant, all that matters is that it is a coin with two sides and that it is tossed. Where did it fall (if not on an edge into a gap and rolled down the slope and disappeared) what dignity it was, how quickly it fell, how high it was thrown, etc. - all this is irrelevant. In the case of a dandelion, all of the above is important, since, for example, if its seed gets on the asphalt or in a pond, it will not grow, it can be destroyed by pests, etc. [2, p.52].

A legitimate question arises about the role of information in ecology: what is the nature of its relationship with matter and energy according to the ISDR and does this relationship exist at all? And if so, in what form? Is it possible to control information by means of any material-energy influences? If information is an ideal display of material-energy interactions, then how can the environment be reflected - as an independent information “field”, or rather, an information environment. And in general, how legitimate is this approach? Can environmental systems be balanced through information flow management?

By definition, an “ecological system” is a spatially defined set of living organisms of different species and their habitat, united by material-energy and information interactions [3].

Provided that for each element of the system two states are possible (ground and excited) and they are equally probable (in this case \(-\log_{2}p_{i} = 1\) bit of information), the ratio \(I_{S} = H/S\) can serve as the information equivalent of entropy: \(I_{S} = 4.38 \cdot 10^{23}\) bits per entropy unit or \(1.045 \cdot 10^{23}\) bits per J / K. Such a value of \(I_{S}\) is obtained as a quotient from dividing the conversion factor of the logarithm base 2 to the natural logarithm \((\log_{2}e = 1.4427 \ln x)\) by the Boltzmann constant. 1 entropy unit (1 e.u.) = 1 cal / deg = 4.18 J/K.

Because the

\[
\Delta S = \Delta Q/T,
\]

where \(Q\) is the amount of heat (energy); 
\(T\) is the absolute temperature, the knowledge of which makes it possible to estimate the information equivalent of energy:
\[ I_E = 1.045 \cdot 10^{23} \frac{1}{T} \text{bit/J} \] (2)

This means that, energetically, structural information itself is extremely “cheap”. Its inverse dependence on temperature has a hidden universal significance and is of independent interest.

The entropy itself and thus the uncertainty of the state of the system can only increase, i.e. information itself can only be lost. Only in open systems (pumped) that give off entropy can information be acquired. Therefore, information processing can be viewed as a kind of private kind of self-organization.

Thus, the problem indicated in the title of the article seems to be important, essential for the currently achieved level of development of the general theory of environmental safety and information theory.

According to the law of energy maximization (LEM) [2] G. and E. Odunov - in competition with other systems, the one that contributes to the flow of energy in the best way and uses its maximum amount in the most efficient way survives (is preserved). “For this purpose, the system: 1) creates accumulators (storage facilities) of high-quality energy; 2) spends (a certain amount) of accumulated energy to ensure the supply of new energy; 3) ensures the circulation of various substances; 4) creates regulation mechanisms that support the stability of the system and its ability to adapt to changing conditions: 5) establishes the exchange with other systems necessary to meet the need for energy of special types” (Odum G., Odum E.). It should be noted that the LEM is also true in relation to information, therefore it can also be considered as the LEM of information: the system that is most conducive to the flow, production and efficient use of energy and information has the best chances of self-preservation. The maximum intake of a substance as such does not guarantee the success of a system in a competitive group of other similar systems.

According to S.I. Ozhegov SI, balance is “the ratio of mutually related process indicators”, in this case - the exchange of matter and energy with the environment in non-equilibrium conditions.

An addition to the second principle of HSEB can be formulated as follows: the information component of the environment contains a physicochemical meaning, which consists in displaying material and energy changes in the form of an information environment (information field) of all subsystems [4-7].

The most common chemical signals in the example of water are changes in: taste, smell, acidity, alkalinity, hardness, etc.

Physical signals include changes in temperature, colour, turbidity, etc.

In the case of atmospheric air, chemical signals are changes in its chemical composition and the chemical composition of atmospheric precipitation and snow cover, etc., and physical signals are background radiation, temperature, pressure, direction and speed of wind in the surface layer.

For soils, chemical signals are, for example, changes in the composition of soil air and the state of water in the soil, while physical signals include changes in soil structure, physical degradation, etc.

The transmission of information in populations occurs through material carriers, making it existing and its reception and processing requires little energy. Information is present in certain structures of organisms and is transmitted by streams of physical and chemical signals.

Reading information includes the reception of physical and chemical signals from the atmosphere, hydrosphere, lithosphere and biota and can be carried out in a contact and non-contact way.

The disadvantage of contact methods is the change in the parameters of environmental elements in the zone of contacting substances, which reduces the reliability of the analysis.

For this reason, the most interesting is the reception of optical signals, especially in the infrared range.

The principle of operation of IR devices is based on the transformation into visible infrared radiation of bodies that is insensitive to the human eye [8].

According to the principle of operation, infrared devices are subdivided into passive ones, which use their own IR radiation of the investigated objects and active ones, with built-in artificial sources of IR radiation, illuminating the analysed bodies [8].

There are two large groups of IR receivers: thermal and photonic [9].
Consequently, to build models of the information environment of ecological systems, a hardware and software complex is required, including monitoring subsystems that read information from the atmosphere, hydrosphere and lithosphere.

At the same time, great attention should be paid to ensuring information security of measurements. The efficiency of the functioning of the system directly depends on the physicochemical nature of the principles of action of the elements.

A distinctive feature of the designed hardware-software complex is the presence of two arrays of sensors - gas sensors and ion-selective electrodes, which requires parallelization of the processes of reading and processing information.

Software can be developed using the C# language.

To train a neural network, a data array is required that will contain measurement data with a previously known concentration of the measured components in the analyte.

To implement a neural network, you can use the free TensorFlow libraries from Google. There are several reasons: the Python language is simple, there is a large amount of teaching material and there is no need for in-depth study of the theoretical principles of creating neural networks.

Common path:
- creating a model;
- compiling the model;
- loading and preparing data;
- training a neural network;
- using the model to determine the results.

3. Materials and method

Thus, a brief analysis of the content of the concept "information" in ecology is given. It is noted that information interactions in ecological systems play a key role in terms of the possibility of maintaining a balance in them to ensure environmental safety.

Information processing can be viewed as a kind of partial modification of self-organization. In open systems (with pumping), which give off entropy, information can be acquired. It is the entropy and, of course, the uncertainty of the position of the system that can only increase, i.e. the information itself can be nothing but lost.

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