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Systematic Approach and its Use During the Environmental Situation Study Experiencing Technogenic Impact.

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ABSTRACT

The article substantiates the possibility of a systematic approach use during the study of a natural and anthropogenic geosystem ecological state. On the basis of a systematic approach the ecological situation of a territory is studied under intense natural and anthropogenic impact. Also the effective environmental protection measures are developed.
Keywords: Systematic approach, natural and anthropogenic geosystem, environmental components, biogeochemical barrier.

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INTRODUCTION

The development of a geosystem ecological environment is directly related to the use of natural resources, resulting in appearance of new anthropogenic, human-induced components besides the natural ones and other natural and anthropogenic systems of new quality are developed. One of the modern methods for natural and technogenic systems investigation is a systematic approach that allows you to explore all the aspects of the environmental problems caused by the mining and metal industry operations. The systematic approach is applied by us during the study of the environment components ecological state which are under the influence of one of the mining and metallurgical factory of the Middle Urals named "Uralgidromed" OJSC. This area is characterized by a unique geological structure and metallogeny determining the natural high and heterogeneous content of chemical elements in the environment, with a long history of Gumeshevsky deposit copper clays which developed a powerful industrial pollution.

PROCEDURE

The results of territory research territory for many years under the influence of Middle Urals mining and metallurgical plant were used in this article. The work is based on a large number of literary source and environmental monitoring data.

Main part

The systematic approach occupies one of the leading places in scientific knowledge, including the environmental problems solution. Its origin is in the distant past. Davis studying the relief formation claimed that the real relief develops in a complex and varied way, but the mechanism of this process may be understood on the basis of the ideal cycle general principles within which they have the stages of childhood, adolescence, youth, maturity, old age and decrepitude [1,2].

A number of other scientists studied geosystems (L. Bertolanfi, Sochava V.B., Armand A.D., Isachenko A.G., et al.). The analysis of research related to the laws of geosystems (GS) development allows them to determine such features as cyclicity, characterized by different age stages of development; one-wayness - the development from the past to the future; unlimited progress - the development from simple to complex things; irregularity - the simultaneous presence of progressive (ordered), stable (chaotic) and regressive (disordered) elements or subsystems (qualities). Taking into account the above made conclusion, we propose the model of geosystem development. A variety of components, processes, communications, which we combine by one term - factors may act as the system elements[1]. Their number determines the system diversity. The higher the number of elements, the more complex the system is. At the same time, taking into account the complexity laws of the system development by K.F. Ruli[2] and the process unboundedness[3], one may talk about the increasing diversity in the system development. However, as N.F. Reymers (1982) notes, the progress is unlimited only at very considerable efforts and self-control as the driving factor, and "unboundedness duration" is limited by evolutionary framework (by the time of its existence for the Earth). The subsystems and elements (or factors in our interpretation) may be in different states within one system. We distinguish progressive factors (contributing to the system development), regressive factors (impeding the development) and neutral factors (they may contribute and impede the system development). The amount and the relationship of all three factors is the structure and the number of connections between them is the resistance. Let's distinguish progressive factors (contributing to the system development), regression factors (impeding the development) and neutral factors (they may as contribute so as impede the system development). Due to the last factor there are not functional but correlated relations, and they determine the system dispersion.

- The term selection is explained by the fact that during the development each element may act as a factor relative to the others due to the relation and the interdependence of the system elements.
- The historical development of living organisms (as well as all other natural and social systems) leads to the complication of their organization by the function differentiation increase and the organs (subsystems) that perform these functions.
- The development from simple to complex things is evolutionary unlimited.

The sum and the relationship of all three factors is the system structure, the change of their amounts - its development, and the number of connections between them is the resistance (Figure 1). During its development, the system goes through three stages: Stage 1 - The system origin, defined by the presence of neutral and progressive factors with the predominance of neutral ones. Stage 2 - the establishment of a system defined by the presence of progressive, neutral and regressive factors.

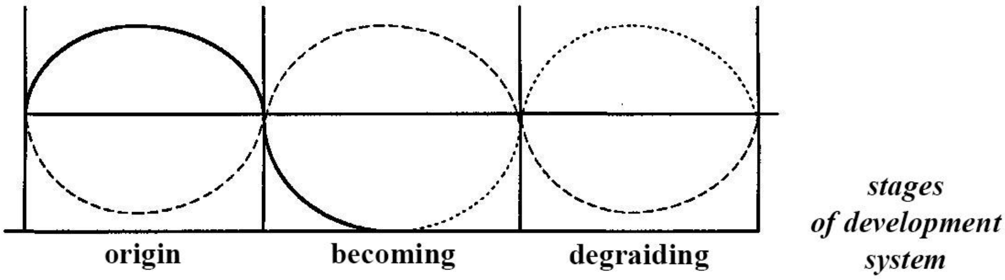

Figure 1: Geosystem development scheme (factors --- ---- progressive .... regressive --------- and neutral).

Progressive factors predominate. Stage 3 - the system expansion determined by the sum of progressive and regressive factors with the predominance of regressive factors. During the second stage a qualitative transformation takes place besides the quantitative one: the neutral factors are transformed into regressive ones. This transition corresponds the dynamic equilibrium state. Then, there is a development as during the first stage. The third stage is finished with a qualitative bounce: the regressive factors are turned into progressive ones and the progressive factors are turned into neutral ones. As a result, the system state is characterized by a new qualitative level (Figure 2).

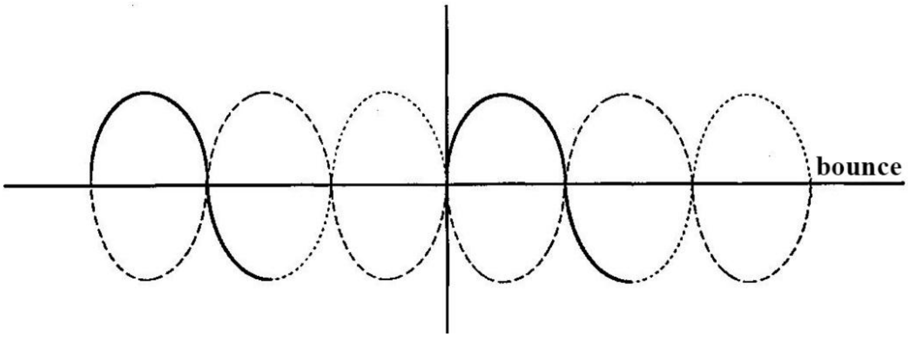

Figure 2: Scheme of factor type change and bounce appearance

The bounce origin may be explained as follows. The relation is the measure of diversity is the link. Geosystem relations are characterized by duplicity. There are relation and interaction links. The relation links are the links, expressing the phenomena, processes or objects relation within the system. These elements may be represented in a qualitative or a quantitative manner. The interaction links are the links, determining the system quality correspondence to its state (the quantity of matter and energy) for a certain period of time. Consequently, they determine the system quality, rather than its individual components. The presence of these two types of links may be represented graphically (Figure 3).

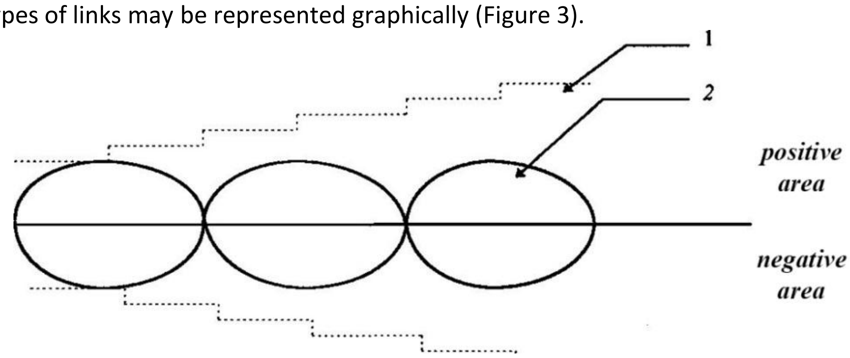

Figure 3: The scheme of link number change - interaction (1) and relation (2) links

The sinusoid corresponds to the relation links which ultimately alter the amount of matter, energy and information in the system. The study of these relations is usually performed by ecologists during their daily environmental studies. There are qualitative changes Along with these usual familiar changes. They are the most stable and occur as small bounces, corresponding to the transition of some system factors into the other ones, or their extremum points. The change of relations-interactions is presented as a stepped line (Figure 3). They exist in the system constantly, but their number is changed only in critical situations (the transition of quantitative changes into qualitative ones). When a sufficient number of quality changes is accumulated the bounce of the whole system occurs. Then it may be developed as for the progress, so as for the regression (Figure 4), depending on which of the total number of factors (positive or negative) prevails.

In this case we are dealing with a slowly developing risk ending by a qualitative bounce. This bounce may be as of a natural so as of an anthropogenic origin. In all cases, the system susceptibility to anthropogenic or natural influences depends on its stability.

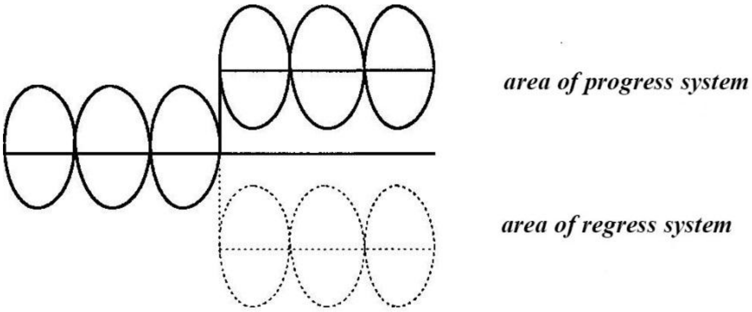

Figure 4: New quality system basis development

Prigogine (1986), A. Toffler (1986), P. Crutchfield (1987) works show that the fluctuations make the system to select randomly according to which the further evolution will take place. This occurs at the moment when the system loses its stability and becomes unstable. The instability may be regarded as the fluctuation result, which was initially localized in a small area of the system, and then was spread and led to its new state. In other words, the echoes of local events are spread throughout the system. The "link channels" should be well developed for this. The system area which undergone fluctuations with these channels, transfers the part of energy and matter through the whole system. It is possible to prevent this by blocking the communication channels. So, if there is a constant source of groundwater pollution within the system A, the pollutants are transported by ground waters outside of this area, and at a long-term availability of this source the pollution concentration within the whole system reaches the value, which ultimately leads to its radical restructuring[4]. The communication channel here is the transportation possibility of groundwater flow. If a new communication channel is developed via a drainage, intercepting the contaminated waters and discharging them into a special sump, then this fluctuation may not lead the system state change, i.e., one may control the changing of the system itself by changing the channels of communication.

In this regard, the management issues associated with the regulation of the object (nature) and the subject (person) interaction are of particular importance and the resulting subject-object relations (Preobrazhensky, 1987). They are represented as blocks on Figure 5. The first includes the objects, which are the main subordinate components of nature: leading (geological structure and topography, climate, surface water and ground waters) and driven ones (soil, flora and fauna). The second block includes the subjects and their possible effects on objects included in the first block. He may be represented by partial blocks, including some natural and man-made components that influence an object in two ways: directly and indirectly (e.g., the surface runoff of suspended solids may be increased as the result of territory plowing). The third block includes the system which changed as the result of its operation, the implementation of the object-subject relations in rocks, exogenous processes, basic meteorological characteristics, hydrodynamic condition values and so on. This block, as the result of the object-subject relations, does not remain passive: its components, in its turn, influence the object (feedback), forcing the latter to operate under changed conditions (Figure 5). These blocks may be considered as a set of basis (I block object) and factors (II and III blocks - the subject and collaterally subordinated components interconnected by relation, interaction and regulation).

Underground drinking water in the city of Berezniki, Perm region in some places is turned into salt water.

The role of the second and third blocks will depend on the object impact nature. If the subject includes not only natural, but anthropogenic component exceeding the natural one by the impact strength and leading to environmental disturbances, then the system virtually become an open one, that is the subject-object links become weaker (Fig. 6). The object transformation occurs mainly due to the transition of quantitative changes into qualitative ones.

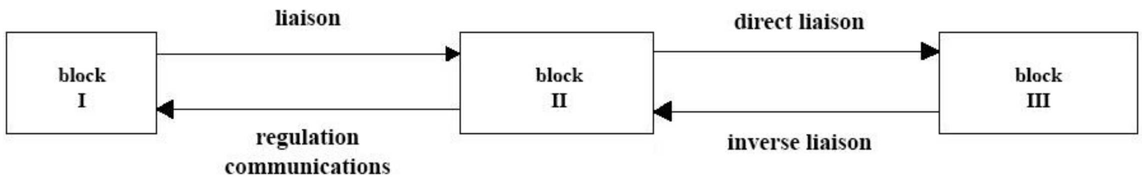

Figure 5: Scheme of natural system functioning

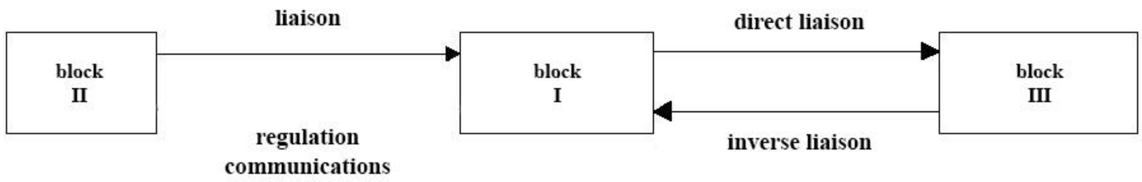

Figure 6: Scheme of geosystem operation under strong anthropogenic influence

Thus, the system changes the original direction of its development and loses its ecological balance. The more the object is modified, the closer the system is suitable for the ecological crisis (the Aral Sea, Sevan lake problems and so on). In order to eliminate the crisis situations a man has to create another kind of relationships between I and III blocks i.e. adaptation links (Fig. 7).

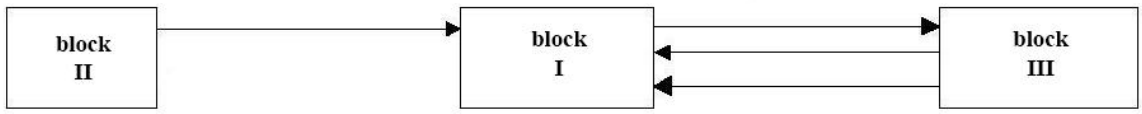

Figure 7: System operation scheme when adaptation links are present

Most currently developed measures (flow transfer, the construction of treatment plants, dams on the Caspian Sea, and so on) allow only accommodate the changing conditions (III block) to the environment (I block). However, as practice shows, the adaptation links do not always guarantee the elimination of the environmental crisis situations. Therefore it is necessary to create management links, locking the system. They should be developed simultaneously with the occurrence of natural and man-made system and regulate the relationships a man (II block) and nature (I block) in such a way that the operation of the developed system won't bring to the ecological balance disruption (Fig. 8).

So, only operation links may protect the systems from the crisis ecological situations, although the use of adaptation links prevail within the existing natural and economic systems.

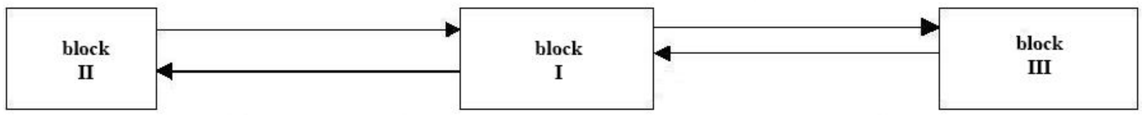

Figure 8: Scheme of closed natural-economic system operation if management links are present

The management links will perform its functions effectively, if they maintain a geosystem (GS) stability.

The development of a natural and anthropogenic geosystem under study depends on its structure and functioning, which in its turn determine the current environmental situation. After the natural and man-made geosystem development its transition into a qualitatively new state occurs, where new elements appear or old elements of a structure are deleted and, therefore, the efficiency of its operation increases or decreases [3]. Depending on the resulting current environmental situation as a geosystem may develop in the direction of regression (the natural component degradation), and in the direction of progress (maintain or keep closer to the natural state of environmental components). To prevent the geosystem degradation, you must manage it. The management, in terms of the nature component natural properties maintaining is associated with the introduction of the environment protection measures (Fig. 9) and shall begin with the assessment of a current environmental situation.

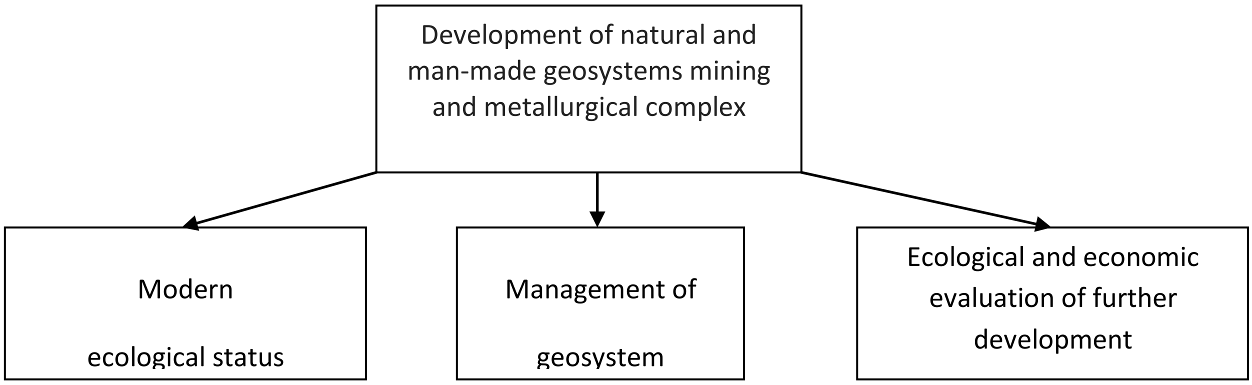

Figure 9: Development of natural and anthropogenic geosystem (Level III)

Then you need to implement the measures for its improvement or stabilization (management). At that the important factor is environmental and economic evaluation of these activities. This way will allow an optimal management of a geosystem (ecological situation) development that we have showed by the example of the copper industry enterprise [4]. As a model object for the study of possible ways for copper ore geosystem (Level III) development and the environmental situation management within this system we chose "Uralgidromed" OJSC as a typical company of mining and metallurgical facility, located at Gumeshevsky copper clay deposit near the city of Polevskoy, Sverdlovsk region and performing the copper production.

Currently, the system of pilot industrial underground leaching is realized at Gumeshevsky deposit. And the extraction of copper is realized through the system supply of different level pumped and loaded stream wells of operational leaching solutions which are the aqueous solutions of technological sulfuric acid at the concentration of 10-30 g/dm^3. Thus, wastes are generated presented by wastewaters. Waste waters flow to the South Bay of Seversky pond developed in the Zhelezyanki river floodplain [5,6]. When wells are unloaded the polluting flows in Zhelezyansky Bay are developed. This Bay is the part of the South bay. The wastewater entering the water bodies, change their natural composition, thereby affecting the ecological status of surface waters and determine the development of geosystem [7,8].

The chemical analysis of 154 water samples from 7 dam sites of the South Bay, showed the maximum excess of zinc and copper exceeding the standards 5 and 100 times, respectively.

The data obtained allow to conclude that the South Bay is actually a man-made pond and the greatest influence on the development of unfavorable environmental condition is performed by surface waters.

In our case, to prevent the transformation of the environmental situation of one component in the "disaster" of the entire geo-system, it is necessary to perform management i.e. to the implementation of nature protection measures. Us as such an event we considered the possibility of a biogeochemical barrier development within the Zhelezyansky Gulf [9,10]. The choice of this type of environmental activities is based on two factors:

- According to the preliminary research, we revealed the presence of plant species with a high self-cleaning ability in the Gulf: marsh horsetail, Typha latifolia, amphibious knotweed, curly pondweed, Lemna minor. However, the amount of vegetation in the pond is insufficient: the area growing makes only 28%, and it can not fully participate in the process of purification.
- The results of analysis for 230 water samples taken from us 10 dam sites of the bay, the measuring of discharges and balance calculations showed a high self-cleaning ability of the pond as a result of the chemical and physico-chemical processes occurring within this pond (the formation of oxyhydrates, sorptions, precipitations).

CONCLUSION

Thus, we may state that there are natural conditions for the establishment of biogeochemical barrier within the Zhelezyansky bay.

We conducted the laboratory and field modeling of bio plateau and the study of reservoir cleaning ability in the presence of highest aquatic plants (Typha angustifolia and marsh horsetail) and it showed that all contaminants, namely, Fe, Cu, Zn, Pb, Cd, As, SO42 achieve a stable concentration reduction to the levels consistent with the requirements for drinking water and water bodies for drinking and general sanitary purposes [11].

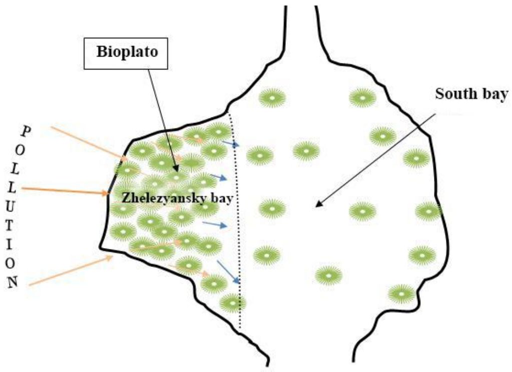

Figure 10: The design of bio plateau to clean the South Bay of the Seversky reservoir.

Thus, to improve the ecological status of surface waters within the territory of "Uralgidromed" OJSC, and thus the entire PTGS, it is necessary to develop within the part of the Southern Gulf territory a biogeochemical barrier, namely, to turn Zhelezyansky Bay into a bio plateau.

RESULTS

The geosystem protection technology proposed on the basis of a systematic approach is an innovative one due to its high environmental performance and the ability of its use in any of the natural and man-made environments. With the help of biogeochemical barriers a geosystem may be controlled, preventing the contaminants flows from the neighboring geosystems.

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