

Basic Methodological Approaches in the Analysis of Environmental Processes

Valentina Bushueva

National Research University
Bauman Moscow State Technical University (BMSTU)
Moscow, Russia
E-mail: vbysh2008@rambler.ru

Nikolay Bushuev

National Research University
Bauman Moscow State Technical University (BMSTU)
Moscow, Russia
E-mail: agrohim1@rambler.ru

Alexander Loshchilin

Moscow State Linguistic University (MSLU)
Moscow, Russia
E-mail: anl888@mail.ru

Abstract—We demonstrated the importance of methodological approaches in the studies of environmental phenomena. We also analyzed the features of the interdisciplinary, integrated, systemic, structural, probabilistic approaches. A comparative analysis of them was done. The limitations of the implementation of each method separately were observed to prove them to be used together for better results, especially its efficiency in ecological studies. The environmental orientation of the examined approaches was of a particular interest, which added a certain novelty to the article. We made conclusions and gave recommendations as a final note.

Keywords—*ecological processes; methodological approaches; interdisciplinary approach; integrated approach; system approach; structural approach; probabilistic approach; interaction and interconnection of approaches*

I. INTRODUCTION

In the XX century the industrial sector developed in various countries of the world regardless to the environmental requirements. Harmful effects on humans and the environment are related to the activities of nuclear energy, chemical industries, etc. It should be noted that economic factors make the use of the environmentally friendly technologies more difficult. That is why the environmental issues today are particularly acute. And the measures being taken to solve it are insufficient. Unfortunately, at the global level, no consensus has yet been reached. World business leaders do not make any minor concessions for the sake of the future, fearing to lose even a small part of their income, while neglecting environmental security. Although even a small part of the economic profit means would be enough to prevent and eliminate dangerous environmental consequences in accordance with the UN documents [1].

Unfortunately, in Russia, since the 90s, due to political and economic instability, there has also been a break in the

financing of environmental protection programs. And environmental problems were not fully resolved. In economic science and practice, up to the present, due attention has not been paid to solving environmental problems. Moreover, for a long time natural resources appeared in economic science and practice, as well as in public consciousness as inexhaustible, which hampered the timely prevention of environmental threats. Therefore, it is necessary today that environmental safety and economic feasibility were regulated together as the ecological-economic system [2]. But for now the environmental threat is not the object of close attention of science, economics, politics, etc., and is not sufficiently substantiated and remains largely the subject of almost vain disputes of scientists [3].

It should be noted that environmental safety is not a concern of everyday awareness as well. A common citizen of any Russian city is well aware that nature must be protected and sincerely believes it unacceptable to do harm to, and at the same time doesn't consider oneself to have a hand in environmental pollution and can scatter garbage, mercury bulbs and other waste without thinking. In other words, the ecological thinking, consciousness, mentality of a Russian citizen does not always meet environmental requirements that are not in demand, and therefore there is not enough motivation to take active steps to protect the environment. Environmental values are declarative, and not supported by legal forms of influence. It is commonly believed, that the option of forming ecological thinking and respect for the environment in an average person looks a bit utopian, although, in our opinion, it's still quite feasible.

So, the environmental issues are now extremely important and relevant [4]. And it requires an urgent reaction, since a sufficient number of negative changes in nature have been accumulated, which are irreversible already as a result of ill-considered irrational technological solutions. Scientists

report the significant loss of natural resources, reduction of viable natural ecosystems, disruption of their functioning, reduction of biodiversity, etc. In other words, the consequences of unreasonable pressures on the environment turned out to be more pernicious than previously thought [5]. All this suggests that environmental issues should be a common cause, the object of close attention of public, political, legal structures, as well as all parts of science aimed at finding alternative solutions.

II. ROLES OF VARIOUS DISCIPLINES IN ENVIRONMENTAL PROBLEMS

Scientific research has the greatest significance in modern conditions for solving environmental problems and their prediction. And special attention is paid to the process of interrelations between the sciences - natural, social and technical. As a result of such approach, new scientific aspects are found, which causes more and more new fields of knowledge be gradually "drawn into" the research process. And this dynamic is basically unlimited. It should also be noted that earlier, while solving environmental problems, great attention was paid to relations with the natural and technical sciences, today researchers have switched to connections with the social and human sciences, and here the humanitarian block of disciplines has a special place [6].

Humanitarian disciplines prove the forms, methods, the need for an environmental outlook, responsibility, allow to determine the place of nature in the system of values. In other words, they form an ecological culture, do the function of belonging to universal humanistic values. As commonly known, it is impossible to solve environmental problems in the immoral and soulless world. Responsibility, the value system of an individual determines its behavior, motivates to look for alternative, environmentally friendly solutions when developing new technology [7].

The growing relation between social, natural and technical sciences is the basis for the formation of a general scientific methodology and research approaches that are significant not only at the theoretical level of the basic and applied sciences, but also have an experimental-empirical orientation. Here they perform a systematizing function. For example, modern ecology is characterized by the accumulation of a significant amount of empirical material of its various directions, which is ahead of the possibilities of its theoretical processing and the systematizing function is especially necessary here [8]. As is known, today, along with the philosophical methodology, it is quite appropriate to talk about the significance of general scientific approaches as well as of the methodology of any particular sciences. But it is necessary to consider some important criteria, for example, that philosophical methods are not associated with appropriate mathematical and logical-symbolic means, and general scientific methods and research approaches are simply not conceivable without their logical and mathematical content [9]. But these two levels are interconnected, affect each other, that is, the methodological function of philosophy remains very important when analyzing particular sciences, specific areas, in this case ecology.

III. BASIC METHODOLOGICAL APPROACHES IN ECOLOGICAL RESEARCH

Today, researchers identify more than 100 directions in ecology [10]. To be more precise, modern ecology is characterized not by its dividing into a large extent of separate disciplines, but into problems that are interdisciplinary, complex, and therefore also require certain research approaches.

The most significant areas in ecology are those that unite, rather than divide, the objects of study, which necessarily requires interdisciplinary research methods [11] and the efforts of representatives of various disciplines in a particular study. An interdisciplinary approach cannot be understood as the transfer of knowledge from one area to another. It requires a certain synthesis, the relationship of knowledge, which allows to solve environmental problems at the intersection of sciences. The interdisciplinary knowledge needs to be expanded not only at the expense of special disciplines, but also at the expense of humanitarian ones, which determine the methodological basis of this method. Interdisciplinary research methods are dominant in areas such as human ecology. It examines the processes of human interaction with the environment.

The interdisciplinary and integrated approaches are closely related. An integrated approach to the research of environmental problems involves the simultaneous analysis of environmentally significant factors by the methods of various sciences, so it is necessary to confirm their truth in other independent ways. Only such a research approach allows to foresee, and therefore prevent, one or other environmental consequences [12]. But it has to be considered that human activity breaks the balance of natural processes, they do not always have time to recover, and therefore irreversible environmental consequences occur. Other research approaches are needed to adjust research results. However, an integrated approach is the prevailing method of research, especially in environmental engineering. It is worth noticing that the problems of integration, like other research methods are not constant, but require constant development, improvement, which leads to new scientific knowledge.

A special place in ecology and research activities takes a systematic approach [13]. This is a rather complicated research method. The systematic approach is dominant in many sections of ecology, and mostly in bioecology.

Of course, research activities cannot be carried out randomly, it is a subject to certain laws. That is to say, in ecology it is impossible to solve one problem first, then another, that is, linearly and consistently, a systematic approach is required. Some common areas or principles are required to allow to link them into a system, to form a holistic view of the natural unity of various scientific data. But this is not a total body of knowledge, but an integral system, in other words, an inseparable unity of its components. So, these parts, the components of the system are subordinate to the whole, that is, to the system, but the optimality of the system does not coincide with the optimality of each element separately. The properties of the system are integrative, they are not reduced to just the total

of all the properties of its elements. Those qualitatively new properties characterizing the system as a whole are absent in any of its elements separately. And only the internal interaction of elements creates a system in all its identity. At the same time, the elements are characterized by relative independence within the system itself, and the scope of such independence depends both on the content nature of the system itself and on the specific aspect of its consideration in each individual case [14]. But in ecology there are often situations when a new scientific discovery can significantly change the idea of the relationship of certain elements and this changes the idea of the system as a whole. By the way, this can be observed in other areas of science as well, although much less often.

It should also be noted that in research activities there is often a situation of relativity of the system status of certain objects, phenomena of reality. That is, what is a system in one respect, can in others be a subsystem or even an element - depending on the scale of the studied phenomena, goals and levels of their analysis. In this case, various system-forming factors can be taken as a basis. This provision is necessarily related to the problem of the structure of system objects. That is, the system approach is closely related to the structural approach. After all, the structure is often understood as the order of elements in the system, the law, the nature of the relationship between its elements. The process of studying any system involves penetrating into its structure, analysis of the methods of internal communication of all its structural elements and levels.

The structured approach is supplemented by a functional one, which is aimed to study the functioning of systems. It is the functioning of systems that is of particular importance for a researcher. The structure of the system is a condition and a means of implementation of its specific functions. That is, one or another function of the system is associated with its specific structure. In practice, this relation should be aimed at optimization of system functioning. The relation between structures and functions is not static. Therefore, the question about the relation between the functioning and development of systems arises here. If the functionality reflects the stability of the system functions, then the development means a change, the emergence of qualitatively new states. But not every change is the development, and so other more complex additional research is required [15].

So, these two methods are interrelated and act as two sides of a single systematic and structured approach. But the system is dynamic, and the structure, which is usually not described by formulas, is static, and each of them dominates in the corresponding study. In some cases, emphasis is placed on the systemic nature of the phenomena studied, in the others - on the structural aspect of the study.

It should also be noted that, in ecology, most phenomena are not strictly deterministic in nature, but, on the contrary, flexible, and are influenced by many factors. Therefore, an important place in the study of environmental processes belongs to the probabilistic approach, which greatly clarifies and enlarges the results of research activities. This approach determines the probability of certain phenomena based on

knowledge of a certain set of already known factors that are interrelated, but this is when it comes to an open system, and here not all factors can be detected. Further, in a similar way to the statistical processing functions, as well as other probabilistic principles, it is possible to predict the missing links. And the probabilistic approach does a kind of predictive function.

The modeling principle has a certain value in research activity in ecology. Each phenomenon can be modeled in many ways. Models can be either material (physical) or ideal (logical). It depends on the object specifications. Usually, logical models prevail. The principle of modeling is based on meaningful analogies between the model and the object of modeling, when heuristic orientation is given to these analogies. A disadvantage of this approach is the limited simulation of certain properties of the object being studied, the inability to simulate a sufficient number of links of the object being modeled, which is associated with significant errors. But in some researches, it gives quite significant results, does a predictive function [16].

So, all the above mentioned research approaches are studies only in general. However, in our opinion, such an analysis already allows us to express some general conclusions of practical significance.

IV. CONCLUSION

In conclusion, it should be noted that research, scientific approaches are constantly being developed, changing, being filled with new content. This process can never be considered complete. An important factor is their organic internal relation with each other, which is especially evident in the study of the directions that lie at the junction of several problems. Moreover, they are so interrelated that often their very distinction becomes more relative. Each approach discussed above is one-sided. Here, only one side of phenomena is studied, even if it is important (systematic, structural, functional, probabilistic, modeling, etc.). Hence the conclusion that any of the considered research approaches, taken in isolation from other methods, cannot be sufficient for the study of any environmental object. Only in interaction with other forms of knowledge, research, they become adequate and effective forms of studying environmental reality. On the other hand, the process of differentiation is also significant when analyzing environmental processes. Such an approach is justified and expedient, since it allows to concentrate the attention of a researcher on a certain, rather narrow direction, and this is often necessary. As a recommendation, it is proposed to intensify the use of information technologies when using the above approaches in ecology.

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