Substantiation of Ecological Safety Criteria in Construction Industry, and Housing and Communal Services

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Abstract. In the article the authors attempt to determine the construction industry’s ecological safety criteria. The authors provide an integrated methodological substantiation for ensuring ecological safety in construction. They consider the ecological monitoring system, the criteria and conditions for implementing this system, and the principles of ecological monitoring laid down in ecologically-oriented standards. An analysis of the ecological monitoring system at all stages of the construction product life cycle shows that the confusion prevailing in the regulatory departments impedes the development of ecological investments in construction projects. Therefore, it is necessary to establish an independent structure focused on environmental protection. By transferring maximum power to this new structure it will be possible to quickly solve problems related to ecological monitoring as part of the movement towards the country’s balanced development.

1. Introduction
At all stages of the construction product life cycle, overt direct impacts (harmful emissions, waste generation, etc.) and indirect effects (influence on human health, quality of the environment, etc.) are assessed. The significance of indirect effects on the environment due to construction is growing, especially over the long term [1]. Given that investment in construction projects affects the quality of the environment, the authors see an ecological monitoring system as an effective means of environmental management because it systematizes and analyses information on the state of the environment, on the causes of observed and probable changes in its quality, on the admissibility of changes and loads on the environment as a whole, and on existing eco-system reserves [2].

The authors believe that sustainable development encompasses a balanced economic, technological and social state of individual territories while preserving a life-sustaining environment in the country. It should be noted that a solution lies in the process of creative, rather than destructive, interaction between the community and nature, while restricting applications of architectural and civil engineering solutions and construction technologies that do not satisfy the specific features of the territories. Lack of such restrictions will lead to drastic alterations in the landscape and to the violation of ecological and economical sustainability. In other words, the destruction of the natural environment will result in a loss of the structural standards properties and functions of the territory; the natural resource potential will change and natural landscapes will be replaced with anthropogenic ones. Therefore, the ecological monitoring system presupposes carrying out the following: assess indicators of state and functional integrity of eco-systems and human habitat; identify the reasons for changes in these indicators; predict the consequences of such changes; define corrective measures in those cases when ecological targets are not achieved; consider prerequisites to determine measures for correcting resultant negative situations before any damage is inflicted. There is really just one goal: to create a favourable environment to sustain the lives of people and business, which could become the foundation for supporting the health and working ability of the general public and balanced economical development.
of the country as a whole \[3\]. In connection with the foregoing, the authors consider an integrated, methodological substantiation for providing ecological safety in the construction industry, study the ecological safety criteria for the construction industry’s sustainable development and the ecological and economic balance as a whole, and analyze the ecological monitoring system, and the criteria and conditions for its implementation.

2. Materials and Methods

The analysis of ecological safety criteria related to the sustainable development of the construction industry is based on identifying system-level ecological and economic processes (as regards a method of ecological balance). In their scientific rationale, the authors adhere to the well-tested Meadows group dynamic model. It is based on the premise that mankind has already exceeded the limits of self-sustainability of Earth’s eco-systems. With a significant growth in the population, favourable scenarios for ecological and economic balance have become unattainable. The consumption of natural resources and the destruction of the environment are leading in more and more unpredictable ways to an extremely grim (basic) scenario. The time for implementing favourable scenarios has been irrevocably lost \[4-5\]. Meadows emphasizes that without a significant change in people’s consumption of natural resources, disastrous changes will inevitably occur in the near future. Meadows’ sustainability model \[6\] assumes five basic indicators: 1) accelerating industrialization, 2) population growth, 3) threat of food shortages, 4) depletion of resources, and 5) environmental deterioration.

The principles of ecological safety and stability presented in the book by B. Commoner \[7\] are significant for this analysis. We briefly review these in the context of forecasting innovative ecologically-friendly technologies. Commoner emphasizes that the least change in nature introduced from outside may entail an avalanche-like destruction of natural systems. For instance, what has happened to the Aral Sea is a real ecological disaster. The excessive withdrawal of water for irrigating agricultural lands has turned the world’s fourth largest lake-sea, once rich in life, into a barren desert. Commoner also talks about the law of redistribution and cycle of elements, which should constitute a closed cycle in the eco-system (producers, decomposers, consumers); however, humans have synthesized hazardous chemicals that do not exist in nature (DDT, polypropylene, polyethylene, etc.). These compounds do not enter the natural process of redistribution. Technological systems have forced people to face the problem of waste disposal. This is why the subject of waste-free production, greening industry and agriculture is so relevant. Commoner considers this principle to be fundamental for sustainable development: nature is perfect. Activities that transform the environment should be carried out with extreme caution; any unnatural changes in the eco-system will inevitably bring about irreversible changes. Development that does not meet ecological safety goals will require payment in one way or another. Anything new necessarily replaces the old in the eco-system. This is the price nature pays for evolution. Human activity, however, disturbs the natural course of events, introducing alterations that are alien to the eco-system. Commoner refers to these as the “bill” payments. Thus, the application of genetically modified foods (GMO) has resulted in our paying with our health for consuming it. Moreover, the self-amplifying destruction process of natural organisms is accompanied by degradation of the immediate environment for human life.

The authors also find the sustainable development model created by N.F. Rejmers significant for the methodology. It is aimed at scientifically substantiating nature conservation and ecological safety in technogenic zones. Cost-cutting in environmental protection and ecological safety results in a considerable deterioration in human health, negative anthropogenic processes and a decline in favourable living conditions. If before socio-economic adaptation followed environmental changes, then now it should precede them, since nature, including humans as biological creatures, have no safety margin left \[8\]. It is also important to consider the fundamental significance of the second biogeochemical law of V.I. Vernadsky \[9\] stating that a migration of chemical elements takes place in the biosphere with the mandatory direct or indirect participation of living organisms. Any loss in the composition of living matter will trigger a landslide destruction of the entire biogeochemical system. The quality of construction directly depends on the correct formulation and solution of ecological problems and continuous assessment of environmental impacts at all stages of the project life cycle. The intensity and diversity of these impacts have in many respects already exceeded the rate of adaptation and sustainability of natural systems. Once again, the natural resource potential should not be less than the level at which resources are withdrawn or the rate of change in people’s living environment. In the
context of environmental protection, it makes sense to talk about the investment attractiveness of ecological constructions, whose facilities should be regarded as innovative products with characteristic features [10]. The authors think that, taken together, such innovative principles allow us to assess the ecological safety of engineering solutions, development options for territories, and investment and construction activities in order to minimize the technological impact on eco-systems, timely identify any dangerous development potentials and forecast optimal sustainability options [11-12].

3. Results
The principles and methods for monitoring the environment are described in ecologically oriented standards. ISO 14000 is one of these standards. According to this standard, a construction company must develop its ecological policy and conduct documented monitoring and measurement procedures based on the characteristics of production processes and their ecological aspects. The standard takes into account the environmental impact of extracting raw materials, manufacturing construction materials, the construction itself, demolition, and disposal of construction waste or recycling [13-14].

In order to overcome the drawbacks of traditional construction, a number of “green” standards has also been developed, based on the principles of sustainable development and providing safe, favourable conditions for human life and an acceptable level of environmental impact, while taking into account a wide range of interests: BREEAM (Building Research Establishment Environmental Assessment Method), developed by BRE Global company; LEED (Leadership in Energy & Environmental Design) offered by the U.S. Green Building Council (USGBC); and DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen), presented by the German Sustainable Building Council in support of “green” construction. All of these contribute to expanding business, hi-tech production, innovations, and information telecommunication technologies, and improving the state of the environment. Thus, the mandatory requirements of the LEED system are aimed at the construction of eco-friendly, economically- and energy-efficient buildings and entire districts suitable for living by using biopositive architectural and planning design solutions (see table 1) [15].

| No. | LEED requirement                                      | Explanation                                                                 |
|-----|-------------------------------------------------------|----------------------------------------------------------------------------|
| 1   | Reduced pollution from construction activities       | To be implemented at the early stages of construction. It is practically impossible to obtain a certificate for constructions not initially planned for LEED |
| 2   | Reduced water consumption                            | This criterion sets rigid requirements for the use of energy-efficient plumbing |
| 3   | Commissioning energy-saving systems in the building  | To be implemented at the early stages of design. It is practically impossible to receive a certificate for constructions not initially planned for LEED |
| 4   | Minimum energy-efficiency requirements               | This criterion assumes compliance with the requirements of American energy-efficiency standards for buildings (ASHRAE) that have strict standards for equipment in HVAC systems, thermal conductivity within enclosed structures, airtightness of building and systems |
| 5   | Air conditioning management                          | This criterion dictates requirements on the use of Freon-containing refrigerants |
| 6   | Collection and storage of secondary resources        | This criterion requires the organization of separate waste collection and site for storing recyclable materials |
| 7   | Microclimate quality                                 | This criterion standardizes the levels of air exchange in the building |

DGNB assesses the entire life cycle of the building in accordance with more than 50 criteria, grouped into six quality categories: environment, economic efficiency, socio-cultural and functionality, technical equipment, process, and site. A rational strategy for investor developers planning to operate real estate
is to increase capital spending in order to minimize operating costs in the long term. This approach assumes consideration of the whole life cycle of the building, an assessment of investments in ecological construction and its return within the period of operation. “Green” construction has a synergetic effect, which is manifested when ecological, economic, technological and other effects complement and amplify each other, creating an overall effect that is many times quantitatively and qualitatively superior to the effects of the separate factors involved in the economic process. Biopositive construction projects generate conditions for a balanced and sustainable relationship between the eco-system and construction economics in a changing environment and internal transformations [16].

Loss of sustainability can occur for the following reasons: changes in system parameters (bifurcation); presence of external influences; disturbance in connections (of the structure) in the system. In light of this, we consider the basic criteria for ecological monitoring in order to preclude irreversible natural processes. These criteria are: continuity over time, unlimited space, reliability of information to ensure accurate assessment, smart-response; and the necessary authority to make decisions. Continuous assessment guarantees that the ecological situation is under control. In order to continuously test the state of the environment associated with the construction facility, a monitoring system is required that will: identify the facility being monitored over time, along with its location, borders, and externally induced problems; then, conduct an initial survey of the facility by way of short-term spot checks, specifying pollution indicators; identify points or zones for further investigation in regard to the integrity of the biotope territory and impact of construction on the ecological safety of the biotic community; establish an information model of the facility being monitored long term with a comprehensive forecast of the possible negative environmental impact from construction activities (when there is a risk that the situation will deteriorate, but before irreparable damage); plan an experiment (as a result of a timely response) to study the state and dynamics of the facility being monitored in order to collect data on possible deviations from the normal value and ensure proper monitoring of the environment and protect it from the anthropogenic impact of construction. Thus, an ecological safety assessment system constitutes the long-term (systematic) observations of the facility and assessment of its condition as a whole, forecast of changes in its quality with an information model (GIS) using stochastic approximation and recurrent assessment methods, approbation of experimentally obtained empirical data depending on expected changes in external conditions, processing and providing the most complete information in the public domain and bringing it to the consumer’s knowledge through innovative methods and scientific research [17].

4. Discussion
The relevant powers of an organizational structure involved in the ecological monitoring system could pertain to the implementation of a complete closed cycle facility assessment, from conducting an evaluation by experts to the suspension of construction due to violation of laws, standards, rules, and instructions, disregard of obligations related to environmental protection, deliberate violation of ecological legislation and natural resources management, abuse of authority, etc. At present, numerous government departments and agencies engage in the functions of environmental monitoring and compliance with legislation, etc. (table 2).

Ecological violations are most frequently connected to the construction industry and require immediate response. Yet, because of the confusion within the departments, the environment cannot be fully protected in all of these cases. A functioning ecological monitoring system involves efficient management of the assessment system, continuous monitoring, accurate information, and prompt response to possible deviations from the regulations. However, such a unified approach to the development and implementation of environmental monitoring programs becomes impossible since each department and sub-department operates only within their own field of information and possesses limited powers. According to N.F. Rejmers, in the current regime of ecological stress, all spheres of society should be subordinated to the requirements of ecological policy. Science, politics and ideology should become a unified tool for cultivating the worldview at the ecological stage of societal development [8]. In this context it is necessary to establish an effective, independent (non-departmental) control authority, endowing it with the power to implement a unified scientific and technical policy in the field of ecological monitoring. The activities of this institution will be related to: coordination of the development and implementation of environmental monitoring programs; regulation and control of
collecting and processing reliable data; storage of information, maintaining special databanks and coordinating them with international environmental information systems; assessing and forecasting the state of the environment, natural resources, eco-system and human health responses to anthropogenic impacts; and making the integrated ecological information accessible to a wide range of consumers. Determining the amount of necessary capital investments that business, including investors in the construction industry, could allocate to preserving Russia’s eco-system remains an urgent task for future research.

Table 2. Departmental distribution of functions within the framework of the Unified State System of Ecological Monitoring (USSEM).

| Federal authority | Functions |
|-------------------|-----------|
| Ministry of Natural Resources and Environment of the Russian Federation | Coordinate activities of the Ministries and departments, enterprises and organizations in the field of environmental monitoring, organize the monitoring of sources of environmental impact and areas of direct impact, organize the monitoring of animal and vegetal life and terrestrial fauna and flora (except forests), ensure the establishment and functioning of ecological information systems, maintain databanks on the environment, natural resources and their use with interested Ministries and departments |
| Federal Service for Hydrometeorology and Environmental Monitoring | Organize the monitoring of the state of the atmosphere, land surface water, marine environment, soil, near-Earth space environment, and integrated background and space monitoring of the state of environment, coordinate the development and functioning of departmental subsystems for background monitoring of environmental pollution, maintain a government data fund on environmental pollution |
| Federal Subsoil Resources Management Agency | Monitor subsoil resources (geological environment), including subsoil waters and dangerous exogenous and endogenous geological processes |
| Federal Forestry Agency | Monitor forests |
| Federal Agency for Water Resources | Monitor the aquatic environment of water management systems and structures at points of water intake and sewage discharge |
| Federal Geodesy and Cartography Agency | Implement topographic-geodesic and cartographic support of USSEM, including creation of digital and electronic maps and geographic information systems |
| Government Authority for Technical Supervision | Coordinate the development and functioning of subsystems for monitoring the geological environment related to the use of subsoil resources at extractive industry companies, and monitor industrial safety (except facilities belonging to the Russian Ministry of Defence) |
| Ministry of Defence of the Russian Federation | At military facilities, monitor the natural environment and sources that impact it, and provide USSEM with dual-use military devices and systems |
| Ministry of Agriculture of the Russian Federation etc. | Ensure the establishment and functioning of the departmental system of environment monitoring. |
| etc. | Transferring maximum authority to an independent structure focused on environmental protection, and quickly solving emerging problems, remains an urgent task for implementing the most important ecological requirement: to balance the rate at which the ecosystem is being exploited with the intensity of its recovery. The natural resource potential should be equal to or exceed the level of resource withdrawal and rate of change in the life support environment. |
5. Conclusions

Finally, the scientific fundamentals of environmental monitoring are to quickly provide the environmental safety system with up-to-date and reliable information, which makes it possible to structure observation, diagnostics and warning while employing the latest technologies and maintaining a holistic vision of the surrounding world. In Russia, the anthropogenic load on the environment continues to grow, and the development of the construction industry with its growing rate of demand for raw materials, despite the declared ecological efficiency, does not meet the sustainable development objectives. Desertification and deforestation are increasing, and problems of urban smog, climate change, depletion of the ozone layer, biological resources, etc., have not been resolved. Urbanized areas are under constant human impact on the eco-system, which is rapidly deteriorating. The overall condition of such areas is critical, and in some places catastrophic. The eco-system’s response to untenable environmental management and anthropogenic pressure has been the depletion of the ecological reserve needed for the balanced and sustainable development of the country. The greening of the construction industry is slow in our country. The departmental confusion, poor management culture, and technocratic thinking obstruct the practical solution of many ecological issues. This analysis of environmental safety criteria in the context of sustainable development of the construction industry has demonstrated that it is necessary to establish an independent structure focused on environmental protection. Transferring maximum powers to this structure will help solve ecological problems quickly, especially in the construction industry.

References

[1] Larionov A and Nezhnikova E 2016 Energy efficiency and the quality of housing projects ARPN J. of Eng. and Appl. Sci. 11(3) 2023–29
[2] Smirnova E 2012 Ohrana Okruzhajushhej Sredy i Osnovy Prirodopol'zovaniya [Environmental protection and environmental management] (Saint Peterburg: SPbGASU) 48 p
[3] Smirnova E and Zaikin V 2019 Problem of urban planning for sustainable development E3S Web Conf. 91 05030
[4] Meadows D H, Meadows D L and Randers J 1995 Beyond the Limits: Global Collapse or a Sustainable Future (London: Earthscan) 300 p
[5] Meadows D H, Randers J and Meadows D L 2006 Limits to Growth. The 30-Year Update (London: Earthscan) 338 p
[6] Meadows D H, Meadows D L, Randers J and Behrens W 1982 The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind (New York: Universe Books) 205 p
[7] Commoner B 2020 The Closing Circle: Nature, Man, and Technology (Mineola, New York: Dover Publ.) 326 p
[8] Rejmers N F 1992 Nadezhdy na Vyzhvanie Chelovechestva. Konceptual'naja Jekologija [Hopes for the survival of mankind. Conceptual ecology] (Moscow: Rossija molodaja) 367 p
[9] Vernadsky V I 2012 Biosphere and Noosphere (Moscow: Airis-Press) 576 p
[10] Larionov A and Nezhnikova E 2016 Role of energy efficiency in improving the quality of housing projects Intern. J. of Appl. Eng. Resear. 11(11) 4433–39
[11] Smirnova E and Gorohov V 2019 Monitoring i Obrashhenie s Othodi v Megapolisah [Monitoring and waste management in megacities] (Saint Peterburg: SPbGASU) 113 p
[12] Larionova Yu and Pavlova S 2014 Features of housing and solving the housing problem in Russia Life Sci. J. 11(12s) 650–53
[13] Hillary R 2017 ISO 14001: Case Studies and Practical Experiences (London: Routledge) 384 p
[14] Affam A C and Ezechi E H 2020 Handbook of Research on Resource Management for Pollution and Waste Treatment (Hershey: IGI Global) 795 p
[15] Zhukovsky S, Surkov A and Kychkin A 2017 Aspekty issledovaniya razvitija vysokotekhnologichnoj gorodskoj sredy [Topical aspects of sustainable development of high-tech urban environment] Vestnik PNPIU. Prikladnaja jekologija. Urbanistika [PNRPU Bul. Urb. Dev.] 11 80–92
[16] Smirnova E 2018 Control capability of environmental safety in the context of ’green' construction paradigm Espacios 39(22) 040
[17] Slesarev M., Telichenko V and Nguyen D 2018 Formation of innovative methods for ecological safety systems of construction MATEC Web of Conf. 251 02010