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# Principles of Ecological Monitoring of Agricultural Lands

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**Abstract.** The article discusses the special aspects of ecological monitoring of agricultural land in current conditions. At the present day over 3.5 million hectares of the reclaimed lands in Russia are in an unsatisfactory meliorative state with secondary salinization, solonchization of soil, erosion, flooding of lands with groundwater, etc. Monitoring is oriented to ensuring environmental sustainability of geological systems of river basins and landscapes to agricultural and water reclamation impacts. As the monitoring objects, reclaimed and adjoining lands, soils, underground and surface waters, reclamation systems are considered. The principles of ecological monitoring organization of reclaimed agricultural lands have been determined, an algorithm and technology for its implementation have been developed.

## 1. Introduction

Increasing the economic efficiency of agriculture and its sustainability in Russia requires the development of integrated land reclamation. Currently, the area of reclaimed agricultural land in the Russian Federation is 9.1 million hectares, of which 4.3 million hectares for irrigated land, and 4.8 million hectares for drained land. Unfortunately, at the present day a considerable part of the reclaimed lands (over 3.5 million hectares) is in an unsatisfactory meliorative state. More than half of the irrigation systems (over 2.4 million hectares) need to carry out reconstruction and technical re-equipment and other activities. The unsatisfactory meliorative state of the lands is determined by the development of negative ecological processes, such as secondary salinization, solonchization of soil, erosion, flooding of lands with groundwater, etc. The widespread development of these processes leads to gradual desertification of lands.

The modern approach to the justification of land reclamation and water management measures in agriculture involves prevention of possible negative consequences of interference in natural processes, preservation of a favorable ecological situation on agricultural lands, rational use and protection of water resources from depletion and pollution. The development of land reclamation and water use to improve the efficiency of agriculture should be adapted to the current and projected changes in the zonal climatic conditions caused by global warming.

One of the main sources of information for decision-making on the development of agriculture, land reclamation, construction and reconstruction of land reclamation systems is the State Environmental Monitoring, within which monitoring of agricultural land, including reclaimed land, is carried out [1].

Studies on the issues and methods of monitoring of the meliorative state of irrigated lands were carried out at All-Russian Research Institute of Hydraulic Engineering and Land Reclamation named af-



ter A.N. Kostyakov in the 1970s and 1980s under the scientific supervision of D.M. Katz. Later, the methodological issues of environmental and meliorative research, the justification of the indicators of environmental sustainability of natural systems in land reclamation and the estimated risk assessment as well as monitoring issues were researched in the works of N.I. Parfenova and N.M. Reshetkina, F.R. Zaydelman, S.D. Isaeva, V.I. Olgaarenko, G.V. Olgaarenko, V.N. Rybkin and others [2-8]. For the past period, there have been significant changes in the economic and regulatory legal fields of agriculture, melioration, and a system of state environmental monitoring has been established. Therefore, there was a need to improve the methodological aspects of reclaimed agricultural land monitoring.

In modern interpretation, ecological monitoring of reclaimed agricultural lands is focused on providing an environmentally sustainable state of geological systems (geosystems) of landscapes and river basins, favorable land reclamation conditions through regulating of the groundwater regime and water-salt regime of soils, on creating conditions for obtaining high and sustainable yields of agricultural crops regardless of natural conditions.

Agriculture in Russia is currently complicated by global climatic changes, manifested in aridization of conditions in the south of the European part of the country and in Western Siberia, and in increase of water availability in a number of regions in the north and the Far East [9,10]. Since the current and predicted changes affect all components of the climate system, shift the radiation, hydrological, temperature regime in the regions, then the factors of the development of natural and man-made processes and, accordingly, the regional patterns of hydrogeochemical flows in landscapes formation that determine the features hydrogeological, hydrological and soil processes are also affected. Zonal indicators of ecological stability of landscapes and river basins also change. Therefore, the importance of ongoing monitoring in order to obtain the necessary information increases. We need up-to-date information on monitoring data for operational management of the situation, for scientific support of decisions on strategic issues of agricultural production development, land reclamation, water supply, soil fertility conservation in new climatic conditions [11,12].

The monitoring focus on ensuring the environmental sustainability of river basins of landscapes and their components identifies the need for observations both for indicators and factors that determine the ecological state of natural systems and the danger of development of environmentally unfavorable processes in monitoring reclaimed lands [3,4,8,10]. Therefore, ecological monitoring of reclaimed lands is considered as a complex system that involves observations of the condition of reclaimed and adjoining lands, soils, ground waters and surface, meliorative systems for estimating and forecasting changes in their condition under the influence of natural factors, agricultural use, water use and melioration. Monitoring is carried out at the intersection of interdepartmental systems of environmental monitoring: state of land, state of subsurface resources, and monitoring of water objects, which implies broad involvement of data from adjacent subsystems of state environmental monitoring. Particular importance in the system of ecological monitoring of reclaimed lands is the mandatory involvement of monitoring data on soil fertility carried out by the agro-chemical service and other organizations. Data in this category provide the basis for additional operational observations or case studies in the monitoring system for reclaimed land.

Based on many years of experience in monitoring the reclamation status of irrigated and drained lands and modern requirements for environmental monitoring, it seems that the organization and monitoring of reclaimed lands should be based on the following principles.

1. It is necessary to have a scientific justification for the monitoring program, which requires the joint participation of hydrogeologists, soil scientists, meliorators, hydrologists. Indicators and methods for assessing the meliorative state and environmental sustainability of geological systems of landscapes and river basins, methods and choice of models for forecasting their dynamics, analysis of monitoring results for decision-making on management of land reclamation and water management in agricultural lands – all of these aspects require scientific evidence.

2. The variety of monitoring objects (groundwater, soils, etc.) defines an interdisciplinary approach to monitoring. Joint participation of specialists in hydrogeologists, soil scientists, meliorators, hydrologists, etc. is necessary in the formation of a monitoring program, (the definition of goals, objectives,

methods of observation, the choice of objects of observations, indicators, factors), when processing and using its results (scenario research and forecasts of the ecological state of landscapes, planning actions to reduce and prevent environmental risks).

3. The relevance of the ecosystem approach in monitoring planning, that determines its focus on ensuring an environmentally friendly and sustainable state of geological systems in land reclamation and water management activities. Activities should be based on monitoring results, taking into account environmental constraints and permissible values of indicators of the state of reclaimed lands.

4. Monitoring of reclaimed lands should be integrated into the agricultural land monitoring system, take into account other subsystems of the State environmental monitoring (monitoring of subsurface, atmosphere, water objects, soil fertility).

5. Comprehensive simultaneous observations on reclaimed lands are required to assess and predict the state of surface and groundwater, reclaimed lands, soil cover.

6. The information that is received in the process of monitoring reclaimed land must be reliable.

7. Monitoring has a practical focus, and also involves obtaining the results that are necessary for the development of fundamental concepts, methodological provisions and technologies for studying hydrogeological, soil and meliorative processes in reclaimed and adjacent lands.

Environmental monitoring of reclaimed lands requires a certain algorithm of work. Based on the proposed principles of monitoring, a technology for its implementation has been developed. Monitoring technology includes the following stages: design, observations, assessment of the current state of monitoring objects, forecasting, making operational decisions (management) to ensure favorable environmental conditions on reclaimed agricultural lands. The technology has been reflected in the developed methodological recommendations for environmental monitoring of reclaimed lands for the irrigation zone. At all stages, as noted, it is of great importance to involve specialists in hydrogeologists, soil scientists, meliorators from specialized zonal scientific organizations in interaction with the service of exploitation of meliorative systems that organizes monitoring.

The project stage includes substantiation of the work, the monitoring program, the register of measured indicators for monitoring objects, statistical justification of the observational network formation, determination of the types, volumes, periodicity of observations, the role of remote, aerospace methods in monitoring, the analysis of the possibility of attracting GIS for formation of databases, fulfillment of forecasts, etc.

In carrying out observations, in addition to regular spatial surveys, a special role is assigned to research at landfills and key sites. The polygons are designed to study the regularities in the development of hydrogeological and soil processes, the scientific and methodological justification for monitoring, the studies necessary to justify the decisions taken to manage the land reclamation state. The most urgent aspects are the management of irrigation regimes, the prevention of the processes of raising the level and flooding of lands, the pollution of surface and groundwater by nitrates, pesticides and other elements, the adverse changes in the water regime of landscapes during the selection of groundwater by water intakes, drainage, etc. In addition, polygons are necessary for approbation, annual calibration of remote sensing methods depending on natural and man-made conditions, selection and adaptation of predictive models of mass transfer. To determine the parameters that are necessary to perform predictive calculations, a network of representative key areas is justified and set.

At the stage of collection and processing of information, a database of primary information is formed, statistically processed; graphic models are created with the involvement of GIS technologies. As a result, an information model of reclaimed lands as a management object is created. The model allows us to proceed to the stage of assessing the state of reclaimed lands based on the justification of evaluation criteria, taking into account the zonal features of the territory. On the basis of the information model, the type and indices of environmental risk are identified, as well as the estimated risk of development of environmentally unfavorable processes according to established criteria. The assessment of the condition of reclaimed lands and ecological risk allows to pass (if necessary) to the adoption of operational decisions. To prevent environmental risks realization, it is planned to carry out operational measures to regulate the operating regime of irrigation canals, to correct irrigation standards,

to provide the meliorative system with the required water resources, etc. Monitoring materials are used for justification of strategic decisions on the development of land reclamation and water management at the regional level, to improve the water availability of the regions.

Ecological monitoring of reclaimed agricultural lands is focused on ensuring the ecological sustainability of river basins, landscapes and their components, which determines the need for observations both for indicators and factors that determine the ecological state of natural systems and the danger of development of environmentally unfavorable processes. Within the framework of environmental monitoring of reclaimed lands in the context of ongoing regional climate changes the importance of constant observations and forecasts is increasing to justify operational land improvement measures and soil fertility measures, as well as long-term scientifically-based planning of agricultural development, water use, and effective use of meliorative measures.

The effectiveness of monitoring depends largely on the principles of its organization and management. Fundamental principles include the obligatory nature of the scientific substantiation of works, the interdisciplinary and environmental approach in the planning and implementation of monitoring, the complexity of the observations necessary for assessing and forecasting the state of all monitoring objects, ensuring the reliability of the information obtained. Monitoring should have not only a practical focus, but also include observations which results are necessary for the development of fundamental concepts and methodological provisions of meliorative hydrogeology, meliorative soil science and meliorative science in general.

## 2. Conclusion

The developed algorithm for performing the work, which is the basis of the technology of ecological monitoring, provides information on the state of reclaimed lands, soils, water bodies and its changes, processing information and presenting the collected data in the form of a complex information model (a set of cartographic, mathematical submodels), which is necessary and sufficient for making decisions on management of land reclamation and soil fertility in order to minimize possible environmental risks in agriculture and to create conditions for obtaining high and sustainable crop yields regardless of climatic conditions.

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