The use of geographical information systems (GIS) for monitoring water bodies

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Abstract. The article is devoted to the use of geographical information systems (GIS) for monitoring water bodies. At present, considerable attention is paid to the use of geographic information systems for monitoring water bodies. The relevance of the study is due to the need to improve the method for applying geographic information systems for effective monitoring of such objects. Theoretical and methodological foundations of development and functioning of geographic information systems of water bodies were analyzed. The regulatory framework for the development of geographic information systems for water bodies was analyzed, and proposals on possible improvements of the mechanism for developing GIS water bodies were made.

1. Introduction
In the modern digital world, information needs are growing. They affect the vast majority of human activities. All data is changing and lose their relevance. Their further use does not meet current needs of the modern market, especially when monitoring activities water bodies. It should be noted that coastal areas are the most important and intensively used areas inhabited by people, therefore preservation and maintenance of the regime of coastal areas is a dominant factor for maintaining a favorable environmental situation. Monitoring of the coastal areas and water bodies continues to be one of the most acute problems in the whole world and Russia.

The relevance of the study is due to the need to get relevant information, process it and analyze monitoring data. The GISs consists of a significant number of both graphical and thematic databases, which are connected with calculation functions for further converting the available data into spatial information for the purpose of subsequent management decisions.

2. Materials and methods
In Russian and foreign publications, including the works by A.A. Mayorova, A.P. Sizova, V.B. Nepoklonova, D.A. Shapovalova, A.V. Materukhina, Bystrova A.Yu., the issue of the use of GIS for monitoring water bodies was not fully developed, which motivated the study, whose results are given in this paper [1].

In the article by A. Mukasheva, the author analyzes modern water legislation in the field of regulation of water protection zones, as well as strips of water bodies and water facilities. The authors consider it necessary to bring the existing water legislation in line with the aim of further eliminating conflicts, contradictions and differences, as well as implementing these provisions, determining the width of the water protection strip and the coastal strip [2].
In his article, Bystrov notes that monitoring of water protection zones is an important and complex task requiring the use and analysis of a significant amount of different spatial data. Modern GIS allow the integration and analysis of existing monitoring data, as a means of supporting management decision-making. The emphasis is on factors which determine the peculiarity of a monitoring method. The main data sources are Earth remote sensing data and crowdsourcing. Modern features of the geoinformation monitoring systems used for water protection zones and main stages of remote sensing data processing are analyzed. A combined monitoring methodology for such territories is described [3].

Bystrov and Mayorova emphasized that the current level of development of geospatial technologies allows users to monitor various territories, including water bodies, but the specifics of water protection zones requires to take into account all the factors influencing them, including legal activities. The paper proposes an up-to-date conceptual model of a monitoring system for water protection zones, based on the integration of heterogeneous data and refinement of results using materials obtained from UAVs and operational field collection methods. To assess the condition of the territory, a specially developed algorithm for determining current violations in the water protection zone is used [1].

3. The study of modern technologies for monitoring water bodies
Modern monitoring technologies are the basis for the geographic information support. They make it possible to obtain the entire spectrum of information of the studied area, namely water bodies. However, an analysis of existing technological solutions and methods shows that they have a number of disadvantages associated with the low efficiency of violation detection, the local nature of works and the low level of automation.

![Figure 1. The flow chart of monitoring water bodies using GIS](image_url)
The alternative flow chart for monitoring water bodies (without the GIS)

The main process of creating a GIS for monitoring water bodies with its stages is presented below: development followed by approval of a business plan; analysis of regulatory documents on the creation and operation of the GIS for monitoring water bodies; development of technical specifications and its approval; technical design; development of documents: GIS operational documentation for monitoring water bodies; database projects; testing of the system, including preliminary testing, further trial operation, acceptance testing and final commissioning.

The developed GIS for monitoring water bodies can filter the following categories: layers (types of objects); rights. The description of the GIS for monitoring water bodies is as follows: an access to the system via the Internet; the GIS is aimed at providing information, supporting the adoption of managerial decisions; monitoring of water bodies; data input is carried out automatically using the analysis and structuring of data from XML files (table 1). It also provides for manual data entry by entering data in the appropriate field [4–6].

At the same time, the main advantage of this system is its accessibility, ease of operation, and possible adjustment of the functional for specified purposes (Fig. 1.2).

After comparing the methods for monitoring water protection zones of rivers and reservoirs, we can conclude that the use of GIS is much more convenient for fulfilling the tasks.

A significant advantage is that the use of GIS technologies will significantly increase the accuracy of assessing the status of water protection zones, increase the speed of managerial decision-making and reduce the number of errors compared to the results of the work of existing water systems.
Table 1. Advantages and disadvantages of the methods

| Criterion                                      | Using the GIS | Without the GIS             |
|------------------------------------------------|---------------|------------------------------|
| Ease of use and training                      | +             | +                            |
| Departments for conducting examinations, making forecasts on the status of water protection territories | +             | +                            |
| Automation of the cycle of obtaining monitoring data | +             | -                            |
| Monitoring of changes in the status of water protection territories | +     | +                            |
|                                              | automatic     | Complex and laborious        |
| Exportation / importation of data into other formats | +             | -                            |
| Recording of water objects                   | +             | +                            |
| Efficiency of receiving information           | +             | -                            |
| Cost of software, licenses                   | Average       | Not required                 |
| Software installation                        | Required      | Not required                 |

4. Conclusion
At the moment, the main part required for the system has been implemented. The advantages of the system are its availability and ease of use, and the ability to add functions. It is planned to add the following functions: entering raster data; downloading aerial photographs of water bodies to obtain operational information about the state of water bodies; exportation of data to other formats; transferring data to other formats for operational interaction with other software systems; interacting with existing databases.

The existing system provides for the prospective development of functions in order to optimize the work and increase the efficiency of obtaining relevant information on water bodies.

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