Cartographic support of the results of geoinformation monitoring of the environment

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SUMMARY

The author's approach to the formation of a system of maps to ensure the results of GIS monitoring of the environment is considered. These are the different types of thematic maps of geo-ecological content. They are selected according to the classification of geographical maps by content. They reflect the state, structure, existing problems, as well as the forecast of the development of relevant phenomena or processes of mapping in space and time within the territories of different spatial levels, etc. in accordance with types of maps by their functionality. It is pointed out that a number of conditions for the construction of GIS environmental monitoring on the basis of GIS software are indicated. The implementation of these conditions generally allows the creation of cartographic works based on the formulated basic principles of mapping. They determine their place and role in GIS monitoring of the environment, as well as are a kind of methodological provisions that outline the content and scope of GIS. The main types of maps that form the system and will provide the results of environmental monitoring are defined inventory, assessment, recommendation and forecast maps in this sequence of their creation by GIS and use for monitoring tasks.

Introduction

Nature management of any form is characterized by certain ecological consequences that lead to changes in the natural environment and, in the ecological situation. The system of nature management is determined by natural, socio-economic and historical factors and directly affects humans.

Reduction of negative impacts on humans, study of the state, structure, development of spatio-temporal forecast, etc. can be done by monitoring. It is a system of continuous observation of objects, phenomena and / or processes occurring in the environment and society, the results of which serve as a basis for the formation of sound decisions to ensure the safety of people and objects of the economy.

An important technical and intellectual component of the environmental monitoring system, which will obtain spatial patterns of distribution of natural and socio-economic factors in the field of nature management, can serve as relevant geographic information systems (GIS). It is a significant innovation achievement, the result of integration of science, technology and technology creation / use of cartographic works with corresponding results.

The development of such GIS will undoubtedly contribute to the implementation of the state system of environmental monitoring, regional environmental programs in accordance with existing and current regulations. In addition, the use of GIS will greatly facilitate access and retrieval of necessary information in relevant databases, which are part of the geographic information support of the environment as a whole, its individual components (in particular, such as aquatic environment, air, soil, biodiversity). This will allow you to form a variety of problem-oriented cartographic models for different tasks that are directly related to the dynamics, assessment, control, examination and forecast of the state of the environment in a given area.

These capabilities of GIS meet the main objectives of monitoring as a multi-purpose information system and define it as geoinformation.

Method and Theory

The main scientific approach to the development of cartographic models as a result of geographic information support and operation of GIS environmental monitoring is a systematic approach, which consists in considering the object of study (environment as a whole and individual components) This is a part of a complex system formed by a number of subsystems functional dependencies and connections within the system, between its individual subsystems. This approach ensures the unity of use of technical, mathematical, informational and linguistic support, their compatibility; determines the methods of research and design of GIS, as well as its structure.

The possibilities of using a systems approach in the development of GIS and mapping for environmental monitoring should be considered in interrelated aspects, namely as: conceptual basis for the creation and application of a single system of the resulting documents; scientific method of application of computer technologies and effective practical organization of monitoring works on the basis of GIS; methodology and methods of developing cartographic models in GIS as a means of geoinformation monitoring.

During the implementation of this study, general and special methods were used, among which the main ones are: analysis and synthesis, which are used to outline the main principles of creating monitoring maps; scientific classification, comparative, mathematical, modeling - for the implementation of the outlined monitoring tasks of GIS; informational, cybernetic - to systematize the primary knowledge about the environment

environment in the form of a GIS database and its use in the methodological scheme of monitoring; geoinformation mapping - for the direct creation of a system of documents in the form of cartographic models, which are visual space-time tools and specific scientific cartographic results of geoinformation support of environmental monitoring at different stages of its implementation.

Examples

The study of the experience of environmental monitoring in Ukraine with a bias towards the use of GIS was carried out by analyzing the existing regulations; scientific publications in the form of monographs, articles in professional journals, as well as other information sources.

The analysis of normative documents (On Environmental Protection, 2020; Provision on the State…, 2019, etc.) in general showed that they contain the formulated framework provisions for the implementation of the State Environmental Monitoring; its structure and levels (national, regional, local); the order of functioning and possible types of support (scientific-methodical, metrological, material-technical, financial). In (Provision on the State…, 2019) it is emphasized that the generalization of information about the state of the environment should be carried out using modern computer technology (without specifying which ones).

The monograph (Bondarenko, 2007) in the context of formulating the theoretical and methodological foundations of geoinformation ecological and geographical mapping of the territory of Ukraine considers the mapping of the results of monitoring the environment as a whole and its individual components, including water, air, biodiversity. But with the increase in the functionality of geographic information software used to create monitoring maps and requirements for them, questions about their types, types, content need further development.

Other monographs are devoted to the peculiarities of monitoring individual components of the environment based on the capabilities of computer tools. In particular, the publication (Pohrebennyk, 2013) considers the development of a measurement and information system (not GIS) for environmental monitoring of a particular component of the environment - the aquatic environment.

The monograph (Mokin et al, 2011) presents the technology of integrating mathematical models into geographic information systems for monitoring surface water as a component of the environment. A set of methods, techniques, algorithms and software that has been tested and implemented in practice to solve important applications in the field of surface water monitoring and modeling of ecological processes in aquatic ecosystems in Ukraine is described.

The main trends in which articles are written in domestic collections of scientific papers are consideration of scientific and technical aspects of GIS creation / use, in particular, general architecture of distributed system for geospatial data processing and presentation of results for environmental and emergency monitoring (Kussul et al, 2010) and features of the component composition of GIS environmental monitoring (Lyashchenko and Patrakeev, 2015).

In general, coverage of geovisualization of monitoring results is limited to the use of the functionality of software products that relate to GIS or perform their individual functions.

Results

Intermediate and final results of environmental observations are traditionally presented in the form of various documents: tables, graphs, diagrams, cartographic models of various types, types and purposes. The latter essentially form the cartographic support of geoinformation monitoring of the environment. They are different types of thematic maps of geo-ecological content. They are distinguished according to the classification of geographical maps by content. They reflect the state structure, existing problems, as well as the forecast of the development of relevant phenomena or mapping processes in space and time within the territories of different spatial levels, etc. in accordance with the allocation of types of maps on different grounds of their typification.

These maps are designed depending on the end user, primarily to familiarize with the natural resource provision of the territory and to help address various negative trends in nature management.

Ensuring geoinformation monitoring of the state of the environment on the basis of cartographic works, provides for compliance with a number of conditions formulated in (Bondarenko, 2007) to build such a system based on GIS using full-featured software: monitoring should be built as a multilevel system, and each of its territorial levels should differ in the generalization of the initial data, systematized in a relational database; the basis of monitoring should be comprehensive remote, ground and underground observations of the state and dynamics of development of nature management facilities; indicators of the state and dynamics of the natural and man-made environment, obtained by different methods, must be consistent with each other; the frequency of observations should depend on the intensity of natural and anthropogenic processes, the more intense and transient they are, the more appropriate it is to choose smaller intervals of observations; for the formation and functioning of the monitoring system it is necessary to organize permanent reference landfills, where

system observations are carried out, the method of modeling and forecasting is developed.
Fulfillment of these conditions in general allows the creation of different types and completeness of cartographic works, understanding the essence and content of which outlines the basic principles of mapping, which determine their place and role in geographic information monitoring, as well as are methodological provisions that define the content and framework application of GIS. These principles also determine the reliability and relevance of monitoring studies.
The principle of *scientific expediency* involves the use of accumulated experience in mapping, as well as known and proven methods and techniques of creating maps. To do this, it is necessary to select qualified personnel and create appropriate information support for the methods already used, techniques, algorithms, programs and results, as well as for the material that provides the current work.
The application of the principle of *territorial coherence* is aimed at determining the ratio of formal and actual territory of the region. If the formal framework can be delineated by administrative boundaries, etc., the actual – only natural or socio-economic features, when, for example, the source of environmental problems is outside the region (transboundary transfer of pollutants, etc.). Cartographically, this can be solved, for example, by displaying adjacent territories or characteristics of connections.
The principle of *modernity* provides for the timely provision of developments with the necessary cartographic information and the use of operational factual data. There are two aspects. The first concerns the natural component, in which the characteristics change relatively slowly and can be entered into the GIS database only once during program execution. The second aspect concerns the data on the socio-economic development of the object with a pronounced dynamics, which requires constant updating of the relevant database.
The principle of *unconventionality* is important from the point of view of ensuring the novelty and reliability of the obtained results. In practice, it can be implemented on the basis of software functionality through the construction of not only two-dimensional maps, but also a variety of digital virtual-realistic models, which can greatly facilitate targeted analysis of the situation.
The principle of *valuation* involves the predominant use of indicators that increase the relevance of maps by bringing their content to the level of territorial gradation and evaluation system according to certain criteria. At the same time, such indicators as the ecological potential of the territory or ecological capacity are an order of magnitude more integrated and more relevant than the known traditional, in particular, maximum permissible concentrations.
In the implementation of these principles, the key is the concept of information, the high quality of which guarantees the success of the cartographic method of research in monitoring tasks. The very process of mapping environmental phenomena requires significant arrays of information (and diverse, which is obtained by transforming or processing primary data). Therefore, the quality of information both in terms of content and its timeliness is crucial in assessing the reliability and relevance of the created maps. In this case, quality means both the content adequacy of the information load of the map and the characteristics of the real object, and their maximum coincidence in time. The latter determines the modernity of the maps.
The main types of maps that will provide the results of environmental monitoring are defined as inventory, assessment, recommendation and forecast maps in this sequence of their creation / use by GIS for the implementation of monitoring tasks.
Inventory (or statement) maps should be considered as those that reflect the most relevant in time and content of the actual monitoring data and (in whole or in part) provide for the use of primary indicators from databases corresponding to observation points (as mapping units) at local and regional territorial levels of maps creation.
The use of the generated databases for their direct purpose allows you to create derivative maps – evaluation and recommendation.
Evaluation maps are maps of purposeful evaluation of an object, phenomenon or process from a certain point of view. They are created at all territorial levels using different mapping units (separate object (observation point), separate territory (according to scientific classification), administrative-

territorial unit).
Recommendations maps are maps that reflect the results of the analysis of processed data by different mapping units by presenting integrated information based on different approaches and techniques in the assessment of phenomena and processes. Such maps are designed for decision-making at different territorial levels. They actually track different variants of the state of the phenomena under study and are essentially a logical development of evaluation maps.
The last link in the use of the cartographic method in the implementation of geographic information monitoring of the environment is the creation of forecast maps that indicate the state of the study area, taking into account the measures taken. That is, it is a maps-conclusions that accumulate and consolidate the final knowledge about the object of study based on the analysis and synthesis of data obtained on the basis of information based on existing theoretical, methodological and practical ideas about the problem.
The result of the functioning of specialized GIS should be cartographic models of information support for practical decisions on environmental protection and environmental safety at all possible territorial levels of mapping. Geovisualization of the proposed map system is possible and appropriate through the creation of interactive cartographic development based on the use of geographical bases of crowdsourcing services.

Conclusions

Cartographic support of the results of geoinformation environmental monitoring based on the formulated methodological principles of mapping is to consistently create a chain of functional types of cartographic models: inventory, evaluation, recommendation and forecasting, which through the use of modern GIS functionality fully enable environmental monitoring at all possible territorial levels.

References

Bondarenko, E.L. [2007]. Geoinformatic ecologo-geographical mapping. Kyiv: Publishing house "Fitosotsiotsentr", 272 p. [in Ukrainian].

Kussul, N.M., Skakun, S.V. and Shelestov, A.Yu. [2010]. Geoinformational infrastructure for environment and disasters monitoring. *Science and innovation*, 6, 4, 21–28.

Lyashchenko, A. and Patrakeev, I. [2015]. Ontology and features of geoinformation monitoring components by geospatial database technology. *Modern achievements of geodetic science and production: a collection of scientific works of the Western Geodetic Society USGC*. Lviv: Lviv Polytechnic Publishing House, 1 (29), 174–177. [in Ukrainian].

Mokin, V. B., Kryzhanovsky, E. M. and Botsula, M. P. [2011]. Information technology of integration of mathematical models into geoinformation systems of surface water monitoring. Monograph. Vinnytsia: VNTU, 152 p. [in Ukrainian].

On Environmental Protection [2020]. Law of Ukraine. Available at: https://zakon.rada.gov.ua/laws/show/1264-12#Text (accessed 10 July 2020) [in Ukrainian].

On the national infrastructure of geospatial data. [2020]. Law of Ukraine. Available at: https://zakon.rada.gov.ua/laws/show/554-20#Text (accessed 27 July 2020) [in Ukrainian].

Pohrebennyk, V. D. [2013]. Computer measuring, and information systems for operational ecological monitoring of the aquatic environment. Monograph. Lviv: Lviv Polytechnic Publishing House, 159 p. [in Ukrainian].

Provision on the State environmental monitoring system [2019]. *Resolution of the Cabinet of Ministers of Ukraine* of March 30, 1998, No. 391 (edition from 12/24/2019). Available at: https://zakon.rada.gov.ua/laws/show/391-98-%D0%BF#Text (accessed 20 July 2020) [in Ukrainian].