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Geophysical monitoring of geospatial data infrastructure as a component of the state environmental monitoring system

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SUMMARY

The aim of the article is to investigate the place, role, nature, purpose of geophysical monitoring in a multi-purpose and multilevel system of monitoring the condition of basic geospatial data based on the analysis of legislation of Ukraine and normative, scientific and reference literature. The information basis of the article consisted of the effective laws and regulations, results of scientific research and analytical materials, which present the problems of environmental monitoring in the context of geospatial data infrastructure development, in substantiating the aim and conclusion we used the abstract and logical methods. Geophysical monitoring is an important element of monitoring the state of geodetic networks. One of the main processes in field work for monitoring the condition of geodetic points and benchmarks for the survey of geodetic points and level benchmarks is their search in the field. The proposed search methods are based on geodetic technologies and provide only localization in the area of the probable location of the center, the benchmark, and to detect them in the soil it is necessary to perform excavations, which do not always give the desired result. The authors have performed the theoretical analysis of the possibility to use the investigations of background and anomalous geophysical fields as a basis for geophysical monitoring to observe the condition of basic geospatial data and it has demonstrated the diversity of application depending on the degree of detail as well as the insufficient efficiency of geophysical information.

Introduction

The modern system of environmental monitoring on the territory of Ukraine is outlined in detail in the legislative act (On approval of the Regulations on the State Environmental Monitoring System, 2019), in particular - the subject matter, elements and components of the monitoring system, objects, principles of the monitoring system, the list of central authorities of the executive power, enterprises, institutions of the organization and other subjects of the monitoring system, which perform the observation of the properties, characteristics of the environmental components and are responsible for its condition, as well as in the normative document (State Service of Geology and Subsoil of Ukraine. On approval of Methodological Recommendations on Monitoring and Scientific Support of Subsoil Use, 2012) suggesting the recommendations on carrying out the subsoil use monitoring.

The aim of the article is to investigate the place, role, nature, purpose of geophysical monitoring in a multi-purpose and multilevel system of monitoring the condition of basic geospatial data based on the analysis of legislation of Ukraine and normative, scientific and reference literature.

Methodology

In the presented article, we used the methods of information processing. The information basis of the article consisted of the effective laws and regulations, results of scientific research (Kamenieva, 2020, Karpinskyi, 2006) and analytical materials, which present the problems of environmental monitoring in the context of geospatial data infrastructure development, in substantiating the aim and conclusion we used the abstract and logical methods.

Results

The Law of Ukraine on the National Geospatial Data Infrastructure adopted in 2020 defines the legal and organizational principles of infrastructure functioning, in particular, Section II provides the list of 17 diverse objects, the information on which is included into the basic geospatial database (On the National Geospatial Data Infrastructure. Law of Ukraine, 2020), which are diverse in their structure, use, purpose. Using the available GIS tools (Shypulin, 2014.) the mentioned geospatial data objects can be identified as points, lines and polygons.

The modern geophysical methods allow to determine the groundwater level in the near-surface layer of the Earth, properties, capacity of different soil layers, the position of karst cavities and other geological phenomena that affect the geospatial database functioning.

In accordance with the authors' opinion, one can consider as the point objects in the context of geophysical monitoring the reference systems of coordinates and altitudes, which are fixed by positions, the state border of Ukraine, in particular: border signs as separate points; the boundaries of administrative-territorial units which are fixed by boundary signs.

The linear elements include geodetic networks (leveling networks, trilateration, triangulation and other types of geodetic networks); boundaries of administrative-territorial units as closed lines, street and road network of settlements, highways, railways, utilities, the planar elements - the territories of administrative-territorial units, hydrographic objects and hydrotechnical structures, settlements, buildings and structures, land and soils, airfields, sea and river ports, land plots.

It is not possible to use geophysical monitoring to observe the condition of other basic objects (street registers, geographical names, digital terrain model, orthophotos) of geospatial data.

At the present stage of geophysics development, the geophysical monitoring (Shevchenko, 2018), includes the following types of geophysical monitoring (Figure 1): gravimetric, magnetometric, electrometric, seismometric, geothermal, radiometric, meteorological. (Kornienko and Liashchuk, 2017) indicate in their paper a set of geophysical monitoring tools, including radio, seismic, acoustic,

magnetic and aerosol and physical phenomena that they register, which form the basis of geophysical monitoring and for what purposes they are used, the degree of geophysical monitoring accurateness.

The proposed methods are used for the national and regional purposes. In the work of (Cherniaha, 2000), geophysical monitoring is presented for observation of several basic geospatial data in combination with the other types of monitoring. In the work of (Astashkina, 2010), geophysical monitoring is presented as one of the components of geological environment monitoring.

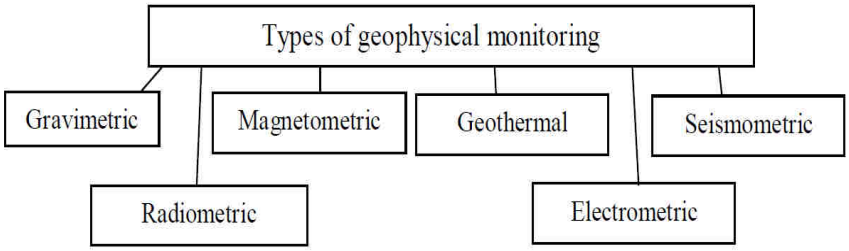

Figure 1. *Types of engineering and geophysical monitoring for geospatial data infrastructure*

Geophysical monitoring is an important element of monitoring the state of geodetic networks. One of the main processes in field work for monitoring the condition of geodetic points and benchmarks for the survey of geodetic points and level benchmarks is their search in the field. The proposed search methods are based on geodetic technologies and provide only localization in the area of the probable location of the center, the benchmark, and to detect them in the soil it is necessary to perform excavations, which do not always give the desired result.

The difference in the physical properties of the materials of the underground centers, benchmarks and the surrounding soil environment determines the prospects for the application of field geophysics methods to search for geodetic points and landmarks in the field. The presence of the center, the benchmark in the near-surface layer of the earth's crust is considered by field geophysics as inhomogeneity and an obstacle in the interpretation of field measurements. Therefore, the question arises of the choice of engineering and geophysical methods to identify in the soil centers of geodetic points and benchmarks.

The results of the application of engineering and geophysical methods for the search in the soil of underground centers or landmarks are quite promising. The physical basis of these studies are: the method of direct current electrical resistance, magnetic exploration and the method of transient processes of inductive geoelectrical exploration.

The use of artificial or processed natural materials for the manufacture of centers, benchmarks locally changes in small sizes the size of normal physical fields of the Earth, which can be detected by methods of engineering geophysics. Among the physical fields should be noted natural fields: magnetic, gravitational, thermal, seismic, nuclear-physical, as well as artificial creation: electromagnetic, seismic fields.

However, it is still necessary to develop scientific, technical and regulatory and economic criteria for the selection of geophysical methods based on the preliminary calculation of anomalies of natural and artificial physical fields in order to possibly use them in the survey of geodetic points and landmarks. When performing calculations, it is necessary to take into account the requirements of current regulations and especially economic requirements, which regulate the procedure, qualitative and quantitative composition of field units that perform surveys, as well as their instrumental and technical support.

Installation, the external design of the geodetic point and the subsequent location of the center in the near-surface layer of the earth's surface changes the physical properties of the soil and geological environment in the locations of geodetic points.

The analysis of the information pool, including research works, legislation, regulations, technology, shows that the use of geophysical monitoring for each of the 17 basic geospatial data is specific and should have its own criteria for use depending on the level of detail.

Thus, the geophysical monitoring for the first three points, in particular the coordinate and altitude reference system, the state border of Ukraine and the boundaries of administrative-territorial units, must have a local level at which geophysical monitoring can (geometrically) be point-like (magnetometric, georadar observations) when observing the state geodesic points of Ukraine or boundary markers and at the same time have a linear or planar nature (electrical profiling, vertical electrical sounding, microseismic zoning, magnetometric survey, shallow frequency sounding (Ortuani et al., 2015).

In megacities, in the territories of large industrial facilities, where their geodetic networks are created and operate, in which the density can reach 8 points per 1 km2, and the number of boundary markers may exceed the density allowed by regulations. Engineering and geophysical monitoring allows to monitor local artificially created geophysical fields that affect the state of underground communications, underground centers, landmarks, soil boundary markers and especially the state of metal centers. The presence of electrified facilities, transformer and distribution stations, cable and overhead power lines, external contact networks for electric trains and contact rails for the subway, all this leads to the appearance of stray currents, the presence of which causes electromagnetic corrosion in metal underground centers. All lead to corrosion of both metal and reinforced concrete - materials for the manufacture of geodetic points, leveling, boundary markers, utilities. Instability in time and the presence of stray currents in such areas is a significant obstacle not only to the detection in the near-surface strata of the Earth signs of geodetic basis, engineering communications, as well as for their identification and monitoring to monitor their condition.

In the system of objects observation, the geophysical monitoring will have point and planar nature at the local or regional level, and will cover the condition of surface pattern at the regional or national level.

Conclusions

The authors have performed the theoretical analysis of the possibility to use the investigations of background and anomalous geophysical fields as a basis for geophysical monitoring to observe the condition of basic geospatial data and it has demonstrated the diversity of application depending on the degree of detail as well as the insufficient efficiency of geophysical information use by geospatial data manager during the observation of their condition, especially the condition of the coordinate and altitude basis sites and boundary points that fix on the Earth's surface the location of the boundaries of administrative-territorial units, and also insufficiently fully represented interaction of thematic geospatial data that are not classified as basic geospatial data at different levels of monitoring.

The use of geophysical monitoring will significantly increase the reliability and accuracy of determining the quantitative parameters of basic geospatial data for their effective consumption by modern society.

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