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ANNIVERSARIES

TECHNOLOGY OF AUTOMATED DESIGNING OF RAILWAYS WITH THE USE OF DIGITAL AND MATHEMATICAL MODELS OF LOCALITY

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The paper considers the modern technology of computer-aided design of railways in Kazakhstan. The computer model of the transport infrastructure object is made taking into account the geometrical dimensions and design features of the real object – the section of the railway "Zhezkazgan – Saksaulskaya". The aim of this work is to develop a method of multivariant design of railway tracks using modern information systems and digital terrain models (DTM). The system use of automation and computer technology allows to use extensively digital and mathematical modeling of the terrain and geotechnical structure of the terrain, to simulate the embankment of the railway in three-dimensional space, modeling the operation of small culverts and bridge crossings and other structures. The use of computer programs allows at the stage of conceptual design to study several variants of the route with competitive technical and economic indicators, built taking into account a variety of factors. As a result of the study, there was developed a new approach to the organization of the process of automated tracing of railways with operational analysis of design solutions for the profile in real time. It was theoretically justified and programmatically implemented.

Key words: DTM, digital elevation model, profile, route, computer-aided design system, railway, construction, three-dimensional modeling.

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REFINEMENT OF ASTROARCHAEOLOGY MONUMENTS DATING AND FUNCTIONING BY ASTRONOMIC-GEODETIC DATA

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The paper considers differential formulas of geodetic astronomy. The application of these formulas in astroarchaeology allows eliminating the systematic errors of the initial direction azimuth and errors caused by atmospheric refraction. It is shown that using these formulas it is possible to estimate the error of astronomical dating, to clarify the place of the observer and/or the conditions of observation, to perform reduction calculations when it is impossible to establish a geodetic tool in the observation point, to clarify the astronomical dating of the archaeological monument under known circumstances of observation in present time, to simulate the chiaroscuro picture for the ancient era in astronomically significant days of the year. The possibilities of applying these formulas in combination with survey measurements, field observations, digital photography and an astronomic program-planetariums on the example of two astroarchaeological monuments (Mountain Altai and Khakassia) are shown. It is noted that such an integrated approach can significantly improve the accuracy of astronomical dating of archaeological sites, as well as to clarify the details of their functioning.

Key words: astroarchaeology, geodesic astronomy, dating of archaeological sites, Lockyer's dating method, summer solstice.

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ESTIMATION OF THE GLOBAL RADIATION SPATIAL DISTRIBUITION DEPENDING ON FORMS AND AMOUNT OF CLOUDS WITH THE SATELLITE DATA OF LINKE TURBIDITY COEFFICIENT AND DIGITAL ELEVATION MODEL

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The global radiation is a key component of the radiation balance equation, which is an important part of the energy balance. Spatial distribution of the global radiation is necessary for surface energy balance models based on the satellite data. The global radiation depends on the geographical location, the relief, the atmospheric transmissivity, and the clouds. Basically, for energy balance models, ground-based measurements of the sunshine duration are used to calculate the global radiation. While on the territory of Russia the visual observations of types and amounts of clouds are standard. The atmospheric transmissivity is usually estimated from ground-based measurements, which do not always indicate the radiation absorption throughout the atmosphere. The atmospheric transmissivity can also be determined from remote sensing data. In this paper we consider a method for estimating global radiation with the visual observation of forms and amount of clouds at meteorological stations and with remote measurements of the atmospheric transmissivity. Slope and aspect are calculated by digital elevation model (DEM) ASTER GDEM to estimate the global radiation spatial distribution. The spatial resolution of ASTER GDEM is 30 m. The atmospheric transmissivity was estimated with satellite measurements of Linke turbidity coefficient, the measurements on the grid 1°×1° are stored in NOAA CLASS system. The radiation measurements data in the World Bank's ESMAP Solar Resource Mapping project were used to validate the calculations. The root-mean-square error was 107.6 W/m^2 and 83.9 W/m^2 for two stations. As a result, a computer program was developed to automatically calculate the global radiation spatial distribution.

Key words: global radiation maps, cloudiness visual observations, digital elevation model, Linke turbidity coefficient.

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IDENTIFICATION OF RESULTS OF REPEATED GEODESIC OBSERVATIONS AT THE ESTIMATION OF THE GEODYNAMIC HAZARD OF SUBSURFACE OBJECTS

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The issues of identification of the results of repeated geodetic observations are considered. It is shown that the lack of an adequate definition of the type, nature and type of regional loading of the fault-block geological environment, as well as the lack of consideration of the relative nature of the measured displacements, leads to incorrect geodynamic interpretation of the results of repeated geodetic observations. In particular, information is given on the study of deformations of the Earth's surface, carried out by satellite and ground-based geodesy in various regions and spatial-temporal scales, which shows that the rates of average annual relative deformations lie in the range of 10^{-8}–10^{-9} per year and weakly depend on base and duration of the observation period. Assuming that the strain rate is linearly proportional to the velocity of the applied stresses, then at typical values of medium stiffness, the rate of change of regional stresses will be about 10-100 Pa per year or 0.1-1 mbar (0.1-1 atm) per year. This means a "soft" regime of regional loading. Formulas for the relationship between the values of relative bending deformations, the curvature of the earth's surface and the radius of this curvature are derived. A variant is presented for assessing the geodynamic hazard of subsurface facilities located near active fault zones. This approach is demonstrated by the example of analyzing the results of repeated leveling observations at a geodynamic test site organized within the Romashkinskoye oil field.

Key words: repeated geodetic observations, geodynamic hazard, deformation tensor, local bending, identification of observational results, dangerous fault.

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ANALYSIS OF OBSERVATION REPEATED LEVELING IN FAULT ZONES METHODS OF DEFORMATION THEORY

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Due to the need for tectonophysical interpretation of anomalous vertical displacements of the earth's surface in active fault zones, a formalized approach was proposed for the selection of movement types. The classification of anomalous, vertical displacements of the earth's surface in fault zones is given. It is shown that all abnormal changes are reduced to three main types of deformations: regional bending, local bending and vertical shear. On the basis of the geometric theory of deformations, dimensionless parameters are used to reveal the dominance of basic geomechanical mechanisms (vertical shear, alternating bending) in time. On a number of geodynamic polygons (seismoprognostic and technogenic), the implementation of the entered parameter F, which is a spatial filter, is shown, which reveals the dominant role of a specific type of anomalous activation. The materials of repeated leveling observations along profiles crossing several fracture zones are presented. The periods of changing the local mechanism of deformation activity of faults in time are revealed. A technique has been developed that allows averaging of shear and bending movements along leveling lines intersecting several fault zones and establishing the dominant type of anomalies over the entire observation period for each fracture.

Key words: modern geodynamics, geodynamic monitoring, geodesy, leveling, vertical movements, fault zones, deformation processes in fault zones, observations.

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COMBINED METHOD FOR DETERMINING OF THE BUGHRIN BRIDGE DEFORMATIONS DURING ITS TESTS

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The article considers various methods of geodetic measurements for testing bridges. It shows the development of combined geodetic measurement method that includes geodetic measurements performed by robotic total stations and a laser scanner for points on a bridge bearing girder, the critical points of which were not available for direct geodetic measurements. The measurement data, after each load series, were transferred to the control center for processing and analysis. Despite the installation of total station on a movable base, the proposed method allowed determining with high accuracy the deformations of the roadway and the bearing beam in the vertical plane. The experiment with the use of satellite measurements showed the shortcomings of the applied measurement scheme and the greater dependence on satellite constellation location in relation to the screening bridge cable grid. Analysis of the literature on bridge tests showed that the technique used by the authors for joint measurements by robotic total stations, laser scanners and GNSS receivers was used for the first time.

Key words: bridge tests, deformation, geodetic measurements, laser scanning, satellite measurements, analysis.

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FUNCTIONAL ZONING – A TOOL FOR MANAGING THE DEVELOPMENT OF GEODYNAMIC POLYGON IN THE STUDY OF THE EARTH CRUST GEODYNAMICS

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In traditional geodynamic research technologies, the management of geodetic constructions development at geodynamic sites is usually carried out taking into account economic, technical or technological factors. The developed theory of the management of geodesic constructions development at geodynamic test sites within the framework of geodetic monitoring of the stress-strain state of the earth's crust in areas of coal deposits development not only excludes this approach, but also takes into account the geodynamic safety requirements. In this monitoring, the author proposes not only to assess the level of geodynamic safety by the method of functional zoning, but also to coordinate the development of geodetic constructions. The main difference of the proposed theory is the correspondence of the territorial, temporal and methodological development of these constructions to the danger degree of the earth's crust blocks deformation and the possible risk of geodynamic phenomena in them. Such an approach provides not only an extended using of geodesic information when interpreting geodynamic studies, but also obtaining new aspects of its use in constructing geodynamic polygons.

Key words: geodetic constructions, the blocks of the Earth’s crust, geodynamic polygon, rank, geodynamic phenomena, functional zoning.

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SPECIFIC ASPECTS OF HEIGHT ELEVATION TOOLS USED FOR DETERMINATION OF HEAT DEFORMATIONS IN SYSTEM "TURBOGENERATOR–FOUNDATION–GROUND"

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The article considers the ways of points transmission to mounting horizons in the process of equipment assembly on the example of heat deformation determination in system "turbogenerator–foundation–ground" (TFG). Main attention is paid to providing required accuracy of measurements. The determination of heat deformations, considered in the article, is caused by the necessity for calculation (on the basis of geodetic data) of shaft line decentering values for their further installation during the process of assembling or reparing a turbogenerator. The article proposes several measurement methods for point transmission, which use high-precision total station and geodetic level. It gives the results of experimental measurements, carried out by the suggested methods. The use of high-precision devices for heat deformation detection of TFG system makes the point transmission process significantly easier, decreases the influence of main error sources and, if required, performs automatic monitoring of column length with a chosen time interval.

Key words: heat deformation, height elevation tools, high-precision level, total station, automatic monitoring system.

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THE RESULTS OF THE MONITORING OF VERTICAL DISPLACEMENTS IN THE PROCESS OF COMPENSATION GROUTING AT THE EXPERIMENTAL SITE OF ZAGORSKAYA PSP-2

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The review of practical experience of application of technology of compensating injection (compensation grouting) for stabilization and rise of buildings and constructions is carried out, the analysis of results of compensation grouting given in domestic and foreign literary sources is carried out. The goals and objectives of the research work at the experimental site Zagorskaya PSP-2, made by specialists of JSC "Institute Hydroproject" in 2016–2017, are described. The scheme of work on the experimental plot and the description of technology of compensation grouting are given. The principles of organization of automated geodetic monitoring of displacements and deformations are shown on the example of the experimental site. The experience of geodetic observations of vertical movements of structures of the experimental site Zagorskaya PSP-2 in the process of compensation grouting is presented. The automated system of geodetic monitoring of movements of structures of the experimental site is described in detail. The results of observations of the vertical movements of the experimental site structures in the process of compensation grouting are presented. The results of automated monitoring of vertical displacements are compared with the results of class II leveling. According to the results of the comparison it was found that the accuracy of the automated determination of the altitude movements of the controlled points by deviations from the results of leveling of class II on average in cycles was ± 3.2 mm. Recommendations for improving the accuracy of automated systems of geodetic monitoring are given.

Key words: compensation grouting, hydraulic structures, automated monitoring, vertical displacements, Zagorskaya PSP-2, class II leveling, geodetic monitoring.

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CARTOGRAPHY AND GEOINFORMATICS

ESSENCE AND MAPPING OF TOURIST-RECREATIONAL INFORMATION SPACE: THE COAST OF LAKE BAIKAL

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The article formulates the scientific principles of the tourist and recreational information space (TRIS) as a phenomenon caused by modern informatization of territorial activities, the peculiarity of which is the creation and use of spatially coordinated resources describing natural and socio-economic objects and processes of interest for tourism and recreation. The organizational block diagram of TRIS is presented and basic information flows forming space are established. The analysis of TRIS components is carried out, the specificity of its territorial, social, functional and regulatory structure is disclosed. The process of information interaction in the sphere of tourism and recreation is considered, sources and features of information resources of tourist and recreational subjects are determined, their content and conditions of accommodation are determined. On the example of the TRIS coast of the lake Baikal was developed a methodical basis for mapping information infrastructure and practice-oriented example of the map.

Key words: subjects of the tourism industry, information resources, information infrastructure, tourist and recreational information space, mapping.

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ANALYSIS OF THE FUNCTIONALITY OF THE WEB APPLICATION KEPLER.GL FORVISUALIZING AND ANALYZING OF LARGE SPATIAL DATASETS

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Currently, there is an active development of the multimedia direction in the cartographic display of large sets of spatial data. The tasks associated with the formation of geo-information space, the analysis of large sets of spatial data and their display by means of digital web-cartography are being solved.

The goal of this article is to analyze the functionality of the Kepler.gl web application designed to visualize and analyze large sets of spatial data. At this stage of development, Kepler.gl allows you to work with data stored in one of three open text formats: CSV, JSON or GeoJSON.

For practical testing of the main program functions, a map of bus and tram stops in the city of Novosibirsk was created. As a source of geodata, a shp-file was taken from the Open Street Map open set to the territory of the Siberian Federal District.

Based on the results of testing some of the functionalities, it can be concluded that Kepler.gl makes it possible to significantly simplify the process of analyzing and visualizing large data sets. To a greater extent, this is provided by a graphical interface, which contains intuitive tools for choosing how to display data, filter and aggregate data, overlay information from various sources, switch between 2D and 3D modes, etc.

Key words: visualization, spatial data, large set of data, geoinformation, thematic map, map layers, data aggregation, web-application.

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3D-MODELING AND VISUALIZATION OF URBAN TERRITORIES WITH USE OF MODERN GEODETIC AND PROGRAMMING MEANS

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The article considers modern tendencies of urban territorial geospatial development within the framework of spatial development strategy in Russia. In modern conditions in order to decrease urban load onto environment and city services the concept "smart city" is successfully realized all over the world. Its purpose is not only to increase operation efficiency of all city services (process automation, problem classification, efficient distribution of city services' resources etc.), but to make the city more secure and comfortable for its inhabitants. Thus modern approaches to spatial development of cities play a key role in effective use and development of urban environment. As

tools for creating digital 3D models of urban objects and infrastructure laser scanners and UAS are successfully used. Digital platforms are used for integration of all kinds of resources to solve problems the society faces. The paper considers the programming complex Autodesk Infraworks as a kind of such digital platform. As an example of modern solution in management and spatial development of metropolis territory in geospace within the concept "smart city" is drawn the project realized in SSUGT as the pilot project against the order of Novosibirsk Administration, residential complex "Vostochnij".

Key words: smart city, 3D model, laser scanning, cloud of points, 3D cadastre, cadastral model, spatial model, geospatial data.

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LAND MANAGEMENT, CADASTRE AND LAND MONITORING

ABOUT THE STABILITY OF GEOSPACE AND TECHNOLOGICAL ASPECTS OF ITS CONTROL

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On the modern stage the key aspect of the economy development in the Russian Federation is its digitizing, which is impossible without creating geospace in corresponding terrestrial entity (TE). One of the most important properties of geospace is the stability of its metrics, which is defined by the coordinates of geodetic control points (GC), equally spaced in TE.

Geodetic control points are positioned, as a rule, on the roofs of buildings and constructions which in urban conditions can be subjected to active anthropogenic and tectonic influence and, hence, change their position in space. That's why geospatial metrics can be deformed.

Objective: to propose mathematical algorithm, which allows on the basis of geodetic measurements to control the stability of geodetic control points, which define the metrics of geospace, and, if necessary, to specify the points coordinates of geodetic measurements.

Methods: the theory of mathematical processing of geodetic measurements.

Results: there was proposed a scheme, consisting of a set of mathematical algorithms. Realization of this scheme allows to control the stability of geodetic control points and, if required, to restore geospatial metrics.

Key words: geoinformational space, terrestrial entity, geospatial metrics, geodetic control, GNSS-technologies, ground-based measurement technologies, ground geodetic stations, statistical criteria, least square methods, root-mean square error, recurrent equalization.

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PATTERNS OF THE STATE CADASTRAL SYSTEM DEVELOPMENT

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The article presents the results of a theoretical study of the laws of the state cadastral system development. The development of the Institute of cadastre and registration of real estate rights leads to the creation of a modern innovation economy. The essence of the innovative economy in relation to real estate is to fully mobilize the existing potential of land resources and other real estate. This requires theoretical studies of the functioning of the state cadastral system, the chronology of the cadastral systems transformation. The study shows that the cadastral system transformation follows the economic system development of society. The advent of world trends of the Informatization of the society, characterizes the transition to a new economic system. The study considers the structure of the cadastral system in terms of structural and functional analysis. The concept of "subfunction of the cadastral system subsystem" is proposed and substantiated. Based on General scientific

system representations, regularities of development of cadastral system in time, and also the stages of development of functions corresponding to them are revealed.

Key words: cadastral system of the state, the economic system of society, structural and functional analysis, patterns of development, mechanisms of deployment / folding functions.

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SUSPENSION AND REFUSALS IN CONDUCT OF STATE CADASTRE OF REAL ESTATE

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This paper considers the analysis of the reasons for suspensions, regulated by the current legislation, restraining the state cadastral registration. It is shown that there is a significant difference between the time spent for conducting state cadastral registration and the duration of suspension. Numerous reasons for the suspension can be reduced to the minimum by issuing two instructions. One of them should be aimed at clarifying bottlenecks in cadastral activities, including the procedure for harmonizing borders and preparing necessary documents, while the other will provide an unambiguous interpretation of the requirements of the registration authority.

The purpose of this paper is to analyze the reasons for the state cadastral registration suspension and develop proposals to reduce their impact. The relevance of the topic lies in the fact

that it contains proposals on reducing the timeframe for the formation of a taxable base in the conduct of the domestic cadastre.

Key words: state cadastral registration, instruction, cadastral activity, taxable base, suspension, refusal.

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ABOUT SOIL FERTILITY AND ITS MONITORING IN BIOFARMING SYSTEM

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The article analyses soil fertility problem, determining the productivity of modern agriculture and the possibilities of its growth together with ecological qualities while going to biological agriculture, minimizing the consumption of chemicals and increasing the role of natural biological processes: preservation of ploughing and others horizons of soil; alternation of plant crops with different root system types; use of postharvest crops and green manure crops for balance control of organic substance, carrying out agroforest melioration activities, and also using microbiological specimen, accelerating the processes of organic humification and mineralization. The article defines the soil fertility monitoring system, some particular elements of which require the attention of subject matter experts. Particularly it concerns means and methods of organic balance control of soil, whose complicated dynamics defines the processes of its preservation, humification and mineralization.

Key words: soil, fertility, agricultural industry, environmentalization, fecal organic matter, humification, mineralization, monitoring.

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IDENTIFICATION OF PROBABILISTIC AND STATISTICAL MODELS OF PROPERTIES OF ECOLOGICAL SYSTEMS AND THEIR INFORMATION ASSESSMENT

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In case of condition monitoring of natural objects and ecological systems under the influence of climatic changes and anthropogenic influences it is necessary to carry out the analysis and comparison in different time points of variability of continual object properties in space, which is especially important for soil assessment. The previous researches showed that the structure of variability of soils properties under the influence of natural and anthropogenic processes is rebuilt that leads to change of functions of their probable distributions. The analysis of property variability of a natural object can be realized by identification of its probable and statistical model which is characterized by a certain type and parameters of mathematical function of probable distribution, or the probable-statistical distribution (PSD). PSD is the most exact and complete statistical standard of object property under study. For scalar integral assessment of variability and its changes we offered to use the information characteristics calculated on the basis of PSD. For the information characteristic of a measure of uncertainty of values of object properties we used information entropy, and for assessment of distinctions – information divergence. The article shows the possibility of free software use for statistical analysis of attributive data of these geosystems on the example of soils. It also considers stages of statistical analysis and program features of PSD identification and also calculations of their information characteristics when using the free software. The article provides the list of the most often defined probable distributions of soil properties and their representation in the software environment of "R". Examples of calculations on the basis of soils monitoring actual data in the South of Western Siberia are reviewed.

Key words: monitoring, properties of soils, databases, probable and statistical models, statistical standard, information characteristics, free software.

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FINDING ROUTE OF THE MINIMAL COST OF THE TRANSPORT PATH WHEN DELIVERING WOOD FROM THE CUTTING AREA

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This article describes a solution algorithm which represents determination of the optimal routes and quantity of goods transportation when the delivery cost of these goods from the starting to the final point is minimal. The algorithm is based on Dijkstra's algorithm (shortest path search) and dynamic programming method. The algorithm is used for calculation of the optimal route when delivering wood from the cutting area. The special features of forest roads relate to transportation costs as well as to a road capacity. These depend on climate and environmental conditions of the route segment. The value includes both, costs depending on the quantity of the goods being transported (transportation), and costs not dependent on it (construction and rehabilitation of roads). The specificity is that in this problem rehabilitation (construction) and transportation costs might vary depending on the quantity of the goods being transported on the route segment.

Key words: solution algorithm, the smallest cost route, wood transport, optimal route, transport costs.

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GEOECOLOGICAL ASSESSMENT AND MAPPING OF URBAN *ROAD VERGES*

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The article considers an approach to geoecological assessment and mapping of urban road verges. The shortcomings of the existed methodological approach to inventory of urban green spaces are stated. The brief description of features of anthropogenic impact to the different classes of urban green spaces is given. The necessity to give particular attention to the urban road verges condition as the most affected by anthropogenic impact is substantiated The main indicators of the tree condition and rational deployment of trees of urban road verges are listed. The mathematical tools for geoecological assessment of urban road verges are characterized. A case-study of geoecological assessment and mapping of urban road verges in Novosibirsk is described.

Key words: urban green spaces, urban road verges, geoinformation mapping, geoecological assessment, digital maps, GIS techniques.

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