

GEOINFORMATION TECHNOLOGIES IN GEOECOLOGY

(№ 11. GIS and digital mapping)

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Abstract

The described technique of complex geocological mapping of administrative level's territories is based both on the component's approach and on the modern geoinformation technologies. The essence of the technique consists in construction of the concerted series of computer integral evaluation maps, in which the pollution of main nature compounds and intensity of technogenic load are considered. Theoretical developments are illustrated by the practical realization on the examples for territories of different administrative regions (Moscow area).

Rates of geoinformation technologies development may compete today only with growth of geocological investigations. Undoubtedly, both first and second are the most urgent areas in Earth's sciences. Using of powerful soft ware is widely widespread for construction and renewing of computer geocological maps and atlases, also for creation of specializing geoinformation systems, appealing to decide tasks of territories managing. Some specialists in geocology is starting to obtain and interpret geocological data with help of new "without paper" technology, which is based on the electronic way of information presentation.

Totally, drawing of geoinformation technologies into process of geocological investigations caused great change of both quantity and quality of ecology-cartographic production. What reasons are responsible for it? Firstly, geoinformation technologies exploration considerably increases promptitude of geocological mapping, which is invaluable for realization of pollution monitoring, observing for the concrete pollution source and others. Secondly, modern software has advantage to bring together different sources of information. They can be cartographic materials, texts, remote sensing material, data bases, graphics and others. Third and the most important, using of geoinformation technologies allows to create and operate with geocological models with help of overlay functions, digital elevation model etc.

In our opinion, these irrefutable dignities of geoinformation technologies are responsible for extensive introduction into geocological investigations as well as into geocological mapping. But despite widespread exploration as well as existing of plenty of software programs (both special and of total purpose) many questions are left unsolved. First of all, they are necessity of putting into computer and processing of great data array and co-ordination of information about nature and social objects and processes, which can differ by type and quality. Also it is need of construction of a number of intermediate results, for example, maps, atlases, texts, graphics, diagrams and others. Important place takes requirement of maps actuality, which assumes to realize operative mapping. The main problem is difficulty of formalization of nature and social processes and phenomena; it inevitably leads to simplification of geocological models. Besides problems of complex evaluation of ecological situation are left unsolved. The main scientific aim consists in solution of these problems.

Modern software sets can't satisfied requirements of cartographers and ecologists. Most of programs have a narrow specialization, which provides only separate stages of ecological mapping. Therefore there is necessity of combination of several programs. The effective technology of computer geoeological mapping has developed by us. It is based on the using of GIS MapInfo (input of cartographic data, edition, co-ordination and storing of information), cartographic editor Digitmap (input of thematic data) as well as such programs as Mag and Surfer (modeling of pollution relief), vector graphic editor Adobe Illustrator (design, printing and preparing of cartographic products to publishing).

The complex software using allows to provide all stages of creation and exploration of ecological maps, series of maps and atlases. The technology has tested on the examples of ecological problems solution for territories of different administrative units of Moscow area as well as local objects. Series of ecology-geographic maps (total amount is more than 300) are based on developed technology.

Among ecology-cartographic production maps of different nature compound pollution are the most popular. These maps show the concentration of chemical elements, their combinations or their exceedings of limited concentration; they can efficiently be used for the determination of concrete sources of pollution. However, interpretation of total ecological situation and reasons, which are responsible for nature degradation, is impossible with help of monoelement maps only. There is a necessity of involving of both integral synthetic maps (which are represented the ecological situation in total, as well as the tendencies of pollutants migration) and maps of technogenic load's structure.

The complex mapping may be carried out by single integral map, by series of concerted maps as well as complex atlases. According to ecology-geographical mapping we assume the most optimal version will be concerted series of ecological maps, including both analytical and synthetical (for evaluation, forecasting and other) ones. Our investigation of this version's efficiency is based on the following topics: maximal detail of researches, expenditure of labour and time, simplicity of information's perception.

Using of geoinformation technologies for the cartographic production gives the best results on the administrative units level. They are especially considerable for geoeological researches. The scale of regional investigation allows to combine the detail of reflected information with the demonstrativeness of integral appropriateness of pollution development process. And application of modern geoinformation technologies greatly increases the possibilities of ecological information analysis. Geoeological mapping is the most actual for the urban territories. Therefore last ones are characterized by long-time history of national economy's development, great population's density as well as high concentration of industrial enterprises.

The chemical composition of soil and snow coverages as well as ground waters was investigated for the Noginsk region's territory (Moscow area). Such complex of works allows to estimate the ecological situation by several directions: firstly, long-time influence; indicator of this kind of technogenic press is a soil pollution. Secondly, modern (seasonal) state of atmospheric air detected by pollutants accumulating in a snow cover. And third part of investigation includes the studying of pollutants penetration to the undersurface compounds such as ground waters. The series of monoelemental maps of different nature compounds pollution for the Noginsk region territory contain more than 50 maps.

The estimation of the main drinkable aquifer's quality was carried out for the territory of the Krasnogorsk region (Moscow area). Created series of monoelemental maps gets possibilities to detect the

most probable ways of pollutants migration, viz. hydrogeologic windows. It is especially important if the industrial objects, polluted reservoirs, sewage disposals as well as dumps are located over of such ones.

The pollution of snow coverage characterises the quality of atmospheric air, therefore it is one of the most important index of ecological situation. There was created the series of snow pollution maps (total amount is 87) for the territory of SChelkovsk region, Moscow area. It allows to evaluate the level of technogenic influence from the side of fixed (industrial and agricultural objects) and movable (auto- and) sources, which are disposed both on the region territory and beyond its boundaries. Analogous works were carried out for the Voskresensk region's territory (Moscow area).

In these cases geochemical mapping was based on the investigations, where there was necessity of analysis of great quantity of components. This fact promotes to geoinformation technologies using. Firstly, created and attached to sampling points data base gets possibilities to construct a number of maps by short space of time. Secondly there is capability of automatic creation of simple cartographic models (pollution surfaces) which are made too easy works of a specialists.

We assume only concerted series of maps of different nature compound's pollution can solve the problem of complex geoecological mapping with maximal completeness, informativeness and demonstrativeness. This series includes maps, illustrating features of technogenic load, as well as conditions of the atmospheric air, soil and snow covers, running and ground waters, vegetation.

Besides concerted series of maps may be supplemented by ecological information which is received from the using of morphometric relief's analysis and modern geoinformation technologies. The pollutants migration's conditions (according to different nature compounds) are determined by relief's features. The relief plays an important rule in ecological system. enveloping all objects and phenomena of environment and society as well as their interaction. It provides a certain type of ecosystem's functioning and state. The displacement of materials as well as energy is controlled by relief therefore it takes the chief place among ecological factors.

The possibilities of the derivative maps of relief using are extraordinarily broad. The synthetic map can be created on the base of two maps: slope angle's map and exposition's map. The obtained map characterizes distribution of heat and moisture by territory and so detects the intensity of ecology-geochemical processes. The map of types of relief's morphoelements is very interesting from the side of sustainable development of territories providing. This map shows the ways of pollutants migration and the areas of their potential accumulation and disposal. The last is especially actual for the analysis of pollution spreading's directions as well as it's development prognosis. The combination of relief's map (which is created in isolines) and gradient scale as well as analytic shadow gets possibilities to carry out an interactive zoning of territories. To select certain relief's forms which for example are particularly subjected by pollutant's accumulation.

The model of complex mapping of pollution can be considered on the example for the Voskresensk region territory. The question of initial data sufficiency should be solved on the stage of primary edition and evaluation of initial materials. In the case of a lack of initial data there is necessity of geochemical sampling network's planning for the nature compound separately. For example additional points of running water's sampling should be located in confluence sites; dispositions of pollution's sources (both higher according to river's flow and lower); as well as in sewage disposal's sites. The main results of this stage are maps of factual material for different nature compounds. On their base the monoelemental maps of pollution can be constructed with help of mathematico-cartographic modelling's

methods. The quantity of such maps (both necessary and sufficient) is determined by diversity and structure of technogenic load. For the Voskresensk region's territory the created series of pollution contain 23 maps for soil cover and 22 ones for snow cover.

According to technogenic load's estimation sources of pollution can be classified by influence's types as mechanical, physical and chemical. Also this classification may be subdivided. For example, the chemical influence can be represented as pollutant's exhaust to atmospheric air, sewage disposal, accumulation of toxic deposits. Second basis of classification consists in direction of influence, i.e. selection of concrete nature compound. Third one characterizes intensity of influence. The map of land-using can help to ascertain types of pollution's sources, to show concentration and set of pollutants which comes to different nature compounds.

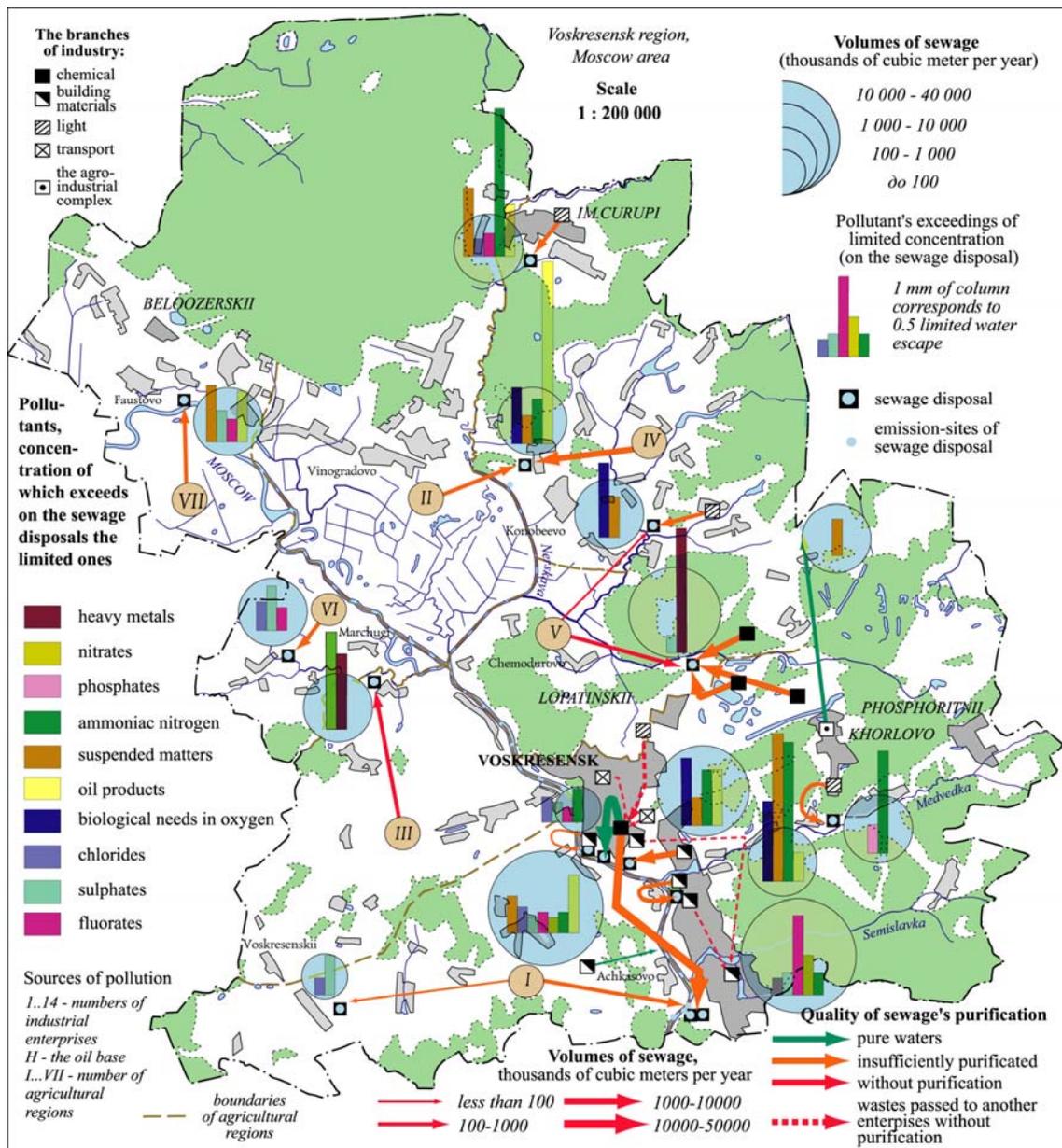
The maps of water-using and sewage disposal (see picture 1) show the intensity of technogenic load on the running waters, including volumes, sources and directions of water's obtaining, as well as volumes and chemical compound of sewages. Such group of indices can explain the reasons of changes in hydrologic regime and nature properties of region's rivers. So the map of pollutant's exhausts to the atmosphere displays the power and composition of large-scale industrial exhausts (industrial enterprises, dumps and other), the density of agricultural ones and also quantity and work's efficiency of fixed pollution's sources.

The technogenic load on the soil cover can be revealed with help of the following maps: agriculture's structure, land-capacity of industrial enterprises, applying of mineral and organic fertilizers, dump of industrial and municipal waste products. On this stage the results can be presented as the maps of technogenic load's structure according to different nature compounds. For example, contributions of agriculture, towns and cities (calculating on 1 inhabitant), one of motor and railway transport (including intensity of streams and toxic's transition), industrial enterprises (with consideration of exhaust's power and prevalent wind-rose) should be taken into account according to atmospheric air.

Sometimes there is need to investigate the concrete pollution's source in detail. Using of geoinformation technologies for complex mapping may be successfully applied on the local level: engineering researches, monitoring of local industrial enterprises or some others. The ecological condition of soil cover was studied for the estimation of the Timokhovo dump's (Noginski region) influence on the environment. It allows to evaluate the pollution of landscapes and ground waters (the main drinkable aquifers).

The analysis of series of soils pollution's maps (total amount is 15) evidently shows the principal directions of technogenic streams. They demonstrate the activity of pollution process: increasing of polluted areas becomes with great intensity. The prognosis researches are especially interested for ground waters quality's estimation. A pollution changes both in three-dimensional space and in time. The question about intensity of pollutant's spreading infringes on persons and structures which are responsible for environ politic. The execution of prognosis task can greatly simplify the process of decision making, for example, about functioning of pollution's source or it's potential increasing e t.c.

The geoecological analysis of Novosyrovo dump's influence on the environment is the enough example of geoinformation technology's using for a studying of local pollution's sources. This dump is located on the territory of Podolsk region (Moscow area). The computer ecology-hydrochemical and ecology-geochemical mapping was carried out for the vicinities of the dump. The main air of it was an



Picture 1. The map of sewage's volumes and structure.

investigation of ecological state of running waters and soils. The analysis of created maps (18) has revealed that the main source of pollution is filtrate's distribution, which leads to intensive pollution of nearest ponds. Now the pollution may be characterized as stationaty, but there is possibility of great deterioration as the dump will functioning. The results of complex mapping allow to recommend the dump's closing with the partial land's recultivation. Then this territory can be used for technical needs (construction of garages, storehouses and other).

The monoelemental maps are necessary to create the integral maps for all nature compounds. They characterize pollutant's distribution, so there is possible to detect polluted areas on the base of mathematic and cartographic models. On the next stage the techniques of synthetic indices of each nature compound should be selected. For example, for the atmospheric air such index may be IZA (index of atmosphere's pollution), for running water – IZV (index of water's pollution), for soils – SPK (summar concentration of pollutants) e t.c.

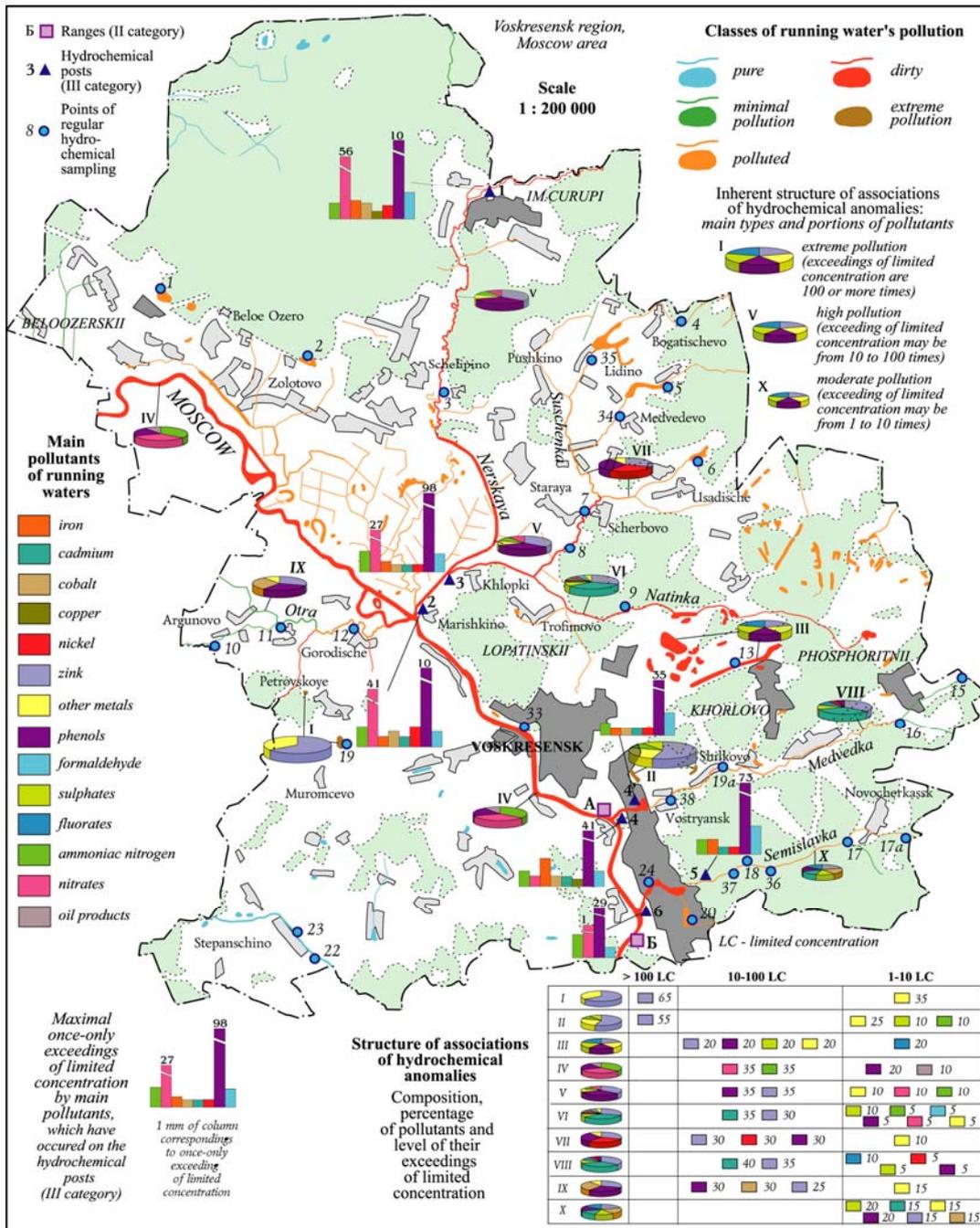
On the map of structure of running water's pollution (see picture 2) the intensity of pollution with the structure of hydrochemical anomalies are shown. The latter includes main types of pollutants, their contribution, level of pollution by exceeding of limited concentrations as well as maximal once-only exceedings, which were occurred on the hydrochemical posts. We suppose such complex of indices allows to characterize the ecological condition of running waters with completeness of both quality and quantity.

According to task's complication and to territory's features the problems of specialized technique's development are appeared. The danger of geochemical anomalies should be detected and estimated for representation of integral soil's pollution. Industrial pollution by heavy metals and oil products, agricultural pollution by pesticides or fertilizers may be responsible for such anomalies. Also they may be caused by such degradational soil's processes as erosion or decreasing of humus's layer.

There are some generally accepted techniques of integral indice's calculation for different nature compounds. For example, the integral pollution's index (SPK – in Russia) is the sum of concentrations coefficient's exceedings over the background. The method, consisting in determination of cumulative effect, is more easy for estimation of pollution's level.

Created on the base of such indices, the integral maps are sufficiently informative to detect main zones of technogenic pollution. But contributions of all pollutants are taking as equal so characteristic of geochemical anomaly will be average. We suggest the technique basing on the determination of cumulative pollution's effect with due regard of significance of each component, composing it. The realization of our technique consists of several stages. The first one proposes the determination of limit's condition, i.e. different types of pollution according to concrete chemical element.

The classification of territory according to combination of selected (on the first stage) influence's types is carried out on the second stage. It is conducted by all components, but without calculation and analysis of integral index's value. The third stage is directed to distribution of sampling points by selected classes. To simplify this work there is expedient to construct the three-dimensional diagrams, on which both concrete concentration's values and integral index's ones will be shown.



Picture 2. The map of pollution's structure according to running waters

The optimal limiting conditions for each class of territory are determined on the fourth stage. Here is carried out the comparison between total value, determining for each sampling point, and defined territory's class. The result of comparison is determination of integral index's values for each territory's classes, subsequently on the base of it the maps of integral geochemical pollution are constructed.

Besides we propose an another way. To definite an integral geochemical pollution there is need to take into account a geochemical features of pollutant's migration. That means a determination of danger's degree of each chemical component. The latter is characterized by a danger's classe, which can be fixed according to 6 criteria (not less than 3): toxicity, soil's and vegetation's stability, limited soil's concentration, migration's feature, influence on agricultural production.

The map of danger degree's estimation of geochemical associations according to different nature compounds can be constructed on the base of integral pollution's index and danger's classes of each pollutant. We can't take their contributions into ecological disbalance as equal so we introduce the weight function into the formula of integral pollution's index. We propose the following version. The effect of first (the most dangerous) class is 1, then ones of second and third classes will be 0.5 and 0.25 correspondingly. It is clear the selection of coefficients is the expert opinion and doesn't pretend on the absolute.

So the integral index of danger's degree represents the sum of all element's exceedings with regard of weight function. The index is normalized, i.e. it is equated with territory's parcel where all element's concentrations are background. The estimation of danger's degree may be carried out according to classifications which are based on the integral index's exceeding of limited concentration. Described technique is illustrated by the map of danger's degree of chemical elements accumulating in soil cover for the Voskresensk region's territory.

Modern geoinformation technologies allow to develop an ecology-cartographic analysis according to investigation of different nature compounds pollution's interaction. Thus the map of pollution's difference was created for the soil and snow covers of Schelkovsk region's territory. This map can help to definite the main reasons, directions and intensity of pollutant's migration.

The integral maps of pollution's structure get possibility to evaluate condition of each nature compound, but they doesn't exist isolated both each other and according to society. Therefore the processes of co-ordination of created maps with regard of nature and technogenic features of territory. So for full evaluation of soils pollution's structure there is need to conduct the analysis of following factors: pollutant's entrance from concrete sources (the map of technogenic load's structure); element's absorption from waters (both running and ground); pollutant's entrance from atmosphere (the maps of snow's and atmospheric air's pollution); as well as absorption of soil's pollutants by vegetation. Such analysis should be carried out for other nature compounds.

In conclusion we want to accentuate the meaning of applied geoecological maps. Both synthetic and analytic geoecological maps are intended for ecologists. But an applied maps are responsible for the "understanding" of existing ecological problems by the general public. The map of limited picking of wild crops (mushroom, berries and some others) for Khibini territory (Kolski peninsula) was created as the illustration of applied ecological researches. The territory is divided on the 3 parts: favourable, limited picking and unfavourable. To create this map we were taken into account both technogenic (composition, periodicity and power of industrial exhausts) as nature (landscape's features, atmospheric circulation's feature, condition of snow's accumulation) factors.

Described cartographic models, based on the modern geoinformation technologies, don't exhaust the diversity of methods and techniques of environment's estimation. But they can considerably simplify the planning of environ-politics and ecological decision making.