The Application of a GIS in Locating Environmental Loads and in Evaluating Their Impacts

Jan Oprchal, Jan Bartoň

GEOtest Brno, a.s., Šmahova 112, 659 01 Brno, Česká republika,
e-mail: oprchal@geotest.cz, barton@geotest.cz.

Abstract

Nowadays the application of a GIS in locating environmental loads and in evaluating their impacts appears as commonplace. The programming environments of professional GIS applications make possible to appropriately compile the methodology of processing data sets for finding requested facts. Thanks to task processing in GIS applications, it is possible to comprehensively and effectively cover the whole process, starting with data collection, through data processing and evaluation, up to the subsequent visualization. The paper analyzes the application of GIS possibilities to a specific project carried out for the Slovak Environmental Agency (SAŽP) in Banská Bystrica.

Keywords: GIS, environmental load, attribute table, overlay layers, intersect layers

1. Introduction

Every human activity influences both the natural and the cultural landscape. The impacts of various activities on the stability and development of ecosystems, on the preservation of biodiversity and natural resources, on sustainable production and consumption, as well as the effect on human health are significant. To fulfil the strategic framework of sustainable development and to improve the overall state of the environment, it is important to remove environmental loads. The problem is caused particularly by old environmental loads. They include a serious contamination of the rock environment, groundwater or surface waters, which occurred by an unsuitable handling of hazardous substances (e.g. petroleum substances, pesticides, PCB, chlorinated and aromatic hydrocarbons, heavy metals) in the past. Contaminated sites are mainly the places of the former plants of heavy or chemical industry, the areas affected by the extraction of mineral resources, waste dumps, agricultural premises, former military bases, and the like. The purpose of this paper is to show how these sites were located, described, comprehensively evaluated and managed in a database. The paper should also serve, among others, for popularizing task solutions in the GIS environment.

2. Presentation

A geographical information system (GIS) is a computer tool for acquiring, storing, analyzing and visualizing data which have a spatial relation to the Earth’s surface. It works with data which have their own geometry, topology, attributes and dynamics. The GIS makes possible to create up-to-date maps with an optimal combination of map layers that can be formed by both tabular databases and layers representing points, lines and surface areas. It enables spatial analyses to be made with these data, it also enables these data to be displayed and maintained and their contents to be updated. Data are divided into layers that represent the individual classes of an object. The layers can be mutually overlaid and transformed, can create envelope zones, can extract elements for further analyses, and can use a large amount of analytical methods and editing tools. Thanks to them we can find new facts across input data. The effective management of data and data sets consists in the possibilities of database organization and metadata creation and editing. It is easy to display the identified facts by cartographic methods, and to add descriptions and annotations.

2. Methodology of Processing

A concrete GIS application will be presented on a pilot project for the Slovak Environmental Agency (SAŽP) in Banská Bystrica, as the author of the methodology of the identification of old environmental loads (EL) and the creation of their registry and the subsequent data processing. The
project “The Regional Evaluation of the Impacts of Environmental Loads on the Environment for Selected Regions” is based on the analytical part of the study. The sites of environmental loads were searched for directly in the field at this stage, on the basis of local investigation and information from competent authorities of the state administration. The stage was focused on the evaluation of the degree of risk of environmental loads and on the quality of the environment (e.g. in relation to protected areas or infrastructure). In this part of the project, a classification of the relative degree of risk of environmental loads was developed, especially on the basis of the type and amount of the identified contamination and its relation to the environment in which it is located. The individual sites were divided on the basis of the degree of risk represented by the value K.

The results of the analytical part were the basis for carrying out the synthetic part. The task was processed in the GIS environment. It included mandatory updating focused notably on the riskiest environmental loads of the appropriate region. All the environmental loads were subjected to the detection of their relation to soil, protected areas, the proposed functional land use, the economic and social development of the area and the quality of the environment. The point sites of loads were compared with these layers by attributes and relative position with the use of possibilities of GIS tools. Intersections and envelope zones were created. Selections were made by means of map algebra, automatically rated and exported to the new columns of an attribute table of the sites produced for this purpose. These were further brought for their mutual addition by the relation to the individual components of the environment and the socioeconomic sphere. The result of the rating was the attribute value R.

The value V was obtained by integrating the results of the systematic inventory of environmental loads (the value K) and the results of the regional evaluation of the impacts of environmental loads on the environment and the socioeconomic sphere (the value R). The resultant value V (V=K+R) determined the priority of the individual environmental loads within the investigated areas.

3. Processing in a GIS

The principle of processing in a GIS consisted above all in the creation and filling of an extensive attribute table. This is usually understood as a matrix of values. The number of rows correspond to the number of the sites of environmental loads (ELs) found directly in the field or identified through the authorities of the state administration. There were 81 columns in the matrix produced. The columns contained, e.g., the values of the name of the sites, their geodetic position and designation in the map, their affiliation to the region and municipality, the level of work carried out at the site (verified, probable, or the environmental load remediated), or the values of the partial parameters R, K and V. Tens of columns were added, each filled with point rating according to the methodology of the SAŽP Banská Bystrica depending on the overlay of the given site with the input map (information) layers and with the individual components of the environmental loads.

The load components were formed by point, line as well as polygon layers, e.g. by layers of water conservancy areas, protection zones of mineral waters, protection zones of water resources, inactivation of pollutants, soil quality, soil types, biocorridors, biocentres, small-scale protected areas, large-scale protected areas, protected bird areas, spa areas, zones of historical monuments, Ramsar wetlands, territories of European significance, functional use of surface areas, density of population, and the like. These layers were often subdivided into subcategories (classes, zoning, degree of protection, yield, and the like). The display of the overlays of layers with the sites of loads is shown in an attached map extract (Fig. 1).

GIS possibilities were applied in the incorporation of all the mutual intersections of layers and in the filling of the attribute table, especially the functions of selection by attribute (e.g. in the grouping of the rated sites for their visualization) and of selection by site occurrence (e.g. only those sites found inside the protected zones of other layers). Other simple methods of map algebra were also applied. The methodology of processing required e.g. grading the resultant point value by the distance from the site of EL. The result was achieved by applying the function creating envelope zones round the layers. It is also possible to achieve the required outputs by using other tools, e.g. defining intersections of layers, overlays, grouping into categories, and arrangement by value, or by using advanced functions of the calculator of fields (e.g. additions of fields across selected layers).
In the subsequent visualization the results were arranged into categories by the degree of risk and the affiliation to the selected classes by threshold values and depicted in the resultant maps (Fig.2). The synthesis of the layers has produced maps of environmental loads and relations of environmental loads to water, soil, protected areas, functional land use and quality of the environment, and maps of designs and priorities. An extract of a map of priorities is shown in Figure 3. The resultant representations have shown the priority sites of loads in relation to health hazards, the quality of life of the population, threats to the sources of groundwater and surface waters and the devaluation of significant protected areas.

4. Conclusion

The advantage of processing in the GIS environment is the possibility of rapid updating and feedback. If a polluted site is remediated, its threat is reduced. Thus, the point rating is subsequently adjusted by the current state in the attribute table. The current list with a changed order of the sites where remedial measures must be taken as a matter of priority can be repeatedly generated.

In locating the sites with environmental loads in the GIS environment, we may encounter a few problems. They relate especially to the insufficient quality of input map or database information. To find informative results across input data, it is necessary in the ideal case to work with data generalized at the same scale with the same detail and accuracy, mapped in the same period of time, in the identical map series, by the same team of authors. Data should contain metadata of acceptable quality. Only thus can we avoid inaccuracies caused by processing inaccurate data by inaccurate methods.

The GIS proves a mighty tool in the process of locating environmental loads and in evaluating their impacts. It gives an integrated picture on the spatial arrangement of different types of risks across partial input layers with respect to the local defensive capability of the environment. If we have a sufficient amount of input data, we can easily divide sites of environmental loads into those where it is necessary to carry out measures as a matter of priority and into those where the addition of risks with respect to local vulnerability is still acceptable. The expended costs will thus serve to the environment more effectively.

Fig. 1.: Extract from a thematic map with evident overlays of map (information) layers
4. References Cited


