WARSZAWA 2004 Vol. 11

Damian Absalon, Andrzej T. Jankowski, Mieczysław Leśniok

University of Silesia, Faculty of Earth Sciences, Będzińska 60, 41-200 Sosnowiec, Poland

E-mail: dabsalon@wnoz.us.edu.pl, ajank@us.edu.pl, mlesniok@wnoz.us.edu.pl

GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN ENVIRONMENTAL RESEARCH AND WATER MANAGEMENT

Abstract: The article presents the content of digital thematic maps: sozological and hydrographic as well as the basic principles of their preparation. It contains selected examples of applications of these maps in the research of natural environment and water management in the Upper Silesia region and its surroundings. This area is one of the most transformed regions due to human economic activity in Europe.

Key words: GIS, environmental protection, water management, hydrology, thematic maps.

INTRODUCTION

Geographic information systems (GIS), which are based on computer technologies and enable the gathering, analysis, presentation and distribution of spatial and non-spatial data, are becoming more and more common in Poland. Due to broad possibilities of use and the advantage of digital maps over analogue ones the creation of a GIS system was initiated at the beginning of the 90s of the 20th century. Its aim was aiding the preparation of thematic maps: environmental (sozologic) and hydrographic, whose scope and selected applications are presented in this paper. The authors have participated in developing the foundations of the system and map sheets of the Upper Silesia region and its surroundings, which is the reason why the presented examples concern this area.

Both maps are created with the use of MapInfo software and are available in this format, therefore in the paper some figures are screen captures from this software.

Printed versions of both map types are available in the 1:50 000 scale. Thematic maps of Poland, environmental and hydrographic, are made in co-operation with regional academic centres and commissioned by the Chief State Geodesist.

ENVIRONMENTAL MAP

An environmental map (in Poland called sozological map) is a cartographic thematic compilation which, in spatial expression and on the basis of scientific

Fig. 1. Location of the analysed area: Św. – Świętochłowice, Ch. – Chorzów, So. – Sosnowiec, RŚl. – Ruda Śląska, DGórn. – Dąbrowa Górnicza.

and objective assessment, presents the state of natural environment as well as the causes and results of environmental transformations (both negative and positive) taking place in the environment under the influence of various activities. It also presents the methods of protecting environmental values.

Maps from the area of Upper Silesia that illustrate some applications of the system have been drawn on the basis of the previous version of the technical guidelines (*Wytyczne techniczne...*, 1990), so the thematic scope of the map presented below is quite different from the one that is currently used (*System...*, 1997b).

The merits of environmental map contain 6 information levels. These are as follows:

1. Protection of the natural environment and its resources
2. Susceptibility of the natural environment to degradation
3. Degradation of the natural environment
4. Counteraction to natural environment degradation
5. The natural environment reclamation
6. Wasteland.

An integral part of the environmental map is a commentary, which is placed on the reverse of the sheet. The commentary is produced according to a strict scheme and contains:

- characteristics of the main components of the natural environment and their selected features,
- supplementary data for the individual informational levels of the map (text, tables, additional maps),
- general evaluation of the natural environment condition and degree of its degradation,
- indicators concerning environmental management and protection,
- other essential information and evaluations.

Fig. 2. Fragment of the layer 'industrial emitters' of a digital sozological map (graphics and database) against the background of the topographic base map (presented in grey-scale) – explanations in the text.

The environmental map is produced by groups of geographers and cartographers, specialists in environmental management and protection, computer specialists and co-operating representatives of the state administration supervised by environmental and cartography specialists.

Particular elements of the thematic content of the environmental map are compiled on the basis of the collected materials and results of field mapping.

The environmental map is considerably important in the case of intensively urbanised and industrialised areas. The most urbanised and industrialised area in Poland is the Upper Silesian Coal Basin. The human impact has influenced the natural environment of this area since the 13th century. These transformations occurred as: ground surface transformations, changes of the surface water and underground water conditions, degradation of the atmospheric air and biotic values degradation.

The illustrations contain selected elements of the sozological map and present some of its applications. For the purposes of this study the fields and records of the database have been translated into English. In the original version the descriptions are in the Polish language. However, the presented fragments of the MapInfo interface are in Polish only because the authors use the Polish version of the software (and are licence holders for it).

Figure 2 presents the MapInfo interface. In the left window, against the background of a topographic base map, the objects from the digital sozological map layer 'industrial emitters' are visible. In the right window there is a database ordered with the use of SQL – dust and gas emitters are ordered according to the total volume of dust and gas emissions (from the largest to the smallest). The 'highlighted' objects in the database window are these which are visible in the map window. The database of this layer contains information about: emitter type (dust, gas), volume of dust emissions in Mg/year, volume of gas emissions in Mg/year, total emission in Mg/year, pollution-reducing equipment and user number.

Figure 3 presents another layer of a digital sozological map – 'anthropogenic forms' containing land forms that are the result of human activity (excavations and dumping grounds). Next to the open window of the map we may see a database window, information window "Informacja" and the region window "Region", that in this case enables the determination of geographical location of the marked object, its area and circumference.

On the sozological map, besides the degree of environmental degradation, we may also find elements connected with its protection. Figure 4 presents some options of the digital map – besides the open map window we may see the open database window of the layer 'natural monuments', the window of a table with the results of a SQL query ("Kobiór Tabela"), where we can see the system's answer to the query about natural monuments located in the selected commune (in this case Kobiór). The window "DBCOMMUNE Table" contains identification numbers that enable us to 'decipher' the names of the locations and in the window "DBMONUMENT Table" we can state what type of natural monument we are dealing with (e.g. tree species, type of rock in the case of inanimate natural monument, etc.)

Fig. 4. Fragment of the layer 'natural monuments' from the digital zoological map. The 'answer' of the database to the query about natural monuments in the Kobiór commune is presented against the background of the topographic base map – the triangles highlighted red and the window 'Kobiór Tabela'. The remaining windows of the tables provide supplementary information – explanations in the text.

Fig. 5. Fragment of a printed (analogue) version of a sozological map (sheet M-34-37-D Dobrodzien). The used materials come from the Voivodship Geodetic and Cartographic Resources under permit no. 2/2005 issued by the Marshal of the Śląskie Voivodship.

Figure 5 presents a fragment of an analogue printed version of a sozological map.

HYDROGRAPHIC MAP

A hydrographic map is a multi-sheet thematic map which presents, in a synthetic depiction, conditions of water circulation in connection with geographical environment, the degree of economic investment of the land and its transformation.

Thematic content of the map consists of seven information levels:

1. Topographic watersheds
2. Surface waters
3. Underground water outflows
4. Underground waters of the first level
5. Ground permeability
6. Phenomena and structures of water management
7. Hydrometric points of stationary measurement

An integral part of the map is a commentary prepared by the scientific consultant to the map sheet. It contains relevant information supplementing map content and characterizes among other things: rainfall relations, river regime and underground water regime, research period, state of surface water purity and transformations of water relations.

The hydrographic map is produced by groups of geographers (specialists in hydrology, water management and climatology) and cartographers, computer specialists and co-operating representatives of the state administration supervised by cartographers.

Particular elements of the hydrographical content of the map are compiled on the basis of the collected materials and results of field mapping.

The pictures present selected elements of a hydrographic map with some applications. Also in this case the fields and records of the database have been translated into English for the purposes of this paper.

Figure 6 presents a fragment of the central part of the Upper Silesia conurbation – an urban area with dense residential and industrial buildings. As a result of long-term mining activity connected with underground mining of hard coal, there occurred significant deformations of the land surface in this area. This resulted in e.g. changes in the courses of watersheds and formation of hollows without drainage. In some of these hollows and in other places that are subject to ground subsidence, water reservoirs and flood lands were formed. In some cases flooding occurred in built-up areas and objects of transport infrastructure (Fig. 7, Fig. 8, Photo 1 and 2). A digital hydrographic map together with other tools, e.g. digital terrain model (DTM), let us follow the development of such phenomena.

In contrast, fig. 9 shows selected layers of a digital hydrographic map (graphics and database) presented as screen capture combined with the interface of the MapInfo software. In the left window highlighted yellow are

Fig. 6. Topographic base-map (presented in grey-scale) overlain with selected layers of a digital hydrographic map: watercourses, reservoirs, watersheds (red lines), unstable watersheds (dashed red lines), watersheds in areas without flow (dashed red lines in bold) – numerous water reservoirs and areas without flow are the result of ground subsidence due to mining.

Photo 1. Water reservoir in a subsidence basin formed as a result of underground mining – flooded buildings can be noticed (compare Fig. 7 and 8) (Photo by G. Jankowski).

Photo 2. Road flooded as a result of ground subsidence due to mining (compare Fig. 7 and 8) (Photo by G. Jankowski).

sewage discharges that were selected in the right window of the database (with black squares on the left side). In the presented sheet the database on discharge had been pre-ordered according to the volume of sewage discharge (from the biggest to the smallest). The database of this layer contains information on: types of sewage (municipal, rain, industrial, agricultural, salty, mixed), discharge volume in $\text{m}^3 \cdot \text{day}^{-1}$, user number and number in the commentary to the map. Under the database window of the layer 'sewage discharge' – a fragment of the user database window is visible which in this case makes it possible to identify the objects that discharge sewage. The layer 'sewage discharge' enables quick analyses regarding e.g. the biggest water polluters, the most endangered river sections, types of discharge prevailing in a given area etc.

CONCLUSIONS

The environmental map, based on scientific, objective and correct evaluation of the present state of the natural environment in certain area, to determine trends of changes and transformations and the degree of permissible human impact on the environment, is a significant tool in spatial policy of a given area (Absalon et al., 1998). The map is also useful in planning the location of economic and municipal objects (industrial plants, livestock farms, waste dumping sites, etc.) as well as housing estates, recreation centres and protected areas.

The map is primarily addressed to the decision makers and planners in the departments and institutions at different levels of state and local administration, especially those dealing with the issues of environment management and protection. It enables them to prepare the inventory of environmental resources, shows its susceptibility to degradation – its reasons and forms, as well as methods and directions of possible counteraction.

The hydrographic map is not only a scientific compilation aimed at recording the phenomena and water or water-farming objects. It presents relevant information that may contribute to proper management of water resources. The map contains elements which are necessary for the right solution to the problems connected with spatial and natural environment management. The hydrographic map may also be useful when solving such issues as: water supply, planning of housing settlements, industrial and service, and hydropower objects, preparation of spatial management plans, anti-flood protection strategies and possible levelling of flood results (Absalon, 1998; Absalon, 1999; Absalon, Jankowski, 1993).

The usefulness of both thematic maps in environmental research is unquestionable, and their complementary use guarantees comprehensive survey of issues connected with natural environment of a given area (Absalon, Jankowski, Leśniok, 1998; Absalon, Jankowski, Leśniok, 2001).

In Poland, these maps evoke greater and greater interest due to common software availability, because they are easy to manage, they are offered in

Fig. 9. Fragment of a digital hydrographic map with the MapInfo interface – explanations in the text.

both analogue and digital versions, and because there exists the possibility of immediate verification of data and bringing the map up to date, and adjusting the map to one's own needs.

The value of the map can hardly be overestimated, especially of the one made in the GIS system. It is these systems that are becoming an important analytical tool in the process of decision making (Jarzębińska, 1998).

REFERENCES

- Absalon D., 1998. Mapa hydrograficzna jako źródło informacji o gospodarowaniu zasobami wodnymi, [in:] Materiały IX Ogólnopolskiej Szkoły Gospodarki Wodnej, *Problemy wykorzystania i ochrony zasobów wodnych w aglomeracjach miejsko-przemysłowych*. IMGW, Warszawa, 7–13.
- Absalon D., 1999. Systemy informacji geograficznej (GIS) w badaniach dorzecza na przykładzie map hydrograficznych i sozologicznych, [in:] *Interdyscyplinarność w badaniach dorzecza*. Instytut Geografii Uniwersytetu Jagiellońskiego, Kraków, 191–199.
- Absalon D., Jankowski A.T., 1993. Mapa hydrograficzna jako źródło informacji o gospodarce wodnej w regionie górnośląskim. *Zeszyty Naukowe Akademii Rolniczej we Wrocławiu* nr 233, *Inżynieria Środowiska* IV, 263–272.
- Absalon D., Jankowski A.T., Leśniok M., 1998. Application of GIS for the estimation of the natural environment hazards (on the example of environmental maps), [in:] *Geographic Information Systems: Information infrastructures and interoperability for the 21st century information society. GIS Brno 98 Conference Proceedings*. Brno.
- Absalon D., Jankowski A.T., Leśniok M., 2001. Thematic maps in environmental and water management, [in:] *Proceedings GIS Polonia 2001*, Warszawa, 124–130.
- Absalon D., Jankowski A.T., Leśniok M., Kokociński P., 1998. Application of GIS for the estimation of the natural environment hazards on the example of Upper Silesian region, [in:] *Proceedings GIS Croatia 1998*, Osijek, 49–51.
- Jarzębińska T., 1998. *Możliwości zastosowania GIS w modelowaniu gospodarki wodnej w zlewniach rolniczych. Gospodarowanie wodą w zlewniach rolniczych*. IMGW Warszawa, 15–23.
- System informacji o terenie, 1997a. Mapa hydrograficzna Polski, skala 1:50 000, w formie analogowej i numerycznej, *Wytyczne techniczne K-3.4*. Główny Urząd Geodezji i Kartografii, Warszawa.
- System informacji o terenie, 1997b. Mapa sozologiczna Polski, skala 1:50 000, w formie analogowej i numerycznej, *Wytyczne techniczne K-3.6*. Główny Urząd Geodezji i Kartografii, Warszawa.
- Wytyczne techniczne K-3.6*. Mapa sozologiczna w skali 1:50 000. Ministerstwo Gospodarki Przemysłowej i Budownictwa. Departament Geodezji, Kartografii i Gospodarki Gruntami. Warszawa, 1990.

Translated by the authors