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THE APPLICATION OF GIS TECHNOLOGIES IN ENVIRONMENTAL MANAGEMENT AND SUSTAINABLE DEVELOPMENT IN POLAND

Mariusz Kistowski

University of Gdańsk, Department of Climatology and Environmental Management
Gdańsk, Poland

Introduction

In the light of experience of high developed countries, an application of computer geographical information systems to environmental management is universal and undispensable today. This situation, paralelly with objective factor as tremendous development of information technologies, results from exponential increase in environmental information quantity; it's impossible to process this information by traditional non-digital methods; acceleration of processing and decrease of GIS application costs; and increasing possibilities of computer software and hardware for data analysis (e.g. environmental modelling).

The beginning of professional application of GIS technologies in Poland was the turn of the 80th and 90th. It resulted from opening of the Polish market for influence of know-how and import of software and hardware from western countries. Althought, a few attempts to establish own spatial information systems were undertaken from the mid-seventies (Truszkowska, 1975), there were very limited, e.g. BIGLEB system (Podlacha, Ostrowski, 1990). In the second half of 80th, Institute of Geodesy and Cartography in Warsaw worked out the theoretical basis of SINUS system (Information System of Environmental Features) (Jankowski, 1990), still on account of simultaneously introduction to Poland proffesional GIS software, SINUS system had not wide practical application.

Althought the development of professional GIS in Poland have run last 10 years, the review of Polish experience in this field achieved in this paper lead to the conclusion, that Poland is still on the preliminary phase of GIS implementation. The characteristic feature of this phase is predominance of inventory application of GIS (Kistowski, Iwańska, 1997), connecting with analog-to-digital conversion. Applications in environmental management are still very poor (see Fig.1). This situation resulted from:

- low rate and lack of co-ordination of geographical data conversion to the digital form;
- low competence and responsibility of institution connected with GIS imple-

mentation on the state level and transfering the majority of responsibility on regional (voivodeship) level in 1999;

- long-term lack of obligatory topographical coordinates system and neglect in overworking of new topographical maps in large and middle scales;
- a weak competition at the comercial GIS market and low level of GIS services.

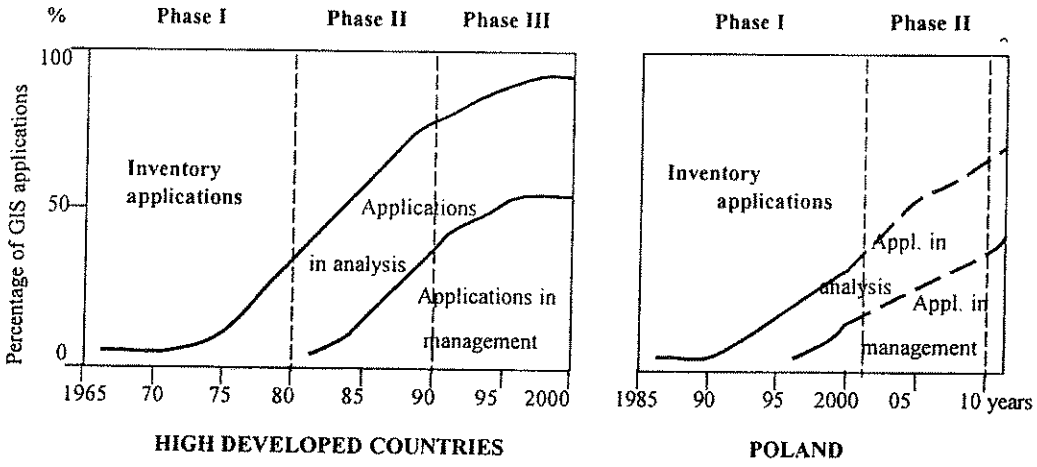

Fig. 1. Comparison of GIS applications development in high technology countries and Poland.

State level

Although it requires the smallest geographical scale of maps and the lowest level of accuracy, an application of GIS technologies to environmental management on the level of the whole country seemes to be the worst. This is an effect of many years neglection in creating theoretical and legislation basement for Polish State Geographical Information System. Except a few GIS databases established for the whole Poland in a small scale (1:500.000 – 1:1.500.000), there are very small number of digital spatial information layers, established for the country. For example, the new „Atlas of the Polish Republic" printed in mid-90th under supervision of General Office of Geodesy and Cartography (GUGiK), was not created with the use of the GIS software. On this background, the map of potential vegetation of Poland appeared as the great achievement. This 1:300.000 scale map was made using Intergraph GIS software in Polish Academy of Science, Institute of Geography and Spatial Organization. Unfortunatelly, this map is comercially accessible only in printed version.

But real problems concern digital spatial information according to large and middle geographical scales, from 1:10.000 to 1:200.000. Information with accuracy of these scales is required by many types of studies in environmental management and spatial develepment, such as:

- studies of spatial management conditioning and trends for communas and voivodeships;
- development plans for part of communas;
- national and landscape parks conservation plans;
- programmes of sustainable development and environmental protection of communas and districts;
- nature conservation programmes for forest divisions;
- environmental Impact Assessments.

The main problem is the lack of current topographical maps of middle and large scales, which should be a baseis for establishing future GIS databases. Nearly all Poland is covered by topographical maps in scales 1:10.000 – 1:50.000 in two coordinates systems: GUGiK 1965 (former civil system) and 1942 (former military system). Still these maps present non-actual information from 1975 - 1985 period. For several last years, the new topographical maps 1:50.000 were created by GUGiK in a new coordinate system 1992, according to European coordinate system (UTM). Still these maps exist only for about 20% of country area, mainly for central and southern part of Poland. Similar is the situation related to 1:10.000 maps. There is no plan to realise 1:25.000 maps in 1992 coordinate system. Althought these maps are prepared in digital version (by different GIS software, e.g. Microstation, MGE Intergraph), General Office of Geodesy and Cartography, which was responsible for establishing these maps to the end of 1998, was interested only in paper version, not in digital. So, there is no integrated resources of particular digital topographical vector data for Poland still. Additionally, the uniform and scanned with high resolution set of 1:50.000 four-colour topographical maps in 1942 coordinate system was prepared just in the beginning of 1999. The scanning was carried out in the Warsaw Technical University for the purpose of the new administration borders vectorization on the order of European Union Headquarter. Althought these digital raster maps have some disadvantages, they can and should be a basis for creation thematic digital vector layers (maps) for all country and new voivodeships. This raster maps are so important, because there is no project or scheme of GIS establishment for all country. Now, the most important task is to create all new topographical maps for Poland in digital vector form and treat digital maps identically with paper (analogue) maps.

For the country area, basic geographical scale of digital maps required for environmental management and sustainable development is 1:50.000. Such maps are prepared in digital version since 1993, but they covered a small part of country. The topographical maps in 1942 projection are the basic maps for them. Thematical environmental layers are presented on this background. Actually, there are five types of these maps:

- sozological (presenting sources and effects of environmental deterioration and protection areas);
- hydrographical (mainly information of surface waters and water management);
- geological (with two types presenting solid and drift geology);
- hydrogeological (mainly information about subsurface waters and their contamination);

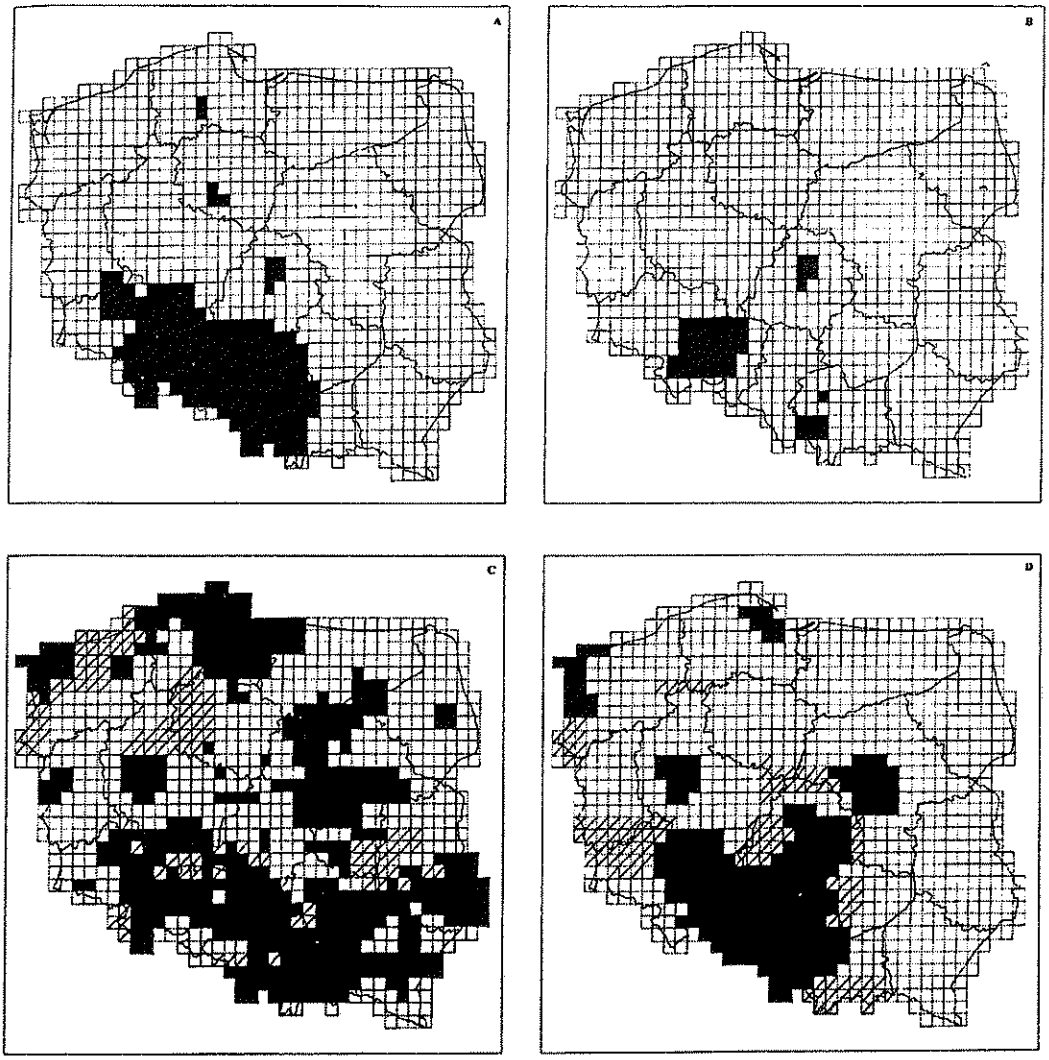

Fig. 2. The area covered by thematical environmental maps in digital form in Poland.
Type of map: A - sozological; B - hydrographical; C - hydrogeological; D - geological-economic.
(grey colour – sheets compiled to the end of 1998; hachure – sheets planned to compile in 1999).

- geological-economic (mineral resources and different information for spatial planning).

The General Office of Geodesy and Cartography was responsible for compiling sozological and hydrographical maps to the end of 1998. In this period, from 1075 sheets of 1:50.000 map covering all country, GUGiK worked out 165 sheets of sozological map in digital version (with application of MapInfo GIS software) and 42 sheets of hydrographical (see Fig. 2 a,b). From the beginning of 1999, the compilation of these maps belongs to new voivodeship authorities. State Geological Institute is responsible for compilation of three next maps types. Geological maps (solid and drift) are established by means of ARC/INFO software (Gogołek et al., 1997) and hydrogeological (Fert et al., 1997; Piłat, 1997), and geological-economic maps (Lewandowski, 1998; Sikorska-Maykowska, Strzelecki, 1998) by means of MGE Intergraph GIS software. The area covered by these maps is shown in Fig. 2 c/d.

Althought the importance of these maps for environmental management is significant, many factors caused that their utilization is not as wide as possible. These factors include:

- slow rate of map compiling (particulary hydrographical);
- duplication of many elements on different types of maps (for example sozological and geological-economic);
- difficult access to digital version of these maps.

A significant is lack of spatial-geoecological digital information in middle and large scales. Althought there is a land cover map of Poland, compiled in scale 1:100.000 based on satellit images from Landsat TM by means of ARC/INFO software, as the element of CORINE LandCover database, but source images for this map were scanned on the turn of the 80th and 90th. The information about forest and soils is very important for landscape ecology studies, too. Unfortunatelly, State Forest Board just in this year start to organize the State Forest Information System (SILP) (*Biuletyn Informacyjny...*, 1998). Institute of Agriculture, Fertilization and Soil Sciences in Puławy (IUNiG) plans to convert analogue soil maps of Poland (1:25.000) into digital form in near future. The problem is that a few institutions establish digital-spatial databases based on their own, non-compatible software. The example of such system is Information System of Industry Pollutions of Arable Lands, compiling in Institute of Land Reclamation and Grasslands (IMUZ) (Ostrowski, 1996).

Althought, it is possible to realise a simple analysis on the base of small scale spatial databases (see Fig. 3), these analyses are rather the intellectual games than a serious research helpful in environmental management. Figure 3 shows that the the administrative and natural borders are the most coincidence in the nort-eastern part of Poland. It can resulted from low level of anthropogenic pressure and high respect of man activity to natural conditions.

However, it's important to begin the discussion among physical geographers and landscape ecologists concerning compiling digital geoecological map of Poland in scale 1:50.000, presenting spatial landscape units and ways of their utilization.

In the light of the above described situation, there is no possibilities for high developed applications of GIS in environmental management. The most successful applications are:

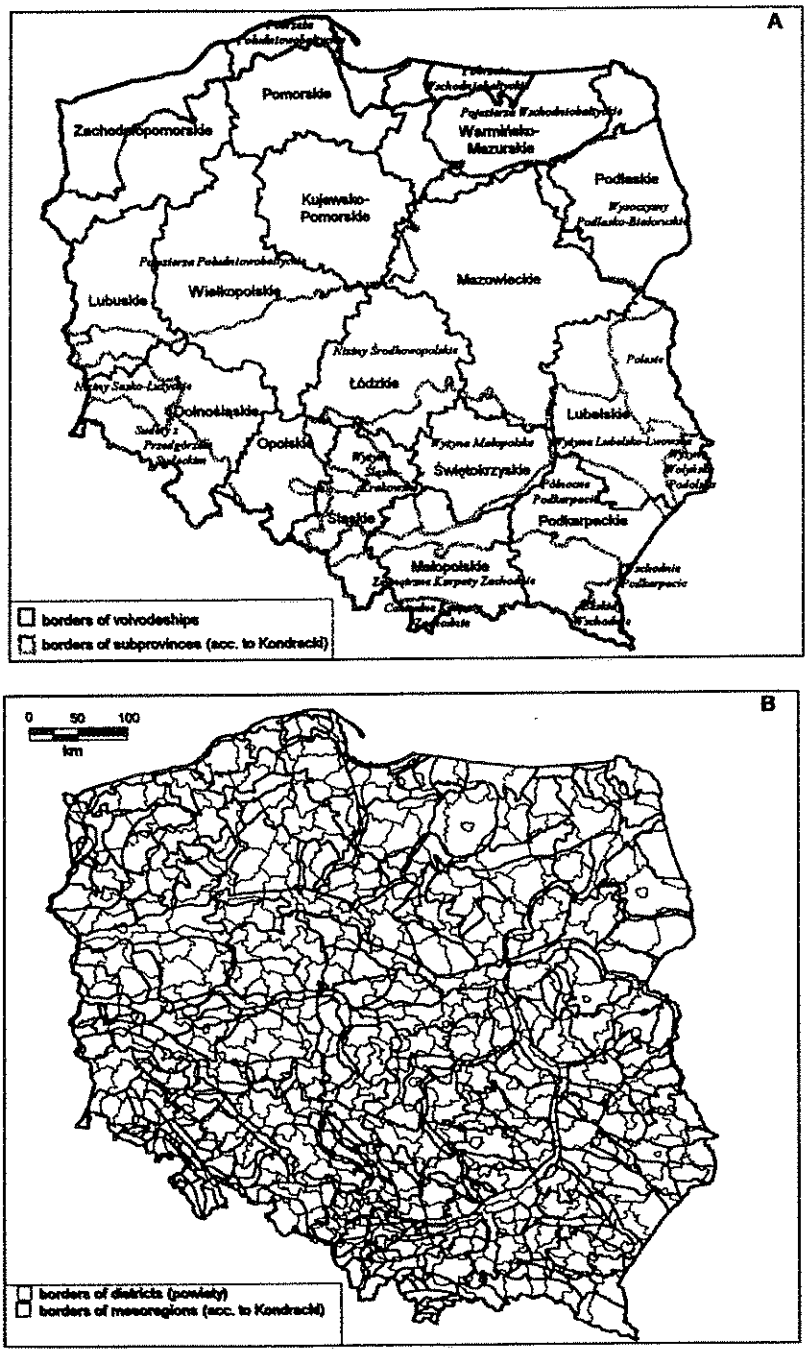

Fig. 3. Comparative analysis of anthropogenical (administrative) and natural (geoecological regions) borders in Poland: A - voivodeships and subprovinces; B - districts (powiaty) and mesoregions (according to Kondracki).

- the State Forests Fire Protection Information System;
- databases of hydrogeological conditions and mineral resources established by State Geological Institute;
- regional systems of air pollution monitoring and prediction (e.g. so named „Black Triangle" in the south-western part of Poland).

However, the application of geographical information systems in environmental monitoring is still not satisfactory.

Regional level – case study: Pomeranian Voivodeship

According to GIS implementation at the state level, the situation at regional level is more differentiated, but generally not better. It is presented on the example of new Pomeranian Voivodeship, established on the 1st January 1999 out of former Gdańsk, Słupsk, Elbląg and little part of Bydgoszcz Voivodeships. For the purpose of existing spatial digital information recognition, special questionaire was mailed to over 30 state and private institutions in Poland. About half of them answered this questionaire. Additionally, the author interviewed representantives of many institutions. It was found that situation of spatial digital information for Pomeranian Voivodeship is unsatisfied and worse than in many other voivodeships. There are not many sources of information and existing information is unintegrated, e.g. digital information is gained from maps in different scales, projections and periods of their compiling. In some cases, integration of different databases is impossible or useless on account of high costs of this process.

The databases compiled by means of MapInfo GIS software are the fundamental sources of spatial-digital information for Pomeranian Voivodeship: about 60 data layers established for former Gdańsk Voivodeship on the base of GUGiK 1965 coordinates system with accuracy of 1:25.000 & 1:50.000 scales; the author of this paper presented these layers, concerning mainly natural environment, in the form of printed and digital atlas on the CD (Kistowski, 1998);

- about 20 layers established for former Słupsk Voivodeship by the planning office in Słupsk on the base of 1942 coordinates system with accuracy of 1:50.000 scale; unfortunatelly, it is impossible to fit this spatial information to other databases, on account of mistakes in coordinates registration; these layers concerning mainly environmental and administration features;
- a few layers for former Elbląg Voivodeship compiled for the planning office in Elbląg on the base of 1942 coordinates system with accuracy of 1:50.000 – 1:100.000 scales;
- about 30 layers established for Regional Board of Water Management in Gdańsk (RZGW), concerning mainly water management (watersheds, rivers, lakes, underground water tables) in 1942 coordinates system with accuracy of 1:100.000 scale.

Among thematical 1:50.000 maps compiled by State Geological Institute, Pomeranian Voivodeship has in GIS version such maps as:

- 10 sheets of geological map;
- over 80 sheets of hydrogeological map;
- 8 sheets of geological-economic map.

The above presented state of regional spatial-digital information is completed by a few projects of consulting companies (e.g. compilation of colour satellite images from SPOT according to the 1:50.000 scale). These projects concern usually very strict topics or little parts of voivodeship. Generally the number and quality of spatial-digital information are insufficient.

Local level

The success at the local level is the key to implementation of GIS technologies in environmental management and sustainable development. Except enormous (catastrophical) natural processes as floods or long-distance air pollutions, the environmental management is the most effective at the local level, so GIS systems should have here the widest application. The practical experience approved this thesis. More and more geographical information is processed to the digital form during compilation of conservation plans for national or landscape parks and after that, the boards of these protection areas use this information for environmental management. Sometimes, Geographical Information Systems are used in environmental impact assessments. Local authorities begin to perceive the necessity of possessing data about own region in digital form. Computer data are required for physical planning and management of commune or district areas.

The applications of GIS technologies for environmental modelling is rare in Poland, because it requires writing sophisticated application programs and co-operation between geographers or ecologists and computer scientists is still not satisfied. However, more and more GIS are used for environmental studies concerning inter-relations between natural environment features, level of anthropopressure and degradation of the nature (e.g. Kistowski, 1997, Graniczny et al., 1998) (see Fig. 4). At the local scale, more of GIS databases are established with accuracy of 1:10.000 scale, sometimes 1:25.000.

Conclusions

The general review of Polish GIS implementations in environmental management and sustainable development lead to the following conclusions:

- on account of a big chaos in creation and application of environmental GIS databeses, it is recommended to establish an institution (the focal point) for co-ordination of GIS databases at state and regional levels out of the geodesy-cartographic survey;
- it is very important to accept the whole country standard of digital map, the best in scale 1:50.000; this map is necessary as the raster background for vectorizing thematic layers; it should be registered in the popular projection and generally

Fig. 4. The simple analysis of underground waters quality according to relief and types of land use (the northern part of Pomeranian Voivodeship).

easy to access for a low costs;

- on account of dominating market position of such GIS software types as: MapInfo, ArcView – ARC/INFO and MGE Intergraph, projects and studies in environmental management should be realised by means of these types of software or other types compatible with them;
- the participation of Polish landscape ecologists and complex physical geographers in development of GIS in environmental management is too poor; they should be more active, especially in the field of geoecological data processing into digital version.

References

Fert M., Jakubicz D., Piłat G. (1997): *Edycja komputerowa Mapy Hydrogeologicznej Polski (MHP) w skali 1:50.000 w Systemie Informacji Geograficznej* (Computer edition of the 1:50.000 Hydrogeological Map of Poland in GIS). Przeg. Geolog., 45, 9, pp. 914-919.

Gogołek W., Jurkun A., Zielke J. (1997): *Program komputerowego opracowania Szczegółowej Mapy Geologicznej Polski w skali 1:50.000* (Program of computer aided production of the 1:50.000 Detailed Geological Maps of Poland), Przeg. Geolog., 45,2, pp. 201-207.

Graniczny M., Kowalski Z., Zachowicz J. (1998): *Studium geośrodowiskowe Zalewu Wiślanego i jego otoczenia przy wykorzystaniu nowoczesnych technik kartograficznych* (Geoenvironmental study of the Vistula Bay & its sorrounding using modern cartographic techniques). Przegl. Geol., 46, 12, pp. 1254-1260.

Jankowski R. (1990): *Przesłanki tworzenia systemu informacji o środowisku* (The basement of Environmental Information System establishing). In: *System informacyjny o środowisku przyrodniczym.* CPBP 04.10., 52, pp. 21-37.

Kistowski M., Iwańska M. (1997): *Systemy Informacji Geograficznej. Podstawy techniczne i metodyczne. Przegląd pakietów oprogramowania i zastosowań w badaniach środowiska przyrodniczego* (Geographical Information Systems. Technical & Mehodological Principles. Review of GIS software & applications in environmental studies). Bogucki Wydawnictwo Naukowe, Poznań, p. 189.

Kistowski M. (1997): *Zastosowanie metod GIS w monitorowaniu środowiska przyrodniczego* (Application of GIS methods in environmental monitoring). In: *Monitoring podstawą obiektywnej oceny jakości środowiska.* Mat. seminarium naukowego, Borucino, pp. 70-78.

Kistowski M. (1998): *Cyfrowy Atlas Środowiska Przyrodniczego Województwa Gdańskiego* (A digital Environmental Atlas of Gdańsk Voivodeship). Wydawnictwo DJ, Gdańsk, p. 62.

Lewandowski P. (1998): *Struktura bazy danych Mapy geologiczno-gospodarczej Polski w skali 1:50.000* (The database structure of the 1:50.000 Geological-Economy Map of Poland). Przeg. Geolog., 46,10, pp. 1060.

Ostrowski J.: *Zastosowanie w rolnictwie – SIP o inwentaryzacji zanieczyszczeń*

przemysłowych (Application in Agriculture – SIS of industry pollutions inventory). In: *Systemy Informacji Geograficznej - GIS w praktyce.* Centrum Promocji Informatyki, Warszawa, pp. 103-110.

Piłat G. (1997): *System Intergraph w realizacji Mapy Hydrogeologicznej Polski (MHP) w skali 1:50.000* (Intergraph system in realisation of the 1:50.000 Hydrogeological Map of Poland). Przeg. Geolog., 45, 9, pp. 926-931.

Podlacha K., Ostrowski J. (1990): *Przegląd opracowanych w Polsce systemów informacji przestrzennej (*A reviev of Polish spatial information systems). In: *System informacyjny o środowisku przyrodniczym.* CPBP 04.10., 52, pp. 9-20.

Sikorska-Maykowska M., Strzelecki R. (1998): *Stan i perspektywy realizacji programu Mapy geologiczno-gospodarczej Polski w skali 1:50.000* (State & perspectives on the 1:50.000 Geological-Economy Map of Poland realisation). Przeg. Geolog., 46, 10, pp.1061-1062.

Truszkowska R. (1975): *Problematyka programu projektowania i wdrażania w Polsce systemu monitoringu środowiska człowieka* (The program of projecting & implementation of man's natural environment monitoring in Poland). Biuletyn IKŚ, 6-7, pp. 52-67.