GIS Education: the Example of Medical Geography

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Abstract

Two approaches can be distinguished in medical geography in Poland, after Mazurkiewicz and Wróbel (1990): ecological and social. In the opinion of the present author, who takes the ecological approach, it rests on the well-documented statement that the distribution of many diseases displays a marked spatial regularity. This means that, apart from internal factors determining the status of the human organism, there are also external factors to be found in the natural and social environments that surround it. Hence, the ecological approach is concerned with the distribution of diseases and the influence exerted on them by components of the natural environment, or speaking more broadly, the geographical environment.

New prospects and possibilities have opened up in modern studies of the geographical environment as a result of advances in computer techniques of database compilation for thematic maps. A wide range of information about the state of the natural environment necessary in medical-geographic research is offered by a sozological map at a scale of 1:50,000, which also implements the basic functions of geographical information systems (GIS). The contents of the map are presented at five information levels (forms of environmental protection, degradation of the individual components of the environment, countermeasures against environmental degradation, reclamation of the environment, and wasteland), composed of a total of about 60 thematic layers. The objects and phenomena presented in the particular layers are connected with a database. The digital version of the map is ideal source material for multicriteria analysis and an assessment of the level of pollution of and threats to man's natural environment.

The application of GIS in medical geography, especially the creation of databases on the environment and health status of the population (morbidity, mortality), facilitates research and the presentation of results. It also opens up new possibilities of inquiry into relations between the state of the natural (geographical) environment and human health.

Introduction

The influence of the natural environment on human health in its various aspects is the subject of interest of various scientific disciplines: ecomedicine (medical ecology, ecology of health), toxicology (mainly environmental toxicology or ecological toxicology), epidemiology or medical geography, the latter represented by the author of this paper.

Medical geography understood in its general form is concerned with illustrating phenomena related to morbidity or mortality, as well as an analysis of risk factor distribution, all this through use of the extensive research apparatus of geography, particularly GIS techniques.

The following paper includes one of the elements of the GIS educational program related to a Geography major based on the example of medical geography within the subject matter of the course "Environmental Health Hazards," taking advantage of subject matter from another subject area: "Sozology and its Tasks."

Aim

The main educational aims of the subject "Sozology and its Tasks" is to acquaint oneself with the sozological map in its analog and digital form, analysis of its subject matter, on the basis of the map of data of creating indices describing the state of environmental pollution and hazards along with their visualization, all this done by means of GIS computer techniques. The aim of education within the subject "Evironmental Health Hazards" contains an analysis of morbidity and mortality data, constructing negative health factors (morbidity and mortality factors), their visualization, together with seeking relationships between the state of the natural environment and the state of human health, all this by means of GIS techniques and methods.

Methods

Due to the fact that medical geography combines in itself both geographical content (in this case, concerning the state of environmental pollution and hazards or the quality of the environment in a given area), including medical qualities (in this case, concerning wholesomeness re: the state of health of the inhabitants in the area being investigated); hence, this research has a dual nature.

The first part of the conducted research concerns an analysis and evaluation of the health situation. The data base is comprised of unpublished medical statistics conducted in hospitals (e.g. Regional Cancer Registry), clinics or detailed registers from the Central Statistics Department (*GUS*) or v*oivodship* statistics departments (insofar as these are available) as well as routine information sources – statistical data published in Polish voivodship statistical yearbooks and environmental protection or medical bulletins. Available data bases are most often employed in the teaching process. At the same time, it should be stressed that new detailed ones should be obtained from hospitals and clinics, as those necessary for realizing research aims in Masters or doctoral theses. These data form the basis for formulations employed in epidemiological research or medical geography, so-called negative measures of wholesomeness, reflecting its lack, hence the existence of various types of pathological phenomena, diseases or their results in the form of temporary work inability, chronic disability or death.

The choice of measures (parameters) is hardly random. These are measures, which reflect in a significant way negative health results, and result due to various chemical substances (pollution and hazards to the natural environment). The following (Dutkiewicz T., 1997) factors have been accepted, on the basis of which individual traits of specific areas of research are chosen:

- the percentage of births with a body mass at birth (below 2500 g),
- the mortality quotient among newly-born infants,
- the mortality quotient of infants with a low bodily mass at birth,
- the individual quotient of mortality among infants due to specific causes:
  a) due to inherent defects,
  b) due to a slow development of the fetus,
  c) early mortality (up to 1 month),
  d) late mortality (later than 1 month),
- mortality quotient due to diseases in various age groups,
- quotient of premature mortality(up to 65 years of age) due to diseases, in consideration of the age,
- unique mortality quotients specifically due to so-called diseases of civilization, mainly:
  a) diseases of the circulatory system,
  b) malignant carcinomas generally: malignant carcinomas of the trachea, bronchi, lungs, stomach, leukemia and other,
  c) diseases of the respiratory system,
  d) chemical traumas and toxemias.

It should, however, be added that a very good indicator evaluating the situation of wholesomeness of a given area are factors of specific morbidity, according to given causes, although data on the basis of which these have been formulated are not always available.

The above factors are analyzed according to sex, in various age categories as well as taking into account residence localization (according to administrative divisions of the country, e.g. on the basis of *voivodships* – at a general level, according to local communities – at the specific level). A subsequent phase in the evaluation of the wholesomeness of a given area is the classification of measures used in its determination, which allows for the indication of largest and smallest risk areas of morbidity and mortality, and in the same, appointment of areas for further, individual research. The end effect is a cartographic visualization of data in the form of cartograms, indicating spatial structures (J. Brzóska, 1998)..

Education of students in GIS within the subject “Environmental Hazards to Health” is based among others on making use of existing data bases concerning morbidity and morbidity, creation of new and detailed data bases, particularly as related to those particular areas, their analysis, creation of numerous factors illustrating the state of morbidity and mortality among the human population inhabiting a given area due to particular diseases (e.g. diseases of civilization), dependent in part on the quality of the natural environment. An important skill, which students acquire in the course of the above classes is the previously mentioned cartographic visualization of various factors by means of cartograms, showing the spatial distribution and density of given phenomena. A skilful choice of a proper number of classes of factors and methods of their classification is very important.

The second part of the conducted research concerns analysis and evaluation of the natural environment, both as regard as natural advantages as well as pollution or hazards. The natural environment is here understood as "the natural elements in general, *i.e.* abiotic and biotic ones, found in both the natural state as well as that transformed by human actions, strictly connected and in a specific state of mutual interaction and conditioning, existing in a constant state of flux and transformation" – T. Bartkowski (1980). Thus an evaluation of the state of the natural environment must be based on a reliable supply of information concerning the state of its individual components and their properties, as well as anthropogenic factors, shaping this state.

New prospects and possibilities among contemporary research of geographical environment appeared with development of computer techniques of creating databases for thematic maps. Sozological map at scale 1:50 000 in analogue and digital version include wide range of information about condition of the environment essential for medical geography research, with simultaneous realization of primary GIS functions.

The sozological map is a thematic map presenting the state of the natural environment, together with the causes and effects, both detrimental and beneficial, of changes occurring in this environment under the influence of various kinds of human activity, as well as ways of protecting its natural qualities. The methodological assumtions underlying the construction of sozological maps include studies concerning the registration, location, identification of the source, kind, range, character and intensity of all disturbances, pollution and contamination of the air, ionisation, radioactive and microbiological hazards, pollution and contamination of surface- and groundwater as well as sea water, disturbances of natural water conditions, artificial water deficit, destruction and transformation of the relief, destruction and contamination of soils, devastation of plant cover, offensive odours, industrial and municipal waste, noise, vibrations, and landscape devastation (Żynda S., 1999).

An integral part of each sheet of a sozological map is a commentary placed on the reverse side or in a separate brochure prepared by the map's scientific consultant. It contains a brief physical-geographic and economic characterisation of the area in question, supplementary data and an explanation of the particular information levels of the map (tables, diagrams), a general assessment of the state of the environment and degree of its degradation, indications concerning environmental planning and protection, and other relevant pieces of information.

The main quality of this map is also its layered structure. It allows gathering of a large amount of data in an ordered fashion (each of the elements of the map's content can be placed in another layer). Thanks to this, it is possible to randomly configure the appearance of the map, choosing combinations of layers of interest to a given user.

The content of the map consists of six information levels in distinctive colours against the grey background of a base topographic map. These levels include:

- Forms of environmental protection,
- Degradation of environmental components: degradation of the land surface, soils, woodland, surface water, groundwater, and air; investments noxious to the natural environment,
- Counteracting environmental degradation,
- Reclamation of the environment,
- Wasteland,
- Supplementary symbols (Jankowski A.T. and others, 1997).

Since 1994 a digital sozological map has been prepared, beside an analogue one. It is being constructed under the MapInfo for Windows system, which has become a fully professional tool for digital map preparation after it had been enriched with a few new applications and tools. The latter include many editing tools, symbol libraries, and tools for colour separation, exposure of printing diapositives, and analogue map printing in accordance with the K-3.6 Technical Directives. An important argument for the choice of the MapInfo system is its low price (in comparison with other GIS packets) and its undemanding hardware requirements, which makes the ranks of its users swell substantially.

The digital sozological map is made up of almost 60 thematic layers complying with the K-3.6 Technical Directives. Additionally, such elements have been introduced as roads, railways, the hydrographic network, boundaries of built-up areas, and the administrative division. Objects and phenomena presented in the particular layers have links to a database. This offers the possibility of their more detailed characteristics, both quantitative and qualitative.

Like its analogue counterpart, the digital map has been constructed in a "92" co-ordinate system and fulfils all the cartographic requirements. Besides, its users can avail themselves of the following options: a fast access to data and their update, viewing the map at an arbitrary scale, editing only selected layers, thus enhancing map readability, defining their own layers on any theme, and combining several sheets into a single one. The map or its fragment can be readily printed by a printer or plotter. The map's graphic

image can be transformed into different co-ordinate systems. Recognising the fact that several GIS packets are currently in use, tools have been designed to export the map to other systems (Jankowski A.T. and others, 1997).

The Polish sozological map at a scale of 1 : 50 000 allows a scientific, objective, and hence correct assessment of the current state of the natural environment, its pattern of change and transformation, and further directions and extent of man's permissible interference with the environment.

Education of students in the course of GIS within the subject of "Sozology" is based, among others, on constructing data bases, recognizing individual phases of creating subject areas, their analysis as well as on the basis of creating numerous indices (measures) showing the state of environmental pollution and hazards of a given area. Of course, it is also possible to make use of skills acquired earlier in creating cartograms, presenting spatial distribution of environmental pollution and hazards of particular spheres, i.e. the atmosphere, hydrosphere, lithosphere, biosphere, etc. or individual qualities of the natural environment.

The appearance of such an ample research tool for the natural environment (a sozological map in its digital version), being at the same time a subject of research, initiates various attempts of developing a methodology of evaluating the state of environmental hazards and pollution based on a digital map employing and indexed evaluation.

Based on a thus obtained data base, it is possible to develop cartographic indices – statistical (measures), allowing for a diagnosis of the state of pollution and hazard to particular components of the natural environment of the investigated area (Fagiewicz K., 2001).

A complement to data bases of the natural environment in the above aspect contains information contained in Statistical Yearbooks of the Environmental Environment or in the currently systematically being published in each *voivodship* "Reports on the State of the Environment...". , showing much quantitative and qualitative data.

In the final phase of the research process, an attempt can be made to show possible relationships among factors describing the state of health of the population, in effect its lack, together with parameters (measures) reflecting the state of the natural environment (environmental quality). One possibility is the use of a correlation matrix of analytical factors (Pearson correlation factors). An analysis of correlation factors allows the showing of factors indicating a significant relationship.

The above research methodology may also be considered as another of the phases of the educational process employing GIS techniques.

Conclusions

The application of GIS in medical geography, especially the creation of databases on the environment and health status of the population (morbidity, mortality), facilitates research and the presentation of results. It also opens up new possibilities of inquiry into relations between the state of the natural (geographical) environment and human health.

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