

BAY OF BAKAR

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ABSTRACT

The paper emphasizes results of working at the project which deals with the environmental geographical information system for the area of the Bay of Bakar, Croatia. The Bay of Bakar is one of the most polluted area in Republic of Croatia, as a result of uncontrolled industrialisation in the period after the Second World War. Semantic model of environmental GIS with respect to natural, geographic and socio-economic characteristics, as well as cultural and historical heritage of the area is projected.

1. INTRODUCTION

The study region is the Bay of Bakar, Croatia. This region was chosen because it has a very complex situation from the aspect of solution of the environmental protection problems. Regarding its natural properties, the Bay of Bakar is one of the most picturesque bays at the North Adriatic Coast. It belongs to the area of Kvarner aquatorium, but there is also one part of the Bay of Rijeka involved. Being the monument of the first category of protection, a true beauty of nature, with cultural and historic heritage, today is one of two worst polluted and endangered areas in the Republic of Croatia, wich has been caused by uncontrolled industrial development in 60's and 70's.

Bakar, a free royal town and a port, whose history reaches as far as the Roman times, when the area of today's Bakar was the site of the town Volcer, was cultural, political and economical center of Croatia during the centuries. In the Middle Ages Bakar was a very important town and county district. The 17th century brought the revival of the trade dealing with specialized export of iron goods, and significant maritime and shipbuilding development. In the 18th and 19th centuries it was the biggest Croatian town and harbour. It used to have even more inhabitants than Zagreb and Rijeka together.

The devastation of the Bay of Bakar started at the middle 1970's. The depth of the sea has predetermined the usage of the area for special harbour activities, because it is possible to moor the ships of deep draught. The creation of modern harbour equipment for the manipulation with the scattered cargo, has initiated the devastation and degradation of the Bay area regarding the spatial aspect, as well as the ecological and historical aspect.

After establishing the harbour position, the idea about the incorporating paleo-industry into the Bay of Bakar was developed gradually, and then the coke plant was built. Industrial development brought new industrial equipments of 'black industry' and new pollutants into this area which has extremely valuable natural characteristics, traditional urban and historical properties.

Today, Bay of Bakar is a typical industrial area with exclusively classical industrial structure, which has relatively low technology and market flexibility and adaptability - production of petroleum products, coke industry, thermo-electric power plant, transshipment service (harbour) and production of chemicals. Besides permanently present sources of pollution, resulting from technological processes, there is a constant potentiality of accident with disastrous effects for people and environment (explosion, poisoning).

Bad impact of air and sea pollution on human health and complete life in this extremely polluted district is evident. INA Refinery, Coke Plant and Thermo-electric Power Plant, the biggest pollutants, transmit over 50 different substances which are dangerous for people and health and nature, and caused emigration of autochtonous population. Changes in demographic structure, air and soil pollution, pollution of the water and sea, noise of the factory ventilators, visual pollution and radio-active radiation which also caused specific poor state of respiratory system health of local population, are the reason why market price of real estates decreased drastically and the residential fond is almost ruined. Objects of architectural worth are abandoned and exposed to decay.

After researchments performed in last few years, it becomes obvious that coke industry was the biggest pollutant in the Bay of Bakar, but influence of all other industrial installations is not negligible. Deteriorated living conditions of the local inhabitants, degradation of the precious space and natural environment, became evident. Realizing the critical state caused by the spatial and ecological failure, the district of Rijeka has been conducting very resolute politics for several years aiming to close the coke plant down and to find out a new possibility to change the economic structure of some existing capacities and to estimate the possibility of substituting the existing activities and purposes with new contents, with respect to its economical and ecological requirements.

With industrial development mechanical flux of inhabitants became, which caused additional difficulties with communal infrastructure. At the relatively small area, residence, agriculture, touristic contents, urban life and roads, air and ship traffic, and industry enter into conflict. But, relevant data about area are incomplete. One of the main problems is ignorance of consequences. There are no chronological, objective and reliable data about influence of pollutants on the environment nor on the people and their health.

Imperriled are air, soils, sea, drinking water, vegetation and human's health. It is obvious, that to protect the area, before all actions demanding alteration of the condition of the area, it is necessary to know what exactly is wished for to change. For effectively definition of the problem, it is necessary to show a deviation of the normal condition, of the condition which existed before or it exists in some other similar environment. Reliable data about that space must be at disposal.

In order to become in situation of possessing the reliable data which could be used as a support for decision making, it is necessary to establish system of:

- a) monitoring of the meteorological parameters,
- b) monitoring of emission parameters,
- c) monitoring of imission parameters,

and project information system which should contain, and manage all these data together, and through analyzing the interaction between different data and different parameters be able to produce new interesting information .

2. ENVIRONMENTAL GIS

The GIS facilitates the analysis of complex environmental issues by allowing the interactions and impacts of contaminants on soil, air, water, and so forth, to be considered simultaneously, and results should be that stuff in multiple program areas who seldom have the opportunity

to work together can readily access each other's data. These regulatory data can be linked with other natural resources, demographic, or reference data to bring all this information to bear on daily programmatic decisions.

Environmental models can be integrated with geographic information systems to improve our knowledge of environmental science and management. A geographical information system (GIS), running on a fast new generation workstation, can provide the appropriate modeling platform for formulating and running sophisticated environmental models. Many of the necessary capabilities are now widely accessible from GIS platforms including abilities to construct or import digital elevation models, to integrate diverse databases for input and output, to access viewshed analyses algorithms and harness the computational power required for complex calculations (Dubayah, Rich, 1995).

Geographical information system is now much more than just a means of coding, storing and retrieving data about aspects of the Earth's surface. In a very real sense the data in geographical information system model the real world. As these data can be accessed, transformed and manipulated interactively in such a system, they can serve as a test bed for studying environmental processes or for analyzing the results of trends, or for anticipating the possible results of planning decisions. By using the geographical information system it is possible for planners and decision makers to explore a range of possible scenarios and to obtain an idea of consequences of a course of action before the mistakes have been made irrevocably in the landscape itself.

Defining systems of representation based upon the identification of entities and their relationships, leaves many questions unanswered about how entities and their behavior are recognized and structured in environmental science. Data models express theories predicting the structure of real world domain in terms of entities and their attributes organized in inter-related sets. One of the basic problems encountered when 'coupling' environmental models with GIS is that the former are specified as process models while the latter are specified as data models. Process and data models can be linked when implemented in object-oriented systems (Raper, Livingstone, 1995).

The process of developing systems usually begins with analyses or knowledge engineering. The results of these can be expressed in the form of a model known as a conceptual model. This conceptual model seeks to capture the essential elements of the real world of interest to the problem. Semantic data models were developed in the late 1970's specifically to make database design more accessible to non-database specialists, such as users, conceptual designers and even application specialists (Sussman, 1993). Basically, these models aim to capture the meaning of the data in more or less formal way, so that

database design can become systematic and the database itself can behave intelligently.

3. GIS OF BAY OF BAKAR

3.1. Air

The biggest problem in the Bay of Bakar is air pollution (emission). The atmosphere of the eastern part of Rijeka, respectively, closer and wider area of Bay of Bakar, is effected by the sources of the emissions of various gases and suspended particles from that very area, and from wider territory, too. The most important influence comes from Oil Refinery Rijeka, Power Plant `Rijeka` and the Coke Industry Bakar which has been removed a few months ago, but consequences of its presence in the bay are still there. Emissions of the injurious substances are the most significant parameters which effect to the air pollution in the zone of influence of emittants.

Favorable conditions for the closer and wider area of the Bay of Bakar, from the aspect of the aquitance of the air quality of that area, is the network for the air quality measurements around the Bay of Bakar. Program of the measurement comprises the measurements of the basic pollutants (sulphur-dioxide, smoke, sediment) as a common indicator of the air pollution from the dominant sources of the area, and specific pollutants of the air (nitrogen-dioxide, ammonia, phenol, hydrogen-sulfide, index PAU), which are characteristic emission from the industrial installations (refinery, coke industry, etc.). In consideration of the program of measurement mentioned above, it is noticeably that basic indicators of the air pollution are observed daily, continuously, whereas some specific pollutants, because of complexity and expensiveness of analyzes, were measured at a certain number of places every second, forth or sixth day. It has to be remarked that observations performed every sixth day are considered as minimum annual program of measurements which gives representative image about the distribution of frequency of particular pollution concentration in the air during the year.

3.1.1. Cadastre of SO₂ emissions

Organized set of data about emission named `Cadastre of emission` gives spatial disposition of emission and comprises data about sources of emission, their physical characteristics and quantities of injurious substances outlet into the atmosphere. By the knowledge of emission, application of model of dispersion and results of measurements of pollution, determination of efficient strategy for air protection of certain area is enabled.

At the urban area, a large number of various inorganic and organic noxious substances, which are the consequences of human activities or which are of the natural origin, exist in the air. From the industrial stoekholds noxious substances are also emitted. Cadastre of SO₂ is given by measurement of substances which cause contamination, in the chimneys before they are going to be let out in the atmosphere, whether by estimation of emission on the basis of fuel used up, sulphur comprised in fuel and coefficient of emission. With the other gases which are product of burning out of the fuel is the same case. Emissions of the suspended particles are determined by measurement. Emission of other contaminators is determined by estimation.

There are two different ways how the cadastre of pollutants can be organized due to data of emission:

1. all relevant data about pollution are related to the individual source of pollution (e.g. Thermo-Electricity Power Plant, Coke Industry, groups of houses, roads, etc.);
2. all pollutants are related to the eight different substances which cause the pollution;
3. all pollutants are related to particular measuring station .

So, managing the data about the pollution, nevertheless which one of models proposed above, is the spatial problem, so , cadastre of emission my be incorporated as an integral part into the environmental GIS.

It is important for the area of Bay of Bakar, because, measurements of emission in last ten years exist, as the measurement about degree of pollution before the Coke Plant was built, too. Data are in analog form and they are not convenient for manipulation by the computer. But if geographical information system should be established, and analog data converted into the digital form, lot of analyzes should be done, especially the comparison of the two stages of the area, before the Coke Plant existed, and during the period when coke industry was in function.

3.2. Impact of the air pollution to inhabitants health

It is founded out correlation between presence of certain niveau of particular pollutants concentration and impact on the people health. In pursuance of information from literature, effects of single pollutants at the human health are being examined by means of laboratory experiments under the persons (examination of acute effect), then examination at the level of professional exposure of the workers, then epidemiological studies. Epidemiological studies were made in real conditions of everyday life of

general population . Results of the research in the bay are also in the analog form of graphical and tabular presentation.

3.3. Waste depots and pollution of drinking water

In the Bay of Bakar, waste depots are very often situated at the locations where ground water penetrate into the underground, so, from the hydrological aspect, they are very susceptible and bring the surroundings into danger. The same situation is with the waste water. Among the air pollution, the most actual problem in the complex of simultaneous negative impacts of great numbers of sources of pollution and disturbance of the condition of surroundings are waste waters, industrial or from private houses, or touristic objects, and their draining directly to the sea, then existing sources of potential air pollution, contamination of the soils and drinking water and waste disposition. Hydrological surveying is present permanently in last twenty years. Data are almost at the analog form of hydrogeological maps, but some data from last few years are stored in digital form. Those are only data, except meteorological data since 1980`s which are in digital form.

3.4. Sea

For a degree of sea pollution, among the natural characteristics of a sea, the most responsible are hydrographical properties. Knowledge about the main physical, chemical and biological properties of the sea water is important for the optimal choice for the destination of the particular parts of the sea. Intensity of this processes is significantly changeable during the seasonal cycluses, but nevertheless, at the basis of available data, it is possible to describe oceanographic characteristics of coastal zones.

Hydrographical characteristics of the Bay of Bakar,(disposition of a temperature, concentration of the salt, density, contents of the sweet water, residual streams), vary because of influence of sweet water, rainfall water and effect of the wind.

3.5. Data and methodology

It is clear now that the problems of the Bay of Bakar could be solved only by the assistance of geographic information system. Manipulation with such big volume of data which represent the condition of environment is not possible without structuring them and managing them with computer. A kind of information system is essential assumption for the ability to manipulate with data. The locations of natural and technological potentials vary geographically, which means taking care about environment is a spatial phenomena. Geographical information system is such kind of system that enable

manipulating the data concerning their spatial characteristics.

For the Bay of Bakar, ideal semantic GIS for the reality was projected. Process of building the conceptual model started with the interviews with potential users of the system, to come to conclusion which information they are really interested in, what information they can offer , and in which form. Also, to define data structure and relationship among the different data sets.

As a result we proposed the GIS which should consist of following databases: geology, hydrology, air and noise, oceanography, social-economical data, vegetation, landuse, soils, historical and cultural heritage and norms and standards. Spatial reference for all databases is surveying reference which is consisted of geodetic points, cadastre and topography.

During the researchment, it became obviously that two kind of spatial representation of various data sets is possible. Results of measurements at the measuring stations (meteorological data and emission) may be represented as a point related data. But all other data, landuse, soils, vegetation, geology, hydrology and also socio-economical data may be referenced to the areal component. This is the reason why we choose cadastre as a common basis for all datasets. Multi-user cadastre system is a frame which at the level of the parcel support entire land information, as are landuse, vegetation, residential fond, population, communal structure, etc. Corners of the parcels at first place are used to define geometry of the parcels, and later, altogether with other points which location in the space is determined, they have a role to connect and register land-related data, like data about soil quality, topography, hydrology, and so on. Modeling the data by the object-oriented paradigm, any object has different properties , named attributes, which describe them.

Different available data are almost in the analog form, in form of maps or tabular reports, which is not convenient for managing in the manner of computer science. All these data should be converted into the digital form especially in order to allow different analyses which GIS offer. Also different data sets are in interrelation. Degree of pollution of the soils, perhaps, depends on the meteorological parameters, quantity of emission and topography, which all together determine the real estate`s value of the parcel. Illness of respiratory system of local population depends on the period of the exposure to different injoures substances and emissson.

Environmental processes in the Bay of Bakar, as it is mentioned before, hardly depend on meteorological conditions and topography. In the purpose of offering a good basis for modeling and visualization of the environmental processes, digital elevation model is produced. Input data for the digital elevation model were

produced by digital photogrammetric mapping of areal photographs. Spots heights, structural forms, as break lines and formlines, also the mass points were considered. It resulted with the digital elevation model of high quality. The special condition for the Bay of Bakar is the existence of abandoned vineyards in the form of terrace, which are some kind of monument of human work and they are under the protection. Visualization of that area without digital elevation model of good quality is not possible, also as well as digital ortophoto production, too.

With the purpose to show which are advantages of modern technologies, digital ortophoto for the area is produced. It represents good basis for urban planning, and as an visual information for protection of monument which is one of the main tasks in the next period. Implemented into the GIS as

one of the layers, digital ortophoto gives to GIS better effectiveness.

3.6.Conclusion

In projecting the environmental GIS it is of the most importance to respect all special conditions and characteristics of the area of interest. For the Bay of Bakar the most important is conflict of traditional i modern conditions. So, in this case, efficient GIS has to give a basis for the solution that should consider rich cultural, architectural and historic heritage, with industrial technologies implemented in the area, in order to protect the area.

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