European Commission's LIFE – ENVIRONMENT Project

A Pilot System for Urban Environmental Impact Assessment in relation with Urban Planned Land Use, using Open-GIS technology and pollution level estimation procedures - ASSURE - (Assessment System for Urban Environment)

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LIST OF KEY-WORDS AND ABBREVIATIONS

KEY – WORDS

1. Assessment System for Urban Environment
2. Urban Environment
3. Air pollution
4. Forward and backward air pollution trajectories
5. Surface water pollution
6. quality model, pollution, transport equation, dispersion coefficient
7. Non-point-source soil surface pollution
8. Underground water pollution
9. Geographic Information System
10. Open-Geographic Information System
11. Digital Terrain Model
12. Global Positioning System

ABBREVIATIONS

1.	ASSURE	- ASsessment System for URban Environment
2.	EIA	- Environmental Impact Assessment
2.	GIS	- Geographic Information System
3.	Open-GIS	– Open-Geographic Information System
4.	DTM	- Digital Terrain Model
5.	GPS	- Global Positioning System

6. NIMH - National Institute of Meteorology and Hydrology

7. CCBM - City Council of Baia-Mare

8. EPI – Baia Mare - Environmental Protection Agency from Baia Mare

9. MF –Toulouse - Meteo-France –Toulouse

10. WEB - World Wide Web

INTRODUCTION

- **Background and problem and objectives:**

Urban planning of land-use is currently carried out in Romania, by using traditional urbanistic design – only occasionally in digital format - accompanied by an estimation of Environmental Impact Assessment (EIA) in relation with the urbanistic planning. The problem arises on the methods used to assess the environmental impact, since most of the assessments are:
- carried out only on the limited amount of measured data and use little or no modeling, most of the
- are limited on local scales taking in account only for small scale local imissions,
- do not integrate georeferenced data (not for the pollution sources nor for the urbanistic features), so they are not in position to assess for multiple overlaid environmental impacts caused by multiple emission sources, as is the case in urban environment. The relevance of the presented aspect may be understood from the fact that at present, most of large or relatively large towns of Romania, undergo urbanistic planning and urbanistic transformations able to allow them to be prepared for further development in the post-transition era. Many of these plans take in consideration extensively the urbanistic needs of the development and emphasize too little on the environmental aspects.

The Life-ASSURE Project aims at developing and implementing an integrated computerized environmental system, as a tool able to assess urban planned land-use for reducing environmental impacts. It's objectives are:

1. To develop a pilot computerized system able to assist urban planning in relation with environmental protection.
2. To assess for environmental impact on air, surface water and underground water pollution in urban areas.
3. To make use of different Geographic Information System (GIS) designed file formats in the approach.
4. To disseminate the outcome of the project on both National and European level.

- **Description of technical/methodological solution:**

The proposed system aims at concurrent description of the environmental parameters on air and water at the town scale and beyond, in it's peri-urban areas. The project is designed as a pilot system on behalf of Baia Mare City Council, a town which has one of the largest and broadest industrial display of activities, with emphasize on overlapping of environmental impacts. For that reason, the most suitable tool for the assessment, is the Open-GIS technology, as the cutting edge of the GIS methodologies for environmental impact assessment.
The system will contain and be able to use deterministic models: digital terrain model, surface water pollution model, underground vulnerability model and air pollution dispersion and transport models as well as pollutant direct/backward trajectory models. The whole system incorporates three main modules (or sub-systems) for pollution assessment: atmosphere, surface

water and underground water all interacting through the OpenGIS integrator system. Starting from it the user shall be able to use special environmental functions as to:- visualize, optionally separate, model results; - optionally dispose of any post-processed diagnostic index, mean /daily pollutant trajectories; - dispose of the score matrix for the integrated system of cumulated impacts as tool for an optimal decision choice for a given event of land-use design; - be able to include designed data into an Expert system for an objective decision indicator.

- **Expected results and environmental benefits:**

Whenever further development of the urbanistic environment is concerned, modeling is the only way in which environmental assessment may be performed, so the impact of such a system on the local industry may be considered as large since it may recommend reduction of the imissions or displacements of planned polluting industries. The system shall be used in issuing the environmental approvals of the local authority (Environmental Agency). The environmental assessment may then integrate air pollution modeling on large and detailed urban scale, surface non-point source water pollution together with it's input into surface water bodies, underground water vulnerability all together with associated risks connected with air contaminants, soil pollution.

EXECUTIVE SUMMARY

Since most of the industries have a major impact on the environment, their overlapping impacts, especially in particular climatological, meteorological, hydro geological conditions, should be assessed in an integrated manner.

One of the main achievements of the ASSURE Project consists in developing and implementing an **integrated computerized environmental protective system**, a tool able to assess for urbanistic planned land-use triggered environmental impacts concerning: atmosphere, surface water and underground water pollution.

At this phase of the Project, the system has been developed in some of it's major components, such as: Database knowledge; Digital georeferenced GIS-based databases; User input interface in GIS environment; Environmental protection models development; Models interface with GIS (air and surface water up to date); Output georeferenced for user analysis (air only up to date).

The main activities accomplished during the previous reported phases, concerned these three main modules of the system, and were focused on: *developing work strategies, data collection and pre-processing, models adaptation to specific purposes, development of the sub-modules' interfaces to the system*

This work led to implement in NIMH and optimally adapt to the concerned area the pollutant transport/diffusion model "MEDIA". The model, developed by Meteo-France was adapted to a very fine mesh local version in order to increase the accuracy over the interest domain for the project. Daily test for validation against measured data provided by the local Baia-Mare pollution survey network was conducted. A trajectories computation package was also developed in order to estimate the pollutant evolution at larger scale at a future moment using forecasted wind by atmospheric modeling (direct trajectories), also to have information about the source location when knowing the measured concentration at a given time and place (backward trajectories), and finally to obtain a trajectories climatology data basis for pollution estimations.

Concerning the overland pollutant transport, starting from an industrial land use design, numerical models are being run on small to middle range hydrological basins at the operational level and 'what if' scenarios are being simulated on the models. The available models are using TOPMODEL method and are integrated in OpenGIS (GeoMedia Intergraph's software) using API software technology. Moreover, overland hydrologic transport models have been run over the areas which have been modeled as receiving high deposits of atmospheric pollutant dusts and

have been routed in order to predict the areas of soil contamination. The approach shall form the basis for necessary pluvial sewage network design. Such type of output shall also constitute one of the inputs towards the underground models predicting groundwater flow and groundwater pollution model.

The groundwater modeling team has been implementing groundwater specific and intrinsic vulnerability analysis through VisualModPath and VisualModFlow software solutions and models.

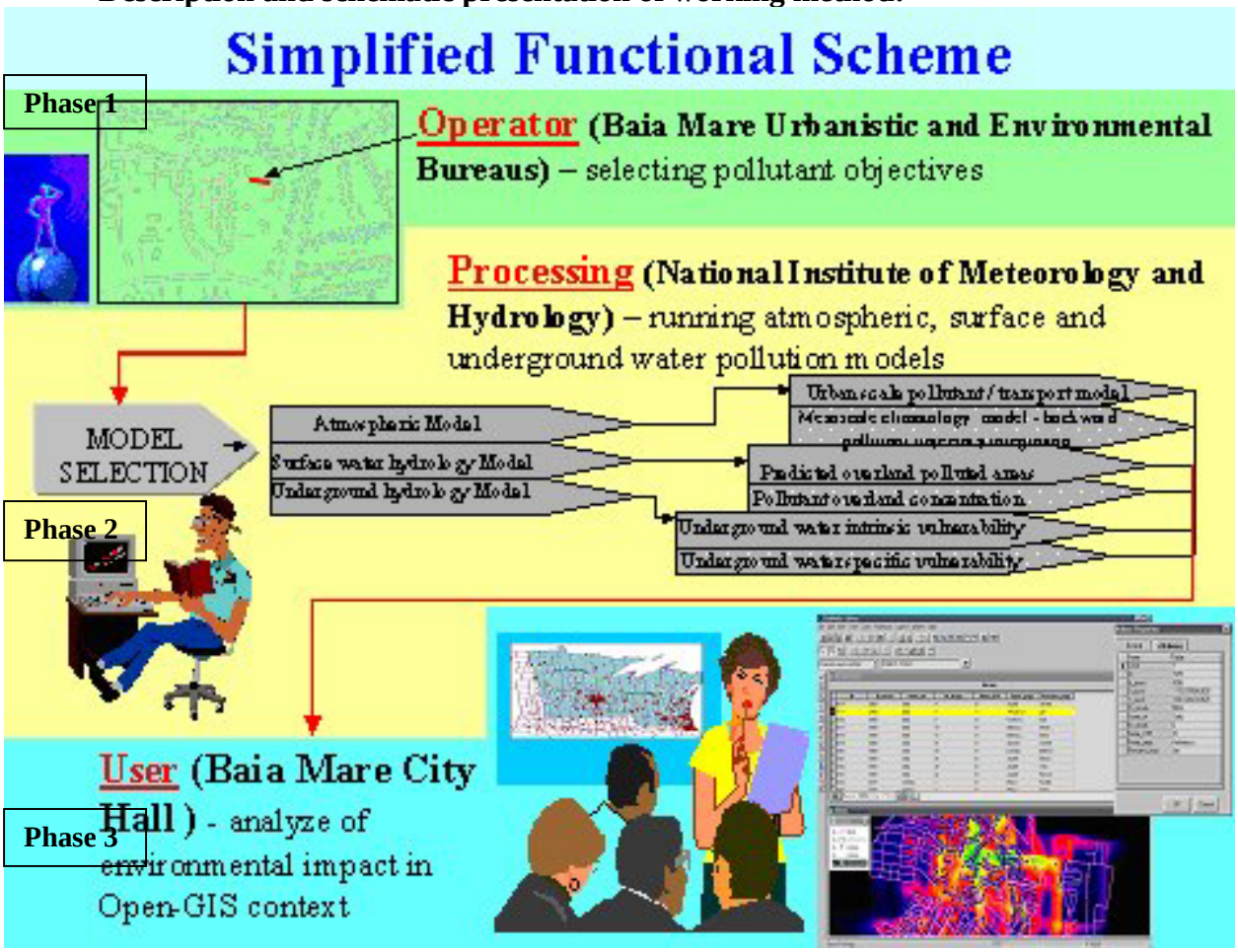
The arisen problems in Project development are presented at the Management task. In brief, we may observe:

This interim report has been presented to the Commission at this stage, due to some unforeseen delays, especially in the data collection task and co financing of the project. Since the beneficiary of the Project – the National Institute of Meteorology and Hydrology - is a governmentally financed institution, the co-financing of the own contribution had to be governmentally approved. As it is stated in the report, the significant governmental co financing has been achieved only at the beginning of year 2001. Although the partners in the Project (Baia Mare City Hall and the Environmental Protection Inspectorate) had presented much interest

The financial plan has been respected in detail and exchange rates in order to compute the amounts spent in Romanian currency have been used from the official WEB site of the European Commission.

'ASSURE ' System - FUNCTIONAL FRAMEWORK

- **Description and schematic presentation of working method:**

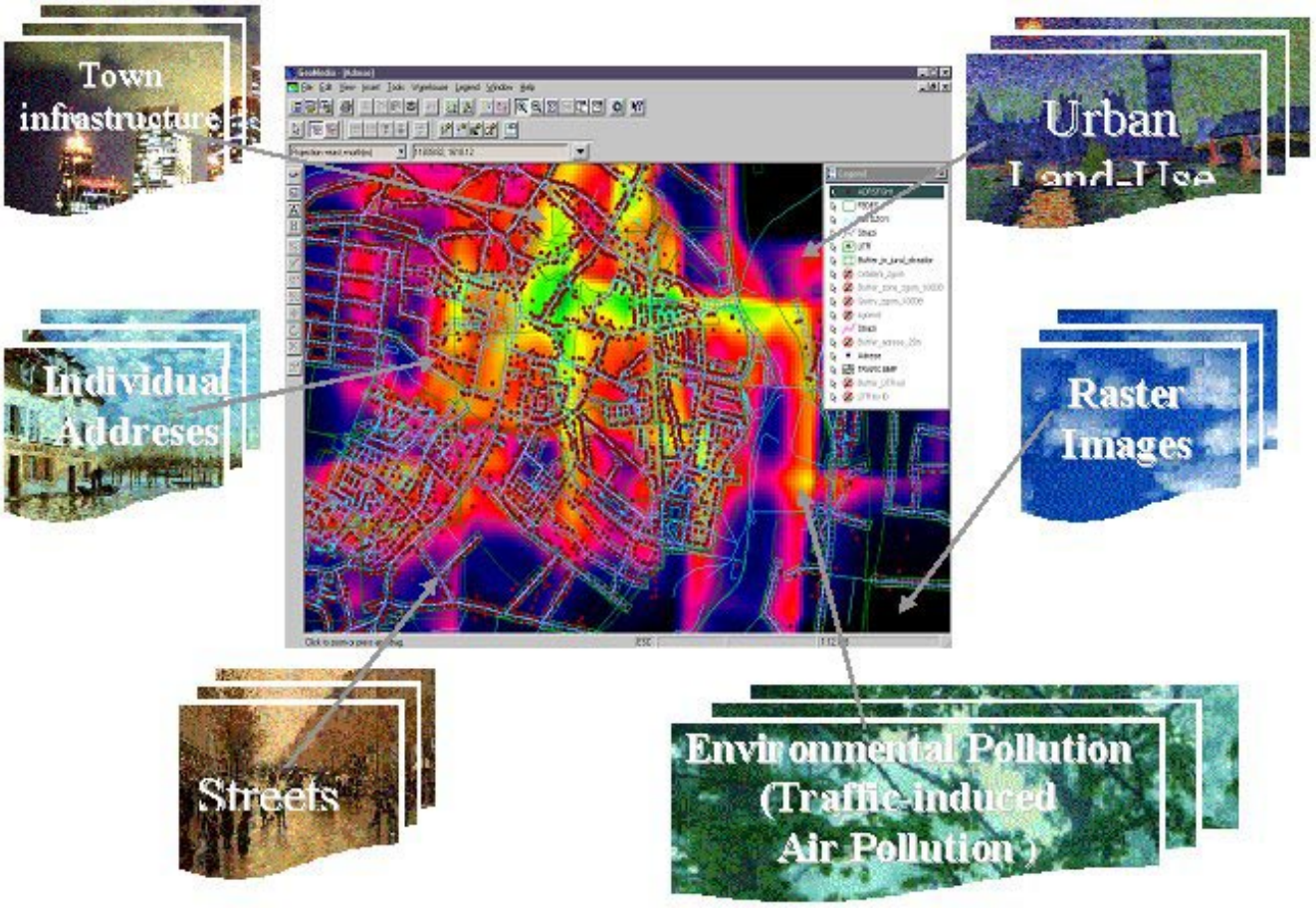


General description of the technology used to construct the pilot system as a system tool for urban pollution estimation in relation with land-use planning, on top of OpenGIS technology

1. **Description of the methodology for system integration: Open-GIS – as an integration tool for the system.**

The Open-GIS environment ensures the easy access to a various types of formats used by the land-use designers operating at the urbanistic bureaus . Thus, in the case of the BMCH urbanistic bureau, Autodesk is the deployment tool for the land-use planning. Using an Open-GIS tool (such as Intergraph's GeoMedia Open-GIS) offers the open architecture environment in order to allow georeferenced input from the urbanistic bureaus, to the environmental modeling.

The following figure, arguments the use of the system being under construction, and the way in which such a system may integrate various databases from the final user (the land-use designer) and the environmental models. In the presented picture, the urban traffic induced air pollution is presented as it is modeled by the system.



Description of the modeling techniques and their methodology

Air pollution estimation tool

The following models will constitute the main tools that the user will activate at the NIMH center, correspondingly to his requirements, that he will express using the front-end menu at Baia-Mare City.

1. MEDIA - model for dispersion and transport of pollutant

MEDIA is a French 3-dimensional Eulerian model for medium and long range transport of pollutant in the atmosphere. It works coupled with a numerical weather prediction model, in the case of this Project the coupling will be realized with the atmospheric model which is operational in Romania, the ALADIN model. This meteorological model is the result of an international co-operation, in which Romania is partner. Both models: the pollution and the atmospheric models, are implemented in the National Institute of Meteorology and Hydrology - Bucharest, ROMANIA.

2. Trajectory model

Trajectory computation

Pollutant trajectories are computed using the forecasted wind components (horizontal and vertical components), which are computed by the Aladin model – operational in NIMH. The trajectories may be computed with positive lag time (direct trajectory) and negative lag time (backward trajectory – negative time lag).

Direct trajectories:

Are computed starting from the initial location of the air pollutant parcel and from the initial timing. The trajectory is computed by following the parcel advance over space and time. This is done either in real time (starting with Aladin data while the model is integrating) or in separate storage mode (starting from stored wind data). The use of this data is for issuing air pollution warnings in case of environmental disasters.

Backward trajectories:

Are computed by specifying the final position of the air polluted parcel and then tracing the pathway of the particle with negative time steps until the initial position is obtained It uses operative 3-hour wind data saved in operational databases. Extensive description is presented in the Annex.

3. Climatologic dispersion model

The climatological dispersion model have been developed in NIMH. It uses as input climatological data basis or real-time measured data at Baia-Mare observation station, giving as

output the pollutant concentration over the domain of integration (due to assumptions made it is working at city to regional scale).

Developments during the project tasks:

For the climatological dispersion model an interface between the atmospheric model and the climatologic model has been created for two aims:

- to be able to use all the information provided by the atmospheric forecast model and
- to obtain output from the dispersion model not only in climatologic means or real-time but also a simulated forecast solution of the model.

The interface implies to provide forecasted, high resolution boundary layer data. These data are those implying the knowledge of:

A) the boundary layer mixing (turbulent fluxes, horizontal diffusion), and

B) the boundary layer stability (in order to quantify the depositions).

The physical process parameterized in the model and having a contribution to the evolution of the variables transported in the boundary layer are especially connected to the turbulent mixing, convective transport and the effects of the radiative budget.

The dynamic process to account for are those advective and diffusive.

In order to analyze these process, the forecasted fields by the atmospheric model taken into account were:

- wind (direction and intensity) at the standard observation level (10 m.),
- air temperature at standard observation height (2 m.),
- diffusion – the diffusion coefficients could be those computed and used by the atmospheric model or computed by any other method using atmospheric model meteorological forecasted data output:

- wind (direction and intensity) at the standard height (10 m.),
- the boundary layer height,
- the u*, W*, ∪* physical parameters,
- the Monin-Obukhov length;
- the mixing length.
- the atmospheric stability;

<u>Surface water pollution estimation tool</u>

The working method is based on the application of the one dimensional transport model for different types of pollutants. The hydrological and morphological information about the analyzed area, necessary for two hydrological pollution transport models:

- Overland pathways of polluted spills model (<u>Over</u>land <u>Pol</u>lution - OVERPOL) integrated in OpenGIS by means of the urban DTM and derived drainage pathways;

Water bodies pollution transport model - <u>Wat</u>er <u>Pol</u>lution (WATPOL) model – with the scope of pollutant transport simulation into the surface water, in order to know the concentration in different sections downstream of pollution sources from Baia Mare city. The analyzed area concerns three important rivers: Sasar, Firiza and Lapus and three small rivers that will be neglected because of their insignificant discharges

The impact of the chemical pollution on the surface water quality is evident for the low discharge, like the “dilution flow” ($Q_{95\%}$). These parameter is calculated by taking into account the hydrological values valuable at the gauging stations as well as the relation between basin mean altitude and the specific discharge H = f(q). The river velocity with a 95% probability ($v_{95\%}$), is calculated by taking into account the relation between the mean river velocity and the river discharge.

The model parameters (dispersion coefficient and decay rate coefficients) will be obtained by the field measurements (table 1).

The surface water pollution is analyzed with the, that is a one-dimension model, with constant speed and dispersion coefficient for each analyzed river section. The model takes into

account the type of pollution source that could be variable in time or instantaneous. The pollution concentration is supposed to be constant in the cross-section and a mean value is considered.

Underground water estimation tool

In order to solve the issues of water supply of the populated and industrial centers, a special role is hold by the groundwater catchments, which is preferable to the surface water ones, especially in the case of drinking water.

Taking into the account the complexity of aquifers, their study in order to establish their types, vulnerability as well as the impact of anthropogenic activities on available resources has to be made in a integrated system which must contain various domains knowledge (geological, hydro geological, hydro chemical etc) and modern modalities of analyze and study.

The study of phenomena in aquifers can be made correctly just in the conditions of the behavior simulation by mean of numerical methods.

It must be emphasized the completion of numerical modeling systems of the phenomena by the geographical information systems (GIS). GIS tools can be used as a base for the pre and post processing of the data and can be used too for analyses and correlation. In this way, the process of result interpretation is easier and thus you can have a correct general view of the system.

GIS tools may be used in the design, construction and developing of bi and tri dimensional flow and transport models of groundwater.

The data preprocessing consists in three major steps:

- Data handling and analyzing
- Conceptual model development
- Numerical model development.

In this preprocessing stage of the input data, there are used a lot of data and parameters.
Taking into account the great amount of information which must be analyzed and studied, the most efficient way is the information organization (for an applied GIS in monitoring, analyze and assessment of anthropogenic impact on the aquifers) in two data categories: graphical information; attribute type information.
The outline of polluted areas is much supported by graphics facilities of GIS tools.
The TIN surfaces obtained will be transposed in the numerical model and used further as initial conditions in the simulation of pollutes transport.
The drawing of the surfaces function of hydraulic permeability represents another step in the data preparation for the numerical simulation model.
In the case of choice of a 3-D numerical simulation model, the simulation program must be chosen so that to be able to represent correctly the geometry drawn up in the conceptual model.
The model discretization can be realized by digitizing the finite junctions or finite elements from the TIN networks.
By means of GIS is realized a points covering which represents the junctions and a polygons covering which represents the finite elements.
The hydraulic characteristics (e.g. recharge and hydraulic conductivity) are attached as attributes of finite elements. The parameter values may be easy modified in the interactive sessions of GIS.
The three-dimensional finite elements network is drawn up starting with the network which discretizes the surfaces, behind each surface element developing the "n" layers which model the geological structure.
The GIS graphic interface represents an efficient tool in defining the schema for drawing areas during calibration process of numerical model. Visual-Mod-Flow as the software that has been selected for performing the task due to it’s interconnectivity to GIS data and due to it’s ability to export modeled data to the GIS.

The following graphical explanation of the project's informatic system functionality unfolds the data and information flow at various stages of processing within the system.

The geographical context of the application is thus presented in figures 1,2 and 3. The impact of the cyanide spill on january 2000 in Maramures Baia Mare area is depicted in figure 2.
Figure 4 presents the design of the data flows – such as the emmission data determined by the local environmentally concerned authorities are fed into the system via FTP and the modelled environmental impacts are consulted and analised bu the same authority after the processing has taken place at the NIMH. The analysis is available on OpenGIS internet server via Internet protocol.
Figure 5 depicts the mean of GPS location of the polluted areas as well as the georeferencing of the GIS data. Figure 6 shows the input interface for the pollution data in AutoCAD environment. Figures 7, 8 presenty the GIS environment for the pollution modelling in urban context. The modelled results are presented in figures 9, 10, 11, 12. As such, figures 9-11 present the air pollution distribution at various levels of resolution and GIS visualisation technioques, while figure 12 presents a model of the aquifer pollution over the modelled Baia Mare area.
Figures 13, 14 and 15 present the OpenGIS context of visualisation and interogation of the modelled data over the Internet. As such, figure 13 presents the OpenGIS – on – line tool for the approach, while figures 14 and 15 present the functioning of the system in WEB context, using the Internet Explorer as a tool for accessing the OpenGIS – on – line server. The figures present a river pollution scenario on Sasar river in Baia Mare city.

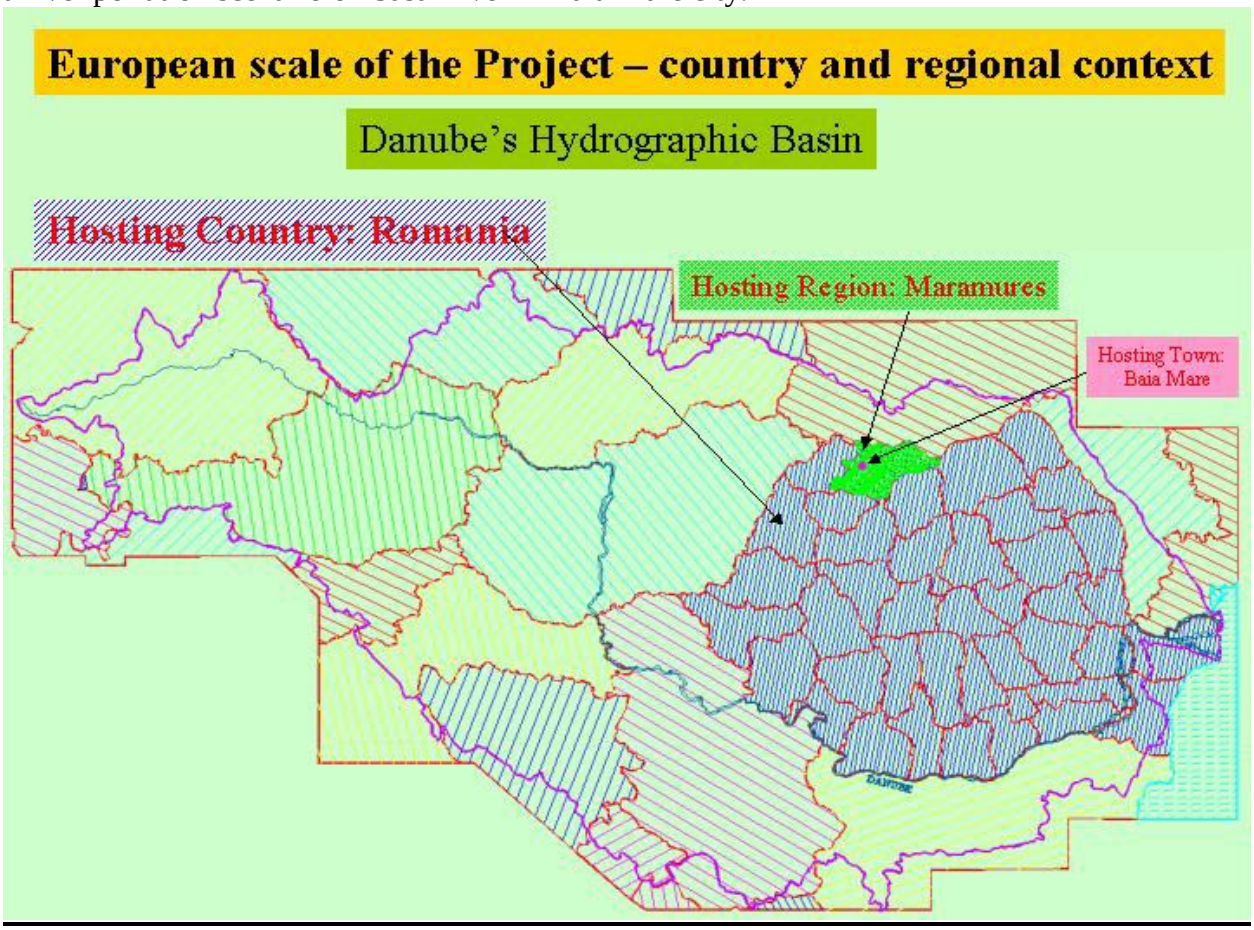


Figure 1

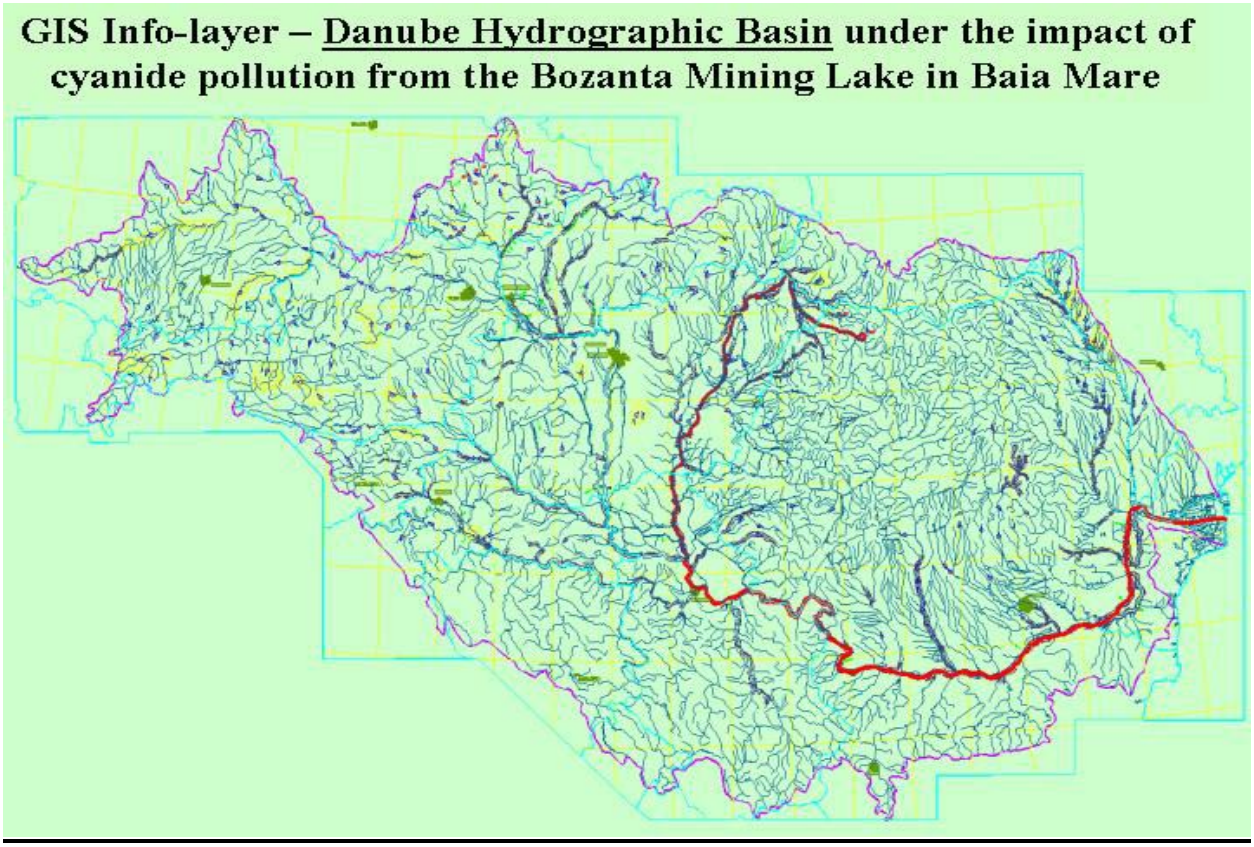


Figure 2

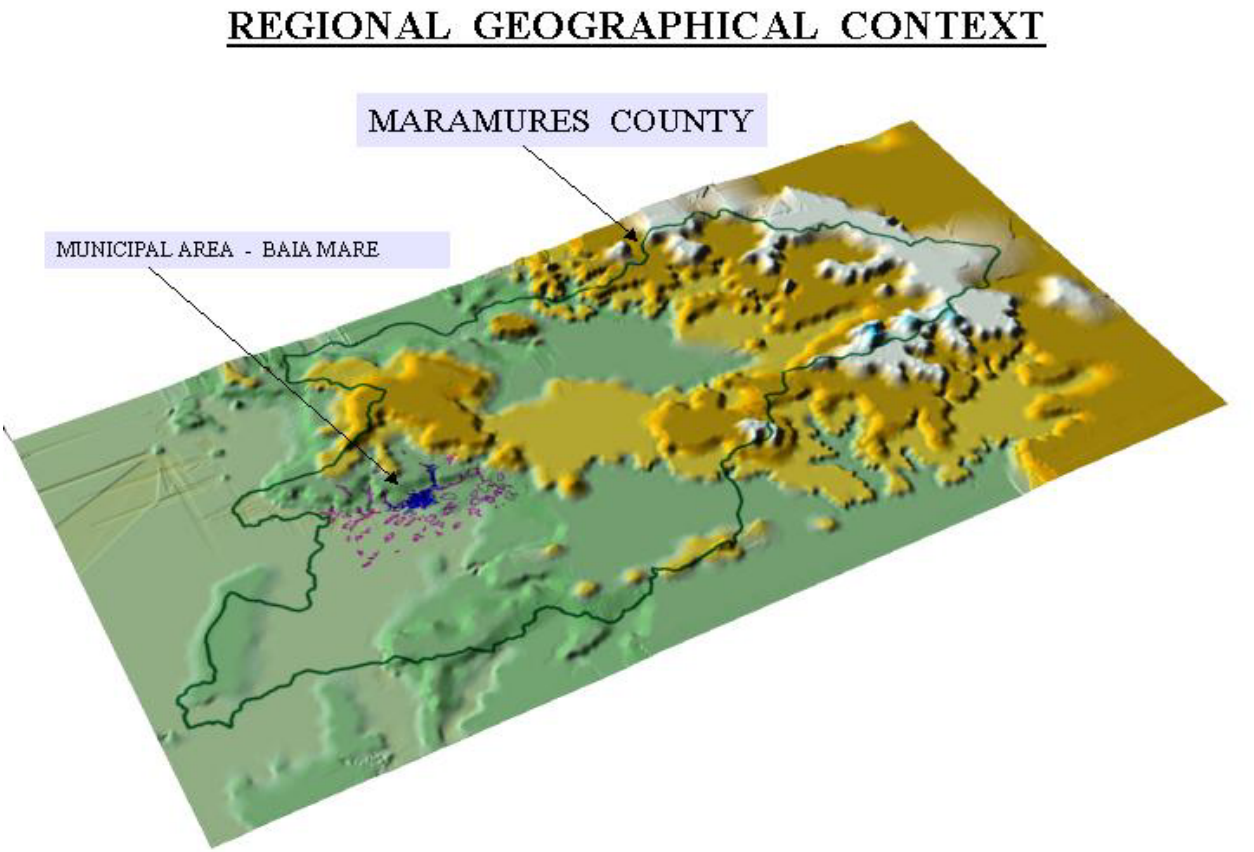


Figure 3

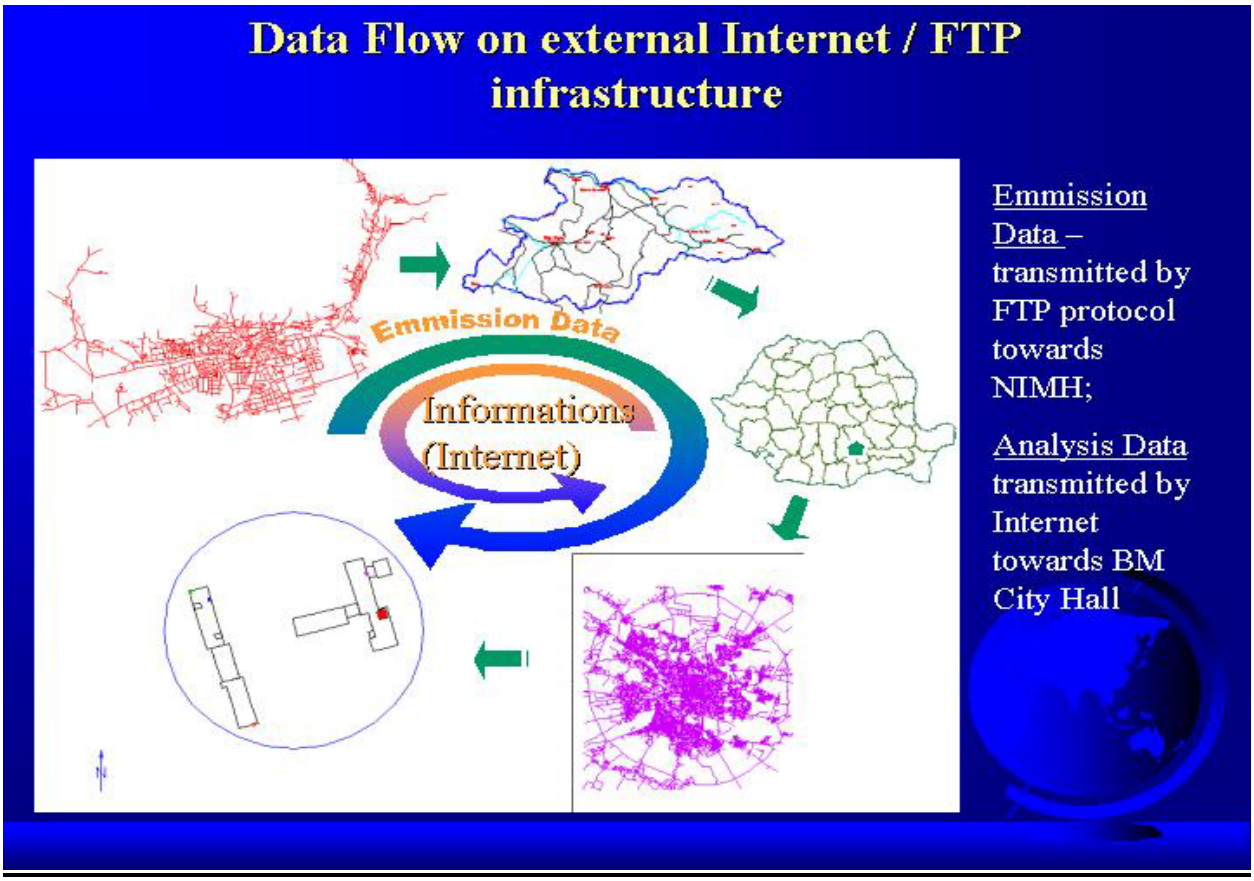


Figure 4

The in-situ measuring campain involved GPS georeferencing referenced points and polluted areas

Figure 5

The interface has been programmed in accordance with user's land-use planning GIS – AutoDesk environment

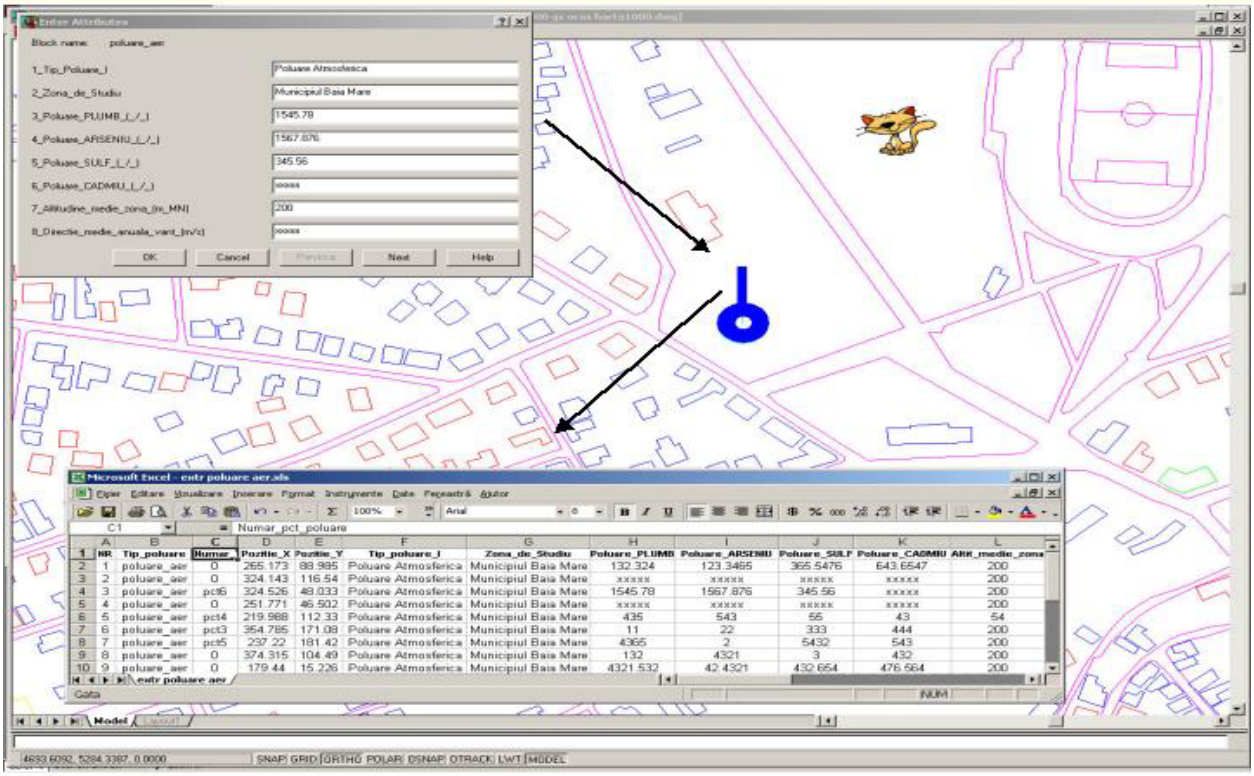


Figure 6

Municipal GIS Info-layers – Georeferencing environmental background

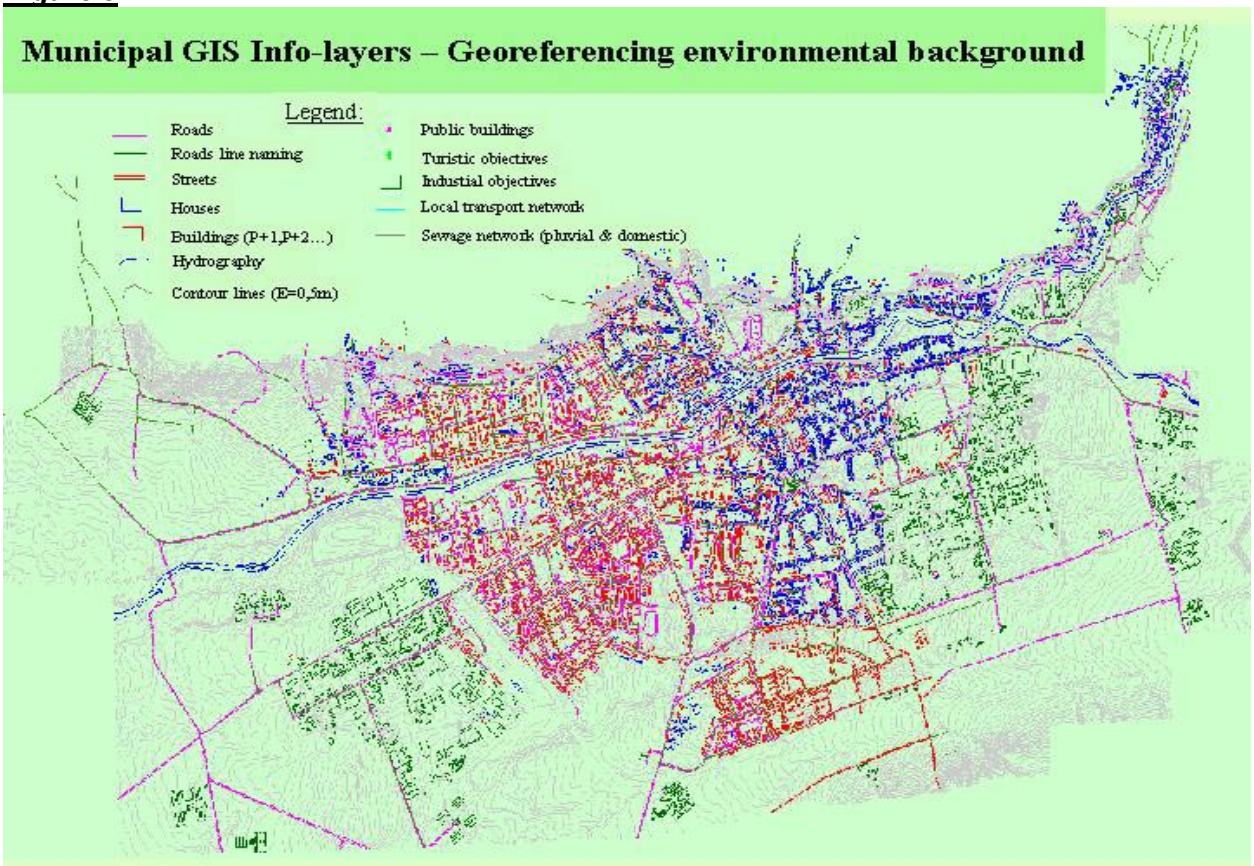
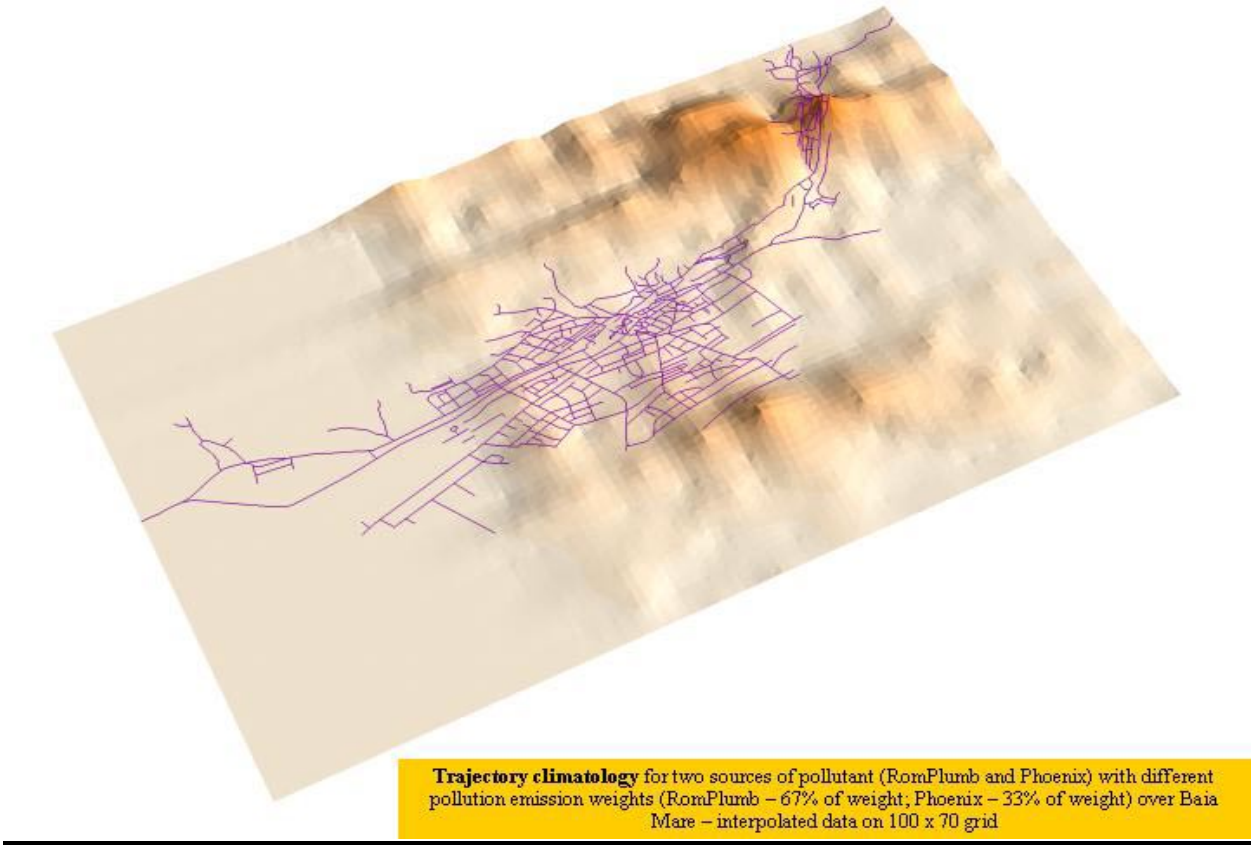


Figure 7

The town of Baia Mare in a 3D perspective, with the differentiation of building height and industrial or housing land-use, over it's contained relief.

Figure 8



Trajectory climatology for two sources of pollutant (RomPlumb and Phoenix) with different pollution emission weights (RomPlumb – 67% of weight; Phoenix – 33% of weight) over Baia Mare – interpolated data on 100 x 70 grid

Figure 9

Climatology of the pollution trajectories probability distribution on detailed Baia Mare domain – Rom-Plumb source of pollution

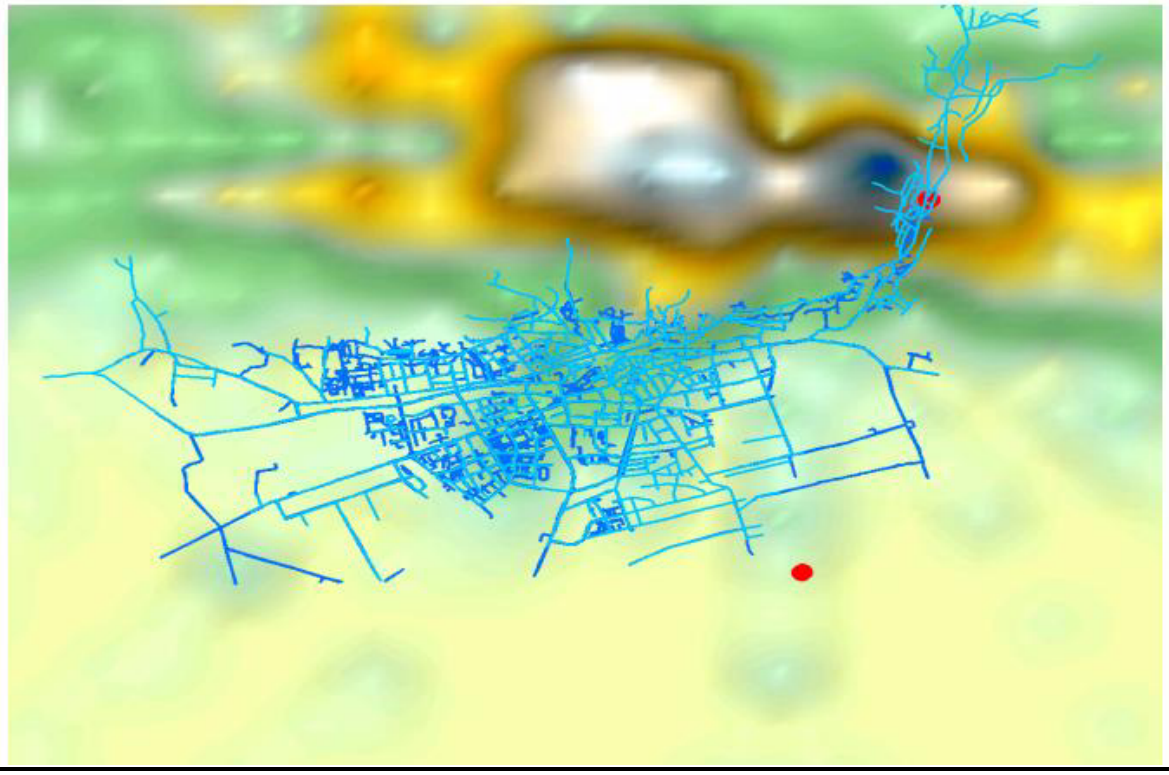


Figure 10

Air pollution –climatologic model with – georeferencing with urbanistic details on Baia Mare

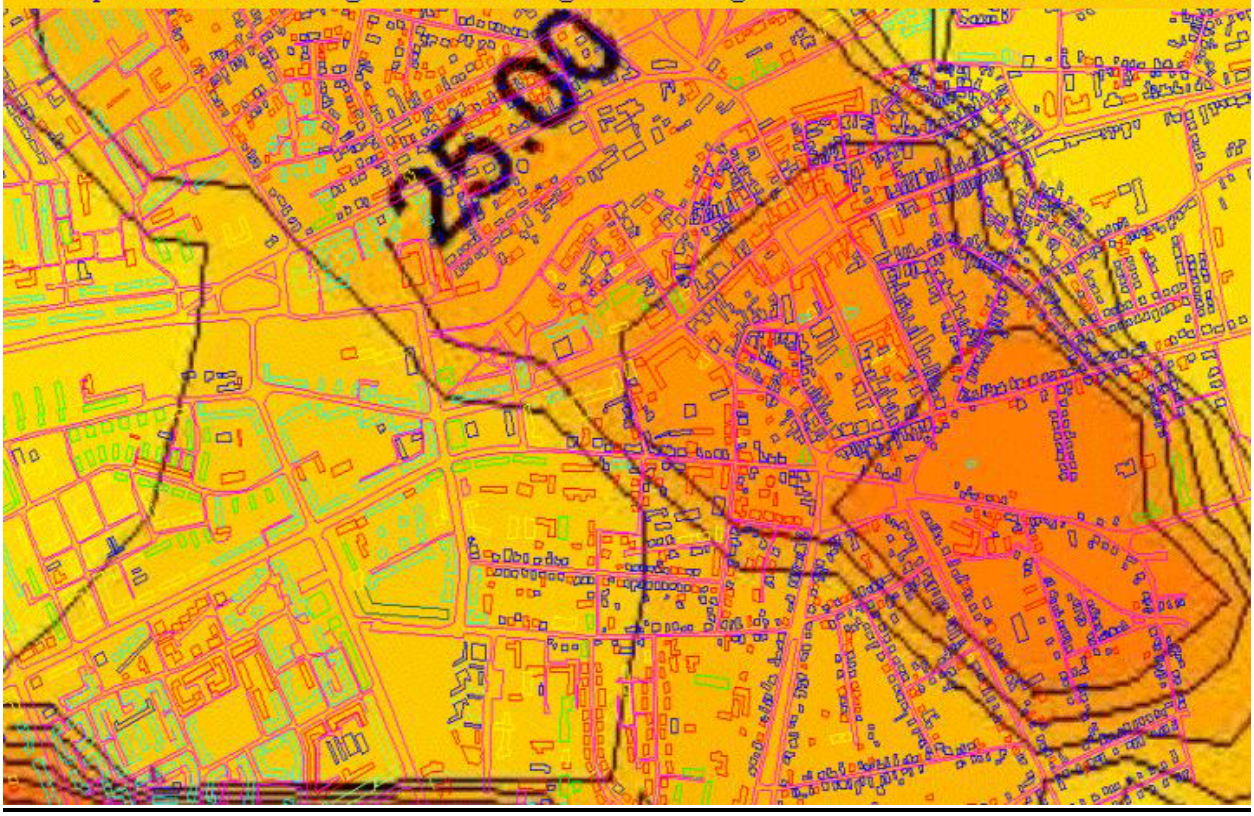


Figure 11

The modeled aquifer for the Baia Mare area – overlay of the modeled aquifer layers

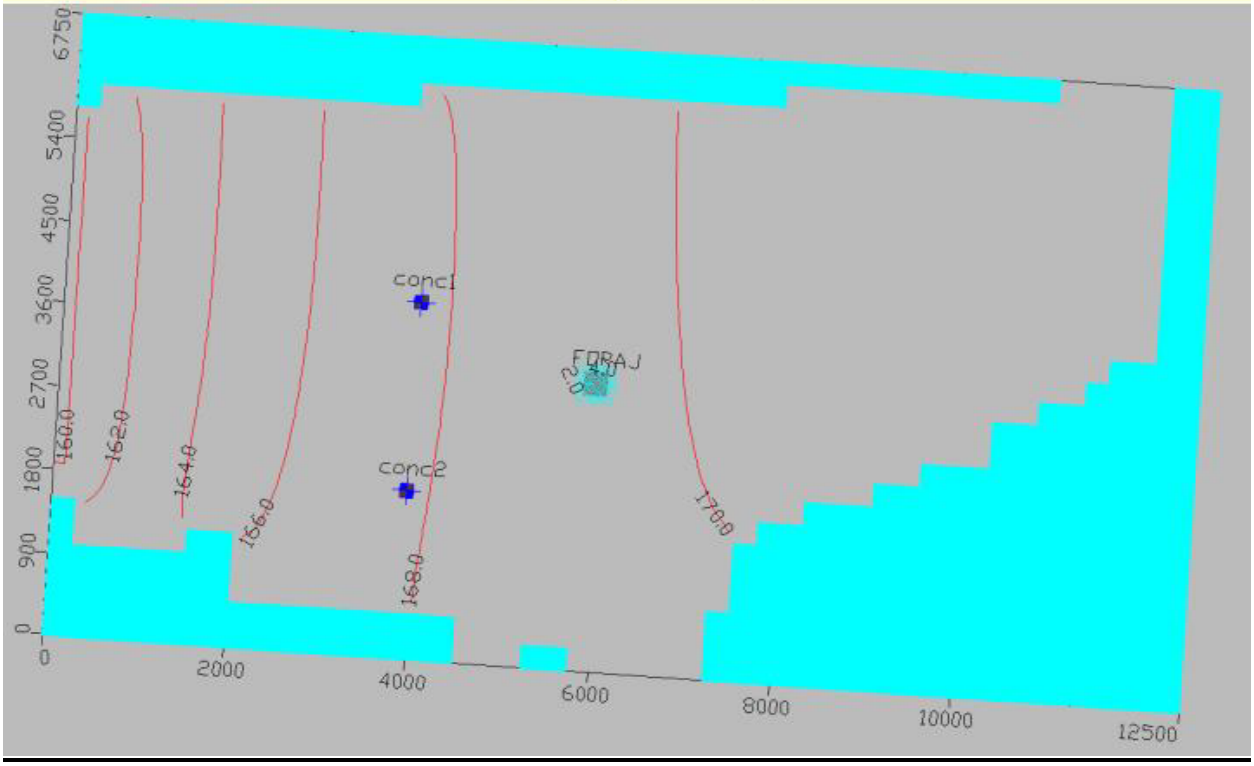


Figure 12

Baia Mare urbanistic GIS structure – visualization using GeoMedia WebMap on top of Internet Explorer

Figure 13

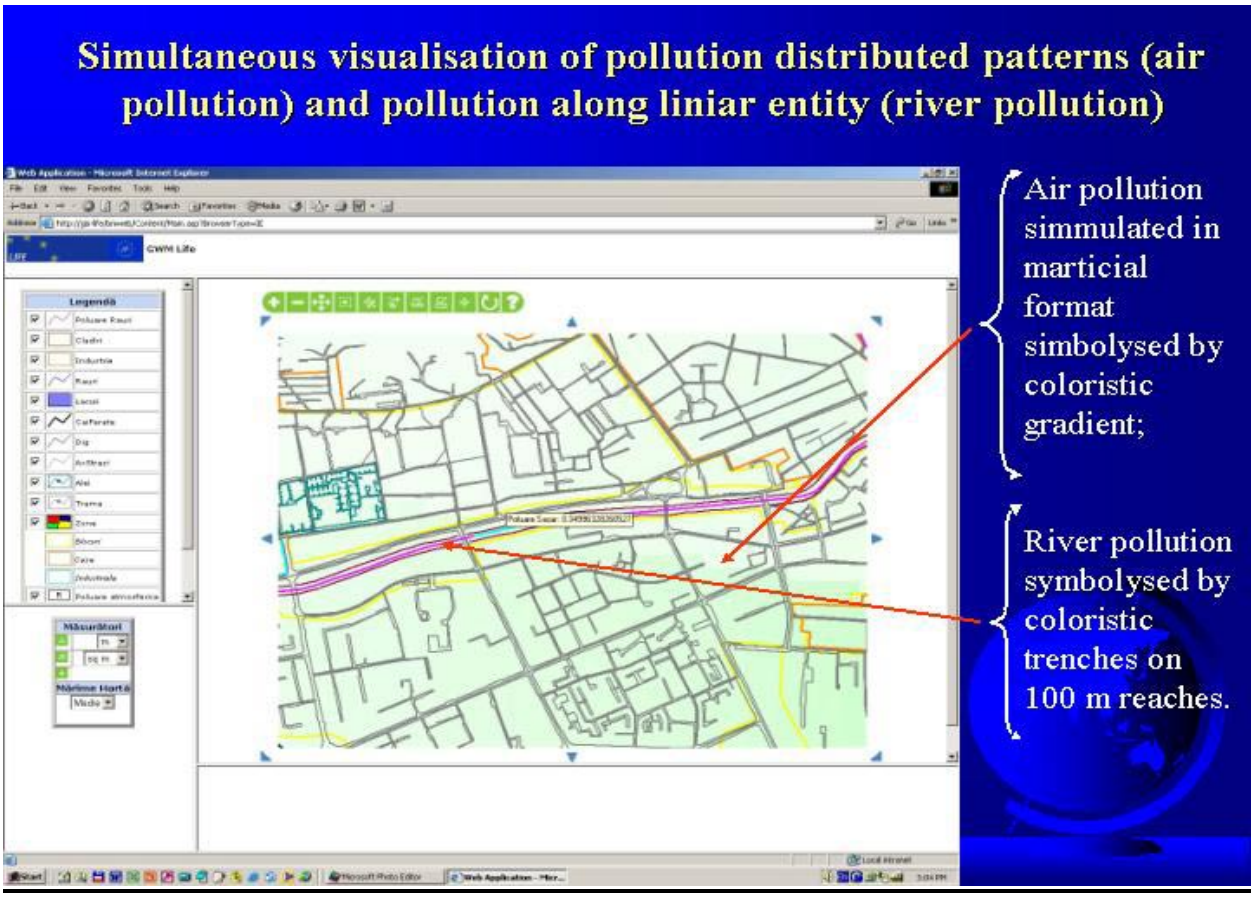


Figure 14

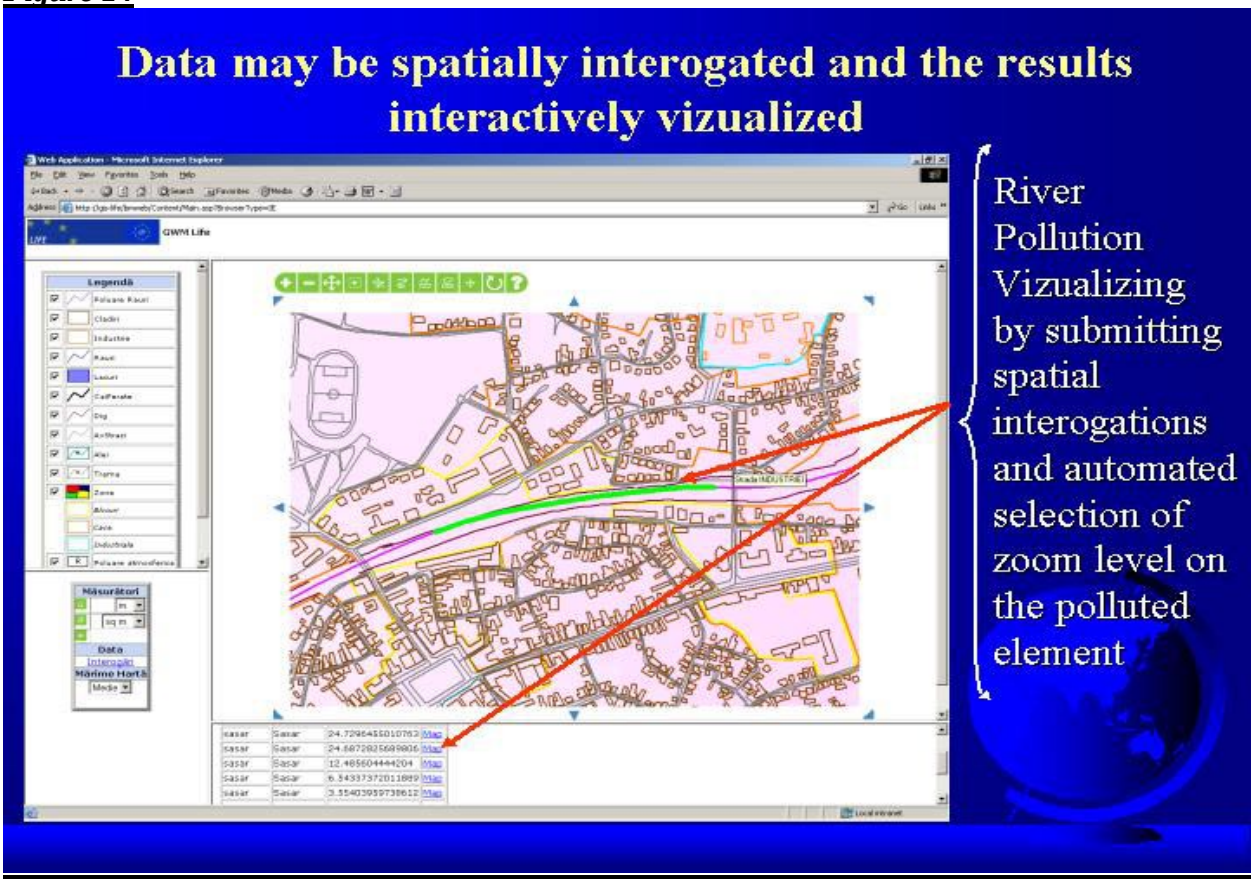


Figure 15