Aspects Concerning the Development of the MEMDUR System

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Abstract. The MEMDUR system has been created and developed with the aim to offer an image of the air pollution in the area of Targoviste city. A spatial database and a mathematical model represent the core structure of the system. The spatial database was designed in SQL Server. Using GeoMedia, the spatial entities were defined taking into account the global coordinate system. The data, collected from different sources, are imported into the GeoMedia workspace and then exported to SQL Server database, generating a geometric entity, automatically. The mathematical model provides an analyze of the pollution status for CO, NO, NO₂, SO₂ and PM10 dusts, comparing their values with the hourly maximum admitted concentrations. For establishing the areas were the level of pollution generated by the stationary pollution sources is at maximum level, the model incorporates source-related and meteorological factors. Once the pollutant concentration in the DTM points was determined, it is possible to show different forms of concentration distribution on the areas of interest. Spatial queries can be made between the areas with concentrations in a given interval and in the entities of interest. There is presented a simulation of a hypothetical situation of a pollution accident to demonstrate the model efficiency, the visual representation of the pollutant concentration and the used symbols, which show the movement gradient of the pollutant. The on-line web publishing system was performed using GeoMedia WebMap application. The system interface offers the possibility to open and consult the designed database and visualize a graphical representation of the area of interest and the technical attributes of the objects or events registered in the critical points.

Keywords: spatial database, air pollution model, predictions, DTM, MEMDUR project.

INTRODUCTION

In the last period, a special attention is given for studies related to the pollutants dispersion which are emitted into the atmosphere by various pollution sources, multiple or isolated, having an operating mode characterized as continuously or accidentally, mainly due to the fact that human activities have already produced strong disturbances in the environment balance. One of the non-expensive ways for evaluating the level of air pollution is represented by the mathematical modeling, which takes into consideration the pollutants dispersion and estimates the pollutant concentrations at ground and distant levels in strong dependence with the characteristics of the pollution sources, weather conditions, physical and chemical transformation processes that pollutants can suffered in the atmosphere and also function of their interaction with the ground surface. In fact, those considerations answer to the actual progress registered in the Environmental Science, which promotes the development of the models based on: (a) interpretation and generalization of the experimental data; (b) using of the theoretical models that lead to results that are confirmed by the experiments.
Data collected from the monitoring activities are essential for calibrating and validating the proposed models, but the temporal and spatial resolution of the measurements is usually insufficient to qualify the monitoring process equivalent to a real world.

In practice, only a dispersion model well-calibrated and well-tested may offer a good representation of the real world, due to the fact that such a model can take into account both the dynamics and response to disturbances that have appeared when take into consideration the air pollution problem.

Generally, an atmospheric dispersion model represents (Bluett et al., 2004): (a) a mathematical simulation of the physics and chemistry factors which govern the transport, dispersion and transformation of pollutants in the atmosphere; (b) means of estimating downwind air pollution concentrations given information about the pollutant emissions and nature of the atmosphere. Dispersion models can take many forms. The simplest are provided in the form of graphs, tables or formulae on paper. Today dispersion models more commonly take the form of computer programs, with user-friendly interfaces and on-line help facilities (Bluett et al., 2004).

The use of the dispersion models able to predict several pollution rates can develop regional strategic plans for ensuring security areas delimited around the major pollution sources. Based on the information estimated by the models, it can be determined the proper decision in case of chemical pollution accidents, involving in this case an important political and economic decision. The air pollution forecast for any area is possible only if there is recorded data related to all the pollution sources. An important influence on the air pollution level is given by the geographical position and meteorological factors (temperature, wind direction and intensity, etc.). In this database, near the industrial plants with a real pollution potential, the road traffic has to be taken into consideration. Nowadays, this fact is one of the major factors of environmental degradation with a serious impact in the quality of life, especially in large urban areas.

An implementation of a system, which is able to offer an image of the air pollution, was made in the area of Targoviste, an important location for possible environmental air crises due to its atmosphere pollution induced by different agents: dusts, gases, noises from the industrial plants and road traffic (Nicolescu et al., 2009). The system manages spatial and temporal databases of the most important climatic and environmental indicators and provide forecasting and solutions to prevent and manage potential crises. It was created and designed in the frame of a national research PN2 project called “Sustainable Management System of Resources Used for Monitoring and Evaluating the Environmental Risks in Order to Prevent the Negative Effects and to Manage Crises Situations-MEMDUR”, (http://memdur.ssaivalahia.ro). The project had as main objective to design, develop, test and implement in Dâmbovița County an advanced management system that has to assure the evaluation of the environmental risk in order to administrate the crises, in accordance with the demands required by the sustainable development on local, regional and national level (Gorghiu et al., 2009).

MATERIALS AND METHODS

The main component of the MEMDUR system is represented by the spatial database. The database was designed in SQL Server using the tools offered by SQL Server Management Studio Express (Gunderloy and Harkins, 2006). After specifying the name of the database, it was designed the basic structure for defining new tables, views and procedures / functions. Figure 1 illustrates the operation where a new database (named as gdata) is created.
The next step is dedicated to the definition of spatial entities. In the initial phase, the necessary tables structure are created in GeoMedia, taking into account the global coordinate system - the national coordinate system, in STEREO 70 projection. In this case, the Database Utilities software application is used (from the GeoMedia Professional associated programmes group) and generates specific metadata tables automatically, as presented in Tab. 1. The GeoMedia applications need specific metadata tables for making connections to SQL Server database. The metadata contains information related to the database tables that contain attributes and geometries.

Tab. 1

<table>
<thead>
<tr>
<th>GeoMedia metadata objects</th>
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<th>GeoMedia metadata objects</th>
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<tbody>
<tr>
<td>AttributeProperties</td>
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<td>GindexColumns</td>
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<td>FieldLookup</td>
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<td>GfieldMapping</td>
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<td>ModificationLog</td>
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Fig. 2 illustrates two specific windows of Database Utilities application (on the left - defining the database connection; on the right - the initial operation for inserting of a new entity, editing / deleting of a predefined entity, choosing of coordinates, defining metadata and deleting the changes registry). The database tables, resulted after the using of the “Database Utilities” application, are presented in Fig. 3.
For the purposes of the MEMDUR project, data from different sources was used. Its introduction in the database involved the following steps: from the initial form, - “shape” file type (“shp” extension), the data is imported into GeoMedia workspace and then exported to SQL Server database. This operation generates a corresponding geometric entity automatically. The interface for data population with the necessary entities in the SQL database is illustrated in figure 4. Here are presented the following entities: roads, vegetation, hydrograph and inner space limits, with the preservation of the existed textual attributes.

Another important component of the MEMDUR system is offered by the mathematical model. An analysis of the pollution status was performed for the most important pollutants affecting the human health established by the national legislation, having in view mainly the following noxes: CO, NO, NO\textsubscript{2}, SO\textsubscript{2} and PM10 dusts. The values were compared with the hourly maximum admitted concentrations with the view to preserve the human health. For establishing the areas were the level of pollution generated by the stationary pollution sources is maximum, it was used a mathematical model that incorporates source-related factors and meteorological factors to estimate pollutant concentration from stationary sources.
The implemented model takes into account the wind speed, altitude point, distance from the main pollution source, etc. (Kumar, 2005). The pollutant concentration in a given point is composed of the contribution of each source that produces the pollutant even this presents a significant variation. When calculating the concentration at a specified point, it is taken into account the pollution sources located in a neighborhood area of specified size. Being able to answer to various problems, spatial queries of the neighborhood area in relation with the pointed sources can be designed.

RESULTS AND DISCUSSION

In the MEMDUR system, the digital terrain model (DTM) is available as a network of points in the ASCII format. The large amount of points generated to capture the terrain details makes difficult the work when it is needed to see the GeoMedia representation. In this case, the points were not registered as separate geometries in the database. For a clear representation of the analyzed situation, it can be overlapped the ortho-photo plan on the digital terrain model of the city. Fig. 5 illustrates the ortho-photo plan of Targoviste area together with the road network and administrative limits. In the figure, different gray tonalities represent the altitude zones.

Once the pollutant concentration in the DTM points was determined, it is possible to show different forms of concentration distribution on areas of interest. In this case, it can be analyzed the areas where the concentration exceeds a specified and standardized threshold, taking into account the regions of interest - for example, a great importance is given to the areas with a great density of population, river basins, water reservoirs in correlation with water fisheries, vegetation and fauna areas, agricultural land, road network etc. As stipulated before, spatial queries can be made between areas with concentrations in a given interval and entities of interest, for determining the affected areas and implementing the necessary measures to minimize the pollution effects.

As an example, it can be reproduced a hypothetical situation of a pollution accident. By making the special intersection between the iso-pollution curves and the geographical entities, the affected areas can be determined (Fig. 6). The iso-pollution curves are arbitrarily chosen for simulating a real situation and demonstrating the model efficiency, the visual representation of the pollutant concentration and the used symbols, which show the movement gradient of the pollutant.
The on-line web publishing of the system was performed using *GeoMedia WebMap* application, including also an *asp.net* solution developed under the MEMDUR project. The system interface offers the possibility to open and consult the designed database that includes the last monitored records of environmental atmospheric parameters or main noxes. In the *Map* submenu, a user can visualize a graphical representation of the area of interest and the technical attributes of the objects or events registered in the critical points (Gorghi et al.,...
CONCLUSIONS

The MEMDUR system was created and developed to provide on-line information on the air pollution status of the Targoviste area. Including a spatial database and a mathematical model, it can provide information on the air pollution status for the most important pollutants for human health: CO, NO, NO₂, SO₂ and PM10 dusts, comparing their values with the hourly maximum admitted concentrations (Nicolescu et al., 2008). The system make possible to show different forms of concentration distribution on the areas of interest. In this way, it is possible to analyze the areas where the concentration exceeds a specified and standardized threshold, taking into account the regions of interest.

The spatial queries that can be made between the areas with concentrations in a given interval and the entities of interest and can be used to determine the affected areas and to implement the necessary measures to minimize the pollution effects.

The system interface offers the possibility to open and consult the last monitored records from the designed database. The user can visualize the graphical representation of the area of interest and the technical attributes of the objects or events registered in the critical points.

Equipped with a user-friendly interface, the MEMDUR system functions as a web system. It can be a useful tool for the air pollution management and crises prediction necessary local Environment Management Agencies and Local Authorities. Internet users can
find here some important information on the status of the air pollution of a specific area of Targoviste city.

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