

MUNICIPAL ENVIRONMENTAL-MONITORING SYSTEM

F. SPEISER[✉], I. MAGYAR, K. ENISZ

University of Pannonia, H-8200 Veszprém, Egyetem str. 10,
[✉]E-mail: ferenc.speiser@gmail.com

Nowadays protection of our environment is playing more and more significant role and within this topic the protection of the human aspects is even more important. The continuous monitoring of the municipal environment came into foreground in Hungary also through the past years. Within the Faculty of Engineering of the University of Pannonia a unique organizational unit was established under the name "Sustainable Development Environmental and Informatics Cooperative Research Centre". This centre started an R+D project on the main topic of environmental protection and its technologies. The goal of this paper is to summarize a measuring method of municipal-environmental parameters (e.g.: CO, O₃, NO_x, NO₂, C₆H₆) using low-cost monitoring devices and open source visualization software. The system integrates the measured data in a GIS for further processing and publishing. The sample-area was given by the location of the University. Hence, the test-measurements were carried out in Veszprém, Hungary. The developed system gives the power of data integration so the user can manage one uniform user interface for processing the data gained from the environmental measurements. On the whole it can be stated that the system is suitable for collecting environmental data with specific low costs at minimal infrastructural build-up. Further measurements and modeling will be managed in the future using the developed system in order to compare the present results of air quality of Veszprém to the collected environmental parameters in other cities and counties.

Keywords: GIS, environmental monitoring, airpollution, environmental modeling

Introduction

The permanent monitoring of the municipal environment becomes more important in Hungary recently. This aim can be realized by modern monitoring stations, but the involvement of local groups, NGOs and, people living there in the control of the environmental parameters is very rare. The best solution for this problem is to publish the available environmental data on-line, through the Internet.

Our R+D project targets to work out the measurement methodologies of environmental pollution data [1]. The main goal is to make it possible to setup and operate an information system based on the collected data that can publish environmental data through the internet.

In connection with the information system mentioned above, the local government/authority can elaborate an attractive, informative, up-to-date information service that provides data on the state of their environment for the inhabitants' purpose.

The database obtained from the measurements is a kind of data source possessed by the local authority that can be effectively used for preparing the annual environmental report, as well as for supporting decision making in fields, where displaying of spatial information on maps plays an important role.

Nevertheless, during the further development of the system there are several possibilities to optimize the process. For example the integration of the dust-concentration meter to the data-collector could be a possible solution. On the basis of this the measured dust-data could be sent via e-mail to the processing server. Furthermore it would be practical to analyze more comprehensive also the (under) surface waters.

The goal

As a result of the measurements carried out by the University of Pannonia, the university earns special measurement experiences and data, which results leading position among the similar faculties in Hungary and also among universities and educational institutes of neighboring countries.

The goal is to develop an information system which is suitable for integrating, processing of data (average, statistics, limit) and then publishing environmental parameters (air, noise, water, soil, and weather attributes) in database tables, diagrams, graphs, and maps in the same way. The information system is available through the web. The system provides other related environmental data like environmental infrastructure (e.g. treatment of waste) and can offer various environmental events as well.

Novelty of the system

During the preliminary consumer research and surveying the existing monitoring systems and services it was apparent that the air pollution-monitoring is the most important in the city-environment. Therefore the processing and representation of measured data is limited only to these parameters. However, the planned system gives the possibility to manage series of environmental parameters and – after loading – publish them immediately.

The managed data is stored in a scalable, fast geodatabase by the system, which means it is easy to search and browse, so a tool is available to achieve data for modelling, spatial statistics, queries, and surveys. Since the same database stores all type of the environmental data, the diversity of formats used by different measurement systems is eliminated – this makes the data collection faster. Furthermore, the user can obtain the proper dataset executing a definite query on a uniform interface.

The application differs from the other services in the mobility of measurements too. The measurements performed by a mobile monitoring station equipped by the proper measurement tools and devices. It is possible to make daily or monthly measurements by this equipment during an optional time period, so conclusions can be drawn; maps regarding the tendencies of the examined area can be prepared as well.

Protection of municipal environment

The work of our world is complex and is getting more and more complicated, people are moving to overcrowded metropolises, so the environmental impacts of the city is significantly influence the human health. The energy and food demand is increasing and for supplying it a device with an appropriate logistic background and adequate trend-prediction is needed. The number of national disasters (rain, fire or earthquake) is increasing in the counties of the world. The geoinformatics as tool can help with forecast, modeling and can help to manage the problems, support the decision-making and preparing for corrective and preventive plans [2, 3]. There are efforts to manage for example the following fields in Hungary for that GI is applied: human health, food quality, epidemiology, ragweed mapping, flood protection.

In addition to these areas, the monitoring and protection of the municipal environment – as the most important fields – are our important tasks too and with the system elaborated by us we try to realize these goals.

The system architecture

The components of the system are working on a Windows 2003 Server (not open source) operating system. The program components are open source (<http://www.opensource.org>) softwares. The developer-team decided to use the following tools:

- MapServer (<http://mapserver.gis.umn.edu/>),
- MS4W application (<http://www.maptools.org/ms4w/>),
- PHP/MapScript (<http://mapserver.gis.umn.edu/doc44/>),
- Apache web server (<http://www.apache.org/>),
- PostgreSQL (<http://www.postgresql.org>),
- PostGIS (<http://postgis.refractory.net>).

If appropriate logic is assigned to the components and a data model then a link can be established to even to a local government information system, providing environmental information.

Fig. 1 shows the communication between the components of the system.

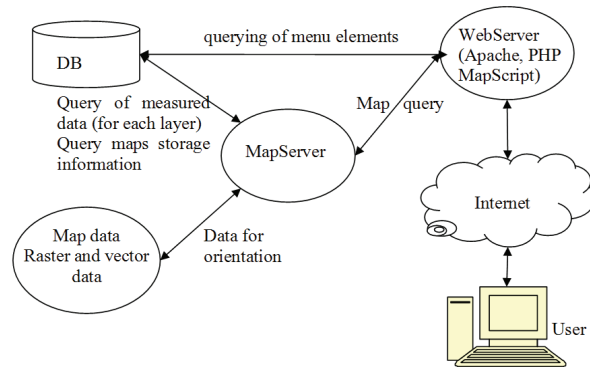


Figure 1: System components and connections

The portal consists of two main modules: the starting page gives general information and a menu-system grouping environmental data regarding the specified area of the municipality. Navigating through this menu, information about the environmental parameters can be obtained as static html pages by selecting a phrase. After starting the service in the window of the browser it is allowed to browse among the classical formed – in tree structure – and stored data. Selecting from this list, html-contents appears in the right side of the page.

The menu of the homepage is sorted according to the following environmental aspects (see below). These are about the environmental status of the given municipality.

Environmental status: Air pollution – information on air-quality, Pollen status – general information on pollen, Tick infection – tick frequency in the given territory, Water – surface-, subsurface-, drinking-water properties, Soil – generally about role and protection of soils, Noise – noise load of the municipality.

Environmental infrastructure: Waste management – general information on waste handling, Drainage – information on drainage, Rainwater network – drainage maps, Sewage works – sewage farms of the area, Environmental protection – natural reserves, Ragweed – general information on ragweed, Street network – street map of the city.

Environmental information: Programs, News, Call for a tender, Associations – information on the city. There is an opportunity to display a map, which serves dynamic information from the database. On the map commonly used navigation tools can be applied to browse the specific measured parameters and data.

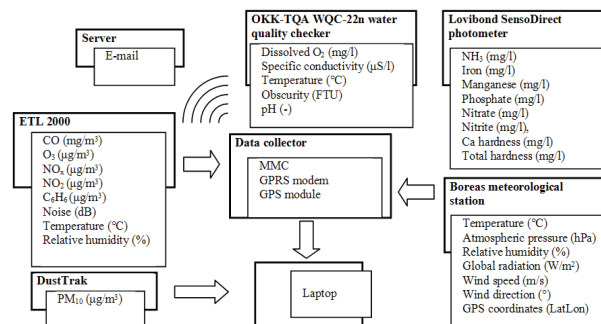


Figure 2: The structure of the measurement system

Measuring method

It was decided to develop a system for measuring environmental parameters, which are extremely important considering the human health. The system was planned to be mobile and capable to measure most of the parameters collected by a normal monitoring station (measuring container). The defined requirements of our system are the followings: it should be significantly better in cost effectiveness; it should be capable to transmit the collected data to the server in a reliable way immediately; the system should be installable at any site of the country. On the contrary costs would be serious to establish in case of a normal monitoring station. In addition to collecting the air quality and meteorological information, an attempt was made to apply on-site water-analytical methods, which are fast, cost effective and suitable to provide reliable information about our surface waters.

On the basis of the acquired information it turned out that the cheaper absorption measuring procedure is appropriate only in the case of two parameters. Moreover the chemical demand of the method is high and it can only provide few information about the given parameters. The air-quality monitoring appliances installed into the automatic monitoring stations and the well-equipped monitoring vehicles are precise, providing a lot of data, but they are extremely expensive.

The chemiluminescent measurement of NO and NO₂, the NDIR meter for measuring CO and the gas-chromatographic measurement of BTX (benzene, toluene and xylene) compounds exhibit high costs. The definition of PM₁₀ based on discolouring of the filter-paper. It is slow and material demanding. On the basis of the calculations it can be concluded that costs are mainly come from the immission measurement of the air quality. Hence, first of all special focus was put on the air analytical measuring system during the system development.

Development of a method was envisaged in order to reach a compromise between the cheap and mobile data acquisition and the numerous, relative reliable data supply. Fig. 2 below shows the measuring system.

Experience of the pilot project

During the planning of the measurements unexpected difficulties were coming up, while our initial expectations were not confirmed in all of the areas. It can be stated that the elaborated system is proper to measure environmental parameters also at remote areas. By means of low initial, operational and maintenance costs the system is possible to be installed at several sites. The results supplied by the device are proper for static measurements, for mobile-measurements further experiments are needed. However, it is interesting to get a snapshot of the air pollution of the city by driving around on the main streets. Although it is not an authenticated measurement method that the air-monitoring system uses, the measured values give a proper image about the actual environmental status. For testing the system more routes were selected in Veszprém, Hungary to represent the area. One of them depicted in Fig. 3. The paper only deals with air pollution and meteorology monitoring but the system is able to measure water parameters too. Meteorology parameters are necessary for calculating the distribution utilizing the known points. Considering that the chosen ETL2000 air quality monitoring device is not widely used in Hungary, reference data were requested for reliable operation. Hence, prior to the measurements a calibration procedure was carried out with using the system of the Hungarian Air Quality Network. After calibration measurements the environmental data provided by the ETL2000 were evaluated regarding the necessary correction to be done. As a result of the calibration the data measured by the two different technologies are correlating well.

Pressure on the blue distribution maps is principally defined by the relief of the town, hence, they are similar, although they show different time period. It can be stated about the benzene pollution that it is higher in the south-eastern part of the town. The hypothetical causes could be the following: the high traffic routes of the area, the prevailing north-western wind direction, the relief. Dark-red colours of Fig. 4 on the south-eastern part of the town are in good correlation with the well-known high traffic roads. On the west side of the city is a family-house area with lot of parks; the pollution is significantly smaller in this area. In addition to the on-line data supply, this technique provides chemical-free, environmentally sound and it is cheaper at site analysis. On the whole it

can be stated that the system is suitable for collecting environmental data with specific low costs at minimal infrastructural build-up.

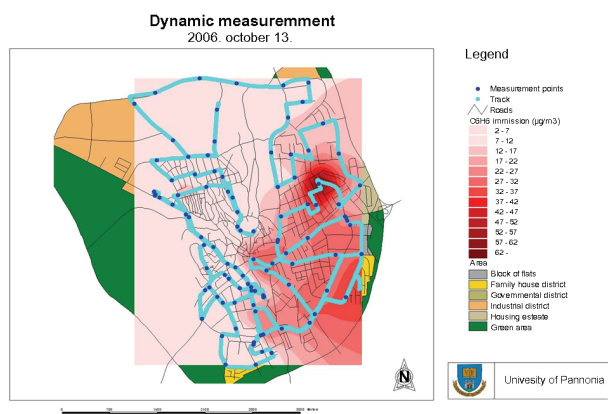


Figure 3: Dynamic measurement

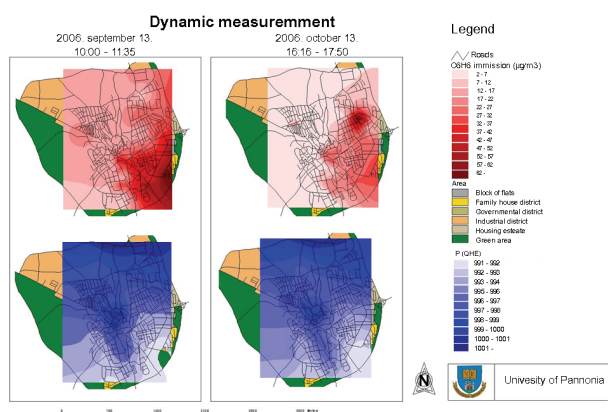


Figure 4: Dispersion map from the collected data

Environmental modelling

There are a lot of efforts to develop an appropriate framework or an easy to use method to control and simulate the urban environment for supporting effective urban air pollution control and management [3, 4]. As the above mentioned experience shows, our system can be used as a primary data source (monitoring system) for an environmental quality modelling system, that uses various algorithms to assess the impact of the environment on the human inhabitants in a city. The elaborated system is able to collect traffic pollution data, that can be used for deeper traffic situation modelling.

Conclusion

The environmental data displayed on maps provided by the information system are beneficial for the local governments and on regional level in environmental protection and also for inhabitants by publishing the information. At public administration level the collected data are used for supporting investments, development policies, and environmental decisions. Every system produced up to the present was specialized to monitor one specific environmental parameter category (air-, soil-, water quality monitoring), hence it was more complicated if all components were requested to be monitored because of the variety of the user interfaces and data formats. In contrast to this the developed system gives the power of data integration so the user can manage one uniform user interface for processing the data gained from the environmental measurements. The strengths of the monitoring system is the integration since every measured data of environmental parameters are loaded to a database, so the publication, retrieval and the later utilization is getting easier. The people can get information on the actual environmental conditions through a continuously available Internet portal.

ACKNOWLEDGEMENTS

We acknowledge the financial support of this work by the Hungarian State and the European Union under the TAMOP-4.2.1/B-09/1/KONV-2010-0003 project.

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