Environmental Coastal Regions III, C.A. Brebbia, G.R. Rodriguez & E. Perez Martell (Editors)
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Web-based pollution monitoring system for the Lake Ohrid

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Abstract

In this paper, we will present a Web-based pollution monitoring system for Lake Ohrid. Our intention is to describe some of the processes that contribute to the eutrophication of Lake Ohrid. Our work is related to the ecological state of Lake Ohrid. Tectonic by origin, Lake Ohrid is situated in the southwestern part of the Republic of Macedonia. The size of the lake is 358 square kilometres. Its average depth is 151m and the maximum depth is 289m. "Man-made" eutrophication, in the absence of control measures, proceeds much faster than the natural phenomenon and is the major reason for pollution of this lake. A Dynamic Integrated Monitoring System (DIMS) was previously presented in another paper. The monitoring system is based on on-line measurements. One of the main objectives of DIMS is to provide a real-time monitoring and efficient protection of the environment. In this paper, we present a Web-application for handling the data for the pollution monitoring system. Data acquisition and analysis is performed by a DBMS server and then presented in HTML format in regular pre-defined time intervals. The Web server and corresponding software are used for this presentation. In this way the data and its analysis is performed in one place and they are available to any user having only a web browser. The Web-based pollution monitoring system is implemented using UNIX/RDBMS environment and GIS software.

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1 Introduction

Our work is related to the ecological state of Lake Ohrid, which represents rare natural ecosystem inhabited by many endemic and relict species. For its outstanding natural surroundings, Lake Ohrid has been placed on the UNESCO world natural heritage list. The lake faces accelerated deterioration of its waters and a change of the trophic state of this aquatic ecosystem, mainly caused by nutrient load. "Man-made" eutrophication, in the absence of control measures, proceeds much faster than the natural phenomenon and is the major reason for pollution of this lake, e.g. World Bank [1], OECD report [2].

We proposed in the paper by Mitreski et al. [3], [4] and Davcev et al. [5] a mathematical model that gives general picture of the level of eutrophication in the Lake Ohrid and shows general trends of the lake behaviour. The specific nature of the lake has been taken into consideration and embodied in the model. Such dynamic model, which tends to predict future eutrophication and the trophic state lake-wide, is the first attempt undertaken in describing the ecological state of Lake Ohrid.

In this paper, we will present a Web-application for handling the data for pollution monitoring system. Data acquisition and analysis is performed by DBMS server and then presented in HTML format in regular pre-defined time intervals.

The paper is organized as follows. Section 2 gives a pollution monitoring system architecture for the Lake Ohrid. In section 3, the design and implementation of Web-based pollution monitoring system for the Lake Ohrid is presented, while section 4 will conclude the paper.

2 Pollution monitoring system architecture

In the paper by Mitreski et.al [6], we presented our scheme for planning a DIMS for the Lake Ohrid. The structure of the pollution monitoring system (PMS) includs three levels: (Fig.1)

- *Data acquisition level* responsible for systematization, validation, comparison of data with alarm limits and creation of dynamic part of the relational database system: the static part of the database with information about standards, limits, models etc.
- *Data handling level* responsible for supervisory control and specialized data analyses and model evaluations; it's also responsible for integration of on-line with off-line information to make statistical reports and data presentation.
- *Management level*, which is responsible for short-term decision and long-term strategies for the pollution reduction approach.

Our PMS consists of 6 measurement points along the coast of Lake Ohrid and 4 measurement points along the rivers. PMS was used for measurement of the following parameters: temperature, pH, total phosphorus, dissolved oxygen, total alkalinity etc.

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For example, temperature measurements were made by Pt100 sensor; pH measurements were made by *HI 1910B* sensor for calm water and with EURO2015 sensor for rivers. Measurement sensors are connected with intelligent microprocesor system PH500122 in local stations. The data are measured on-line by the instruments and transmitted to the central station where they are processed by the computer system.

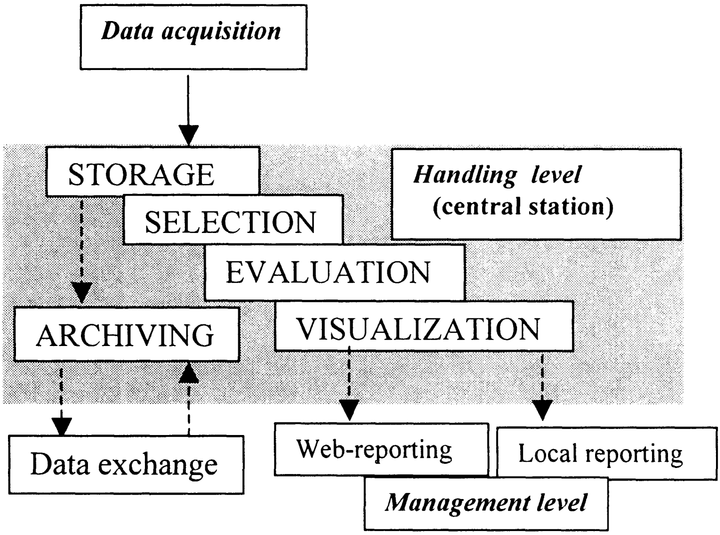
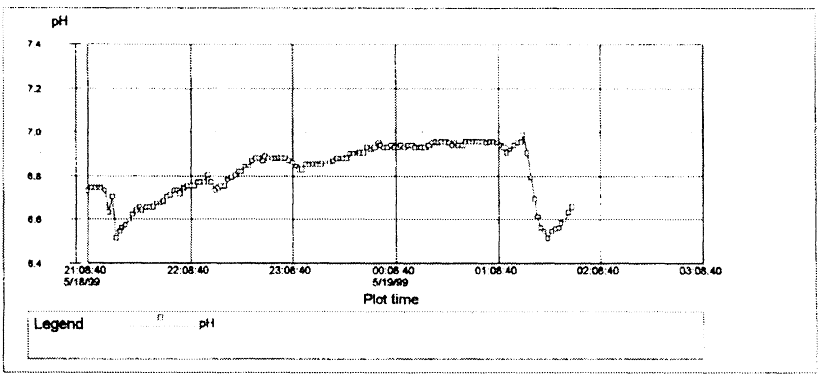


Fig.1 Process steps of monitoring system

The measured values are organized as relational database, which is suitable for statistical analysis using different OLAP (on-line analitical processing) tools. One example of graphical presentation of pH measurements if given on Tab.1



Tab 1. Graphical presentation for the pH measurements

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Aquatic ecosystems are extremely complex and the basic objective of most PMS is to determine the status of the ecosystem. Mathematical model [3] are build and validated with empirical data from our PMS. Web-based pollution monitoring system will gave more possibility for predictive models about Lake Ohrid in the future.

Web-based pollution monitoring system architecture for the Lake Ohrid is based on client-server technology (Fig.2). DBMS, WEB and GIS servers are connected with Intranet/Internet network.

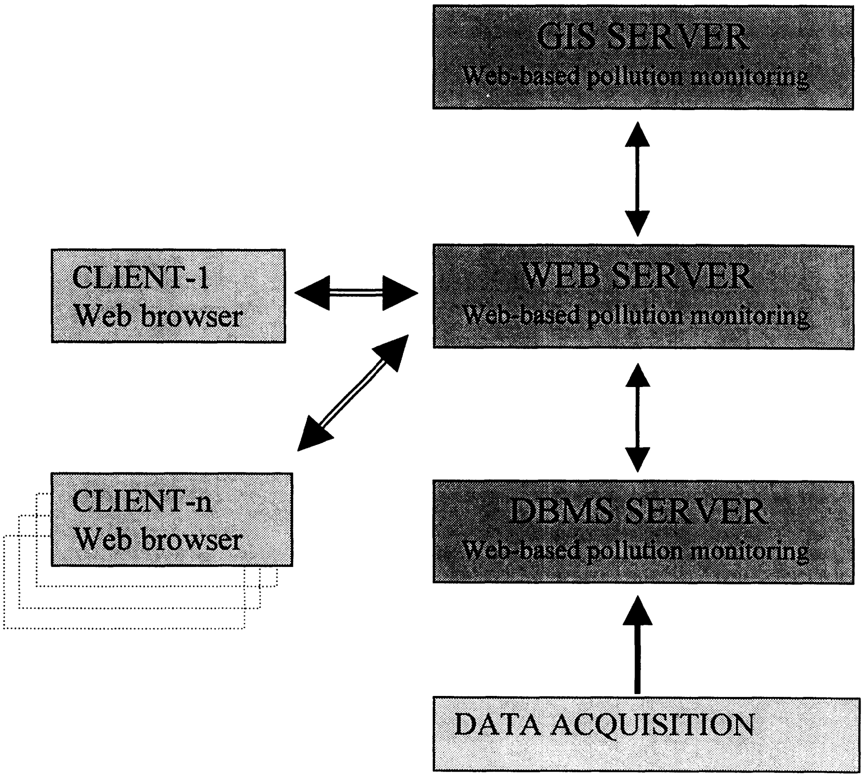

Fig.2 Pollution monitoring system architecture

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3 The design and implementation of Web-based pollution monitoring system for the Lake Ohrid

The interface of the Web application is presented on Fig.3. Web-based pollution monitoring system is implemented using Red-Hat Linux and SQL RDBMS. Clicking on the picture or on the hyperlink could choose the location. (Fig.4).

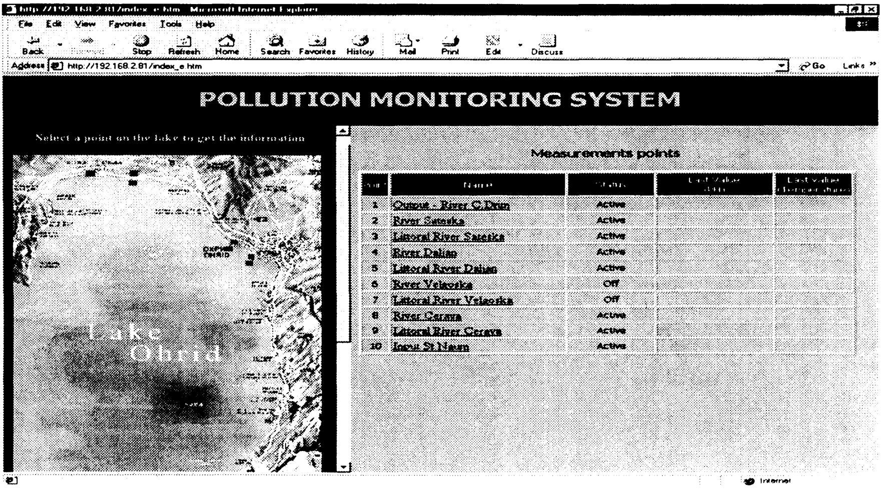

Fig.3 Main screen of the Web interface of the PMS

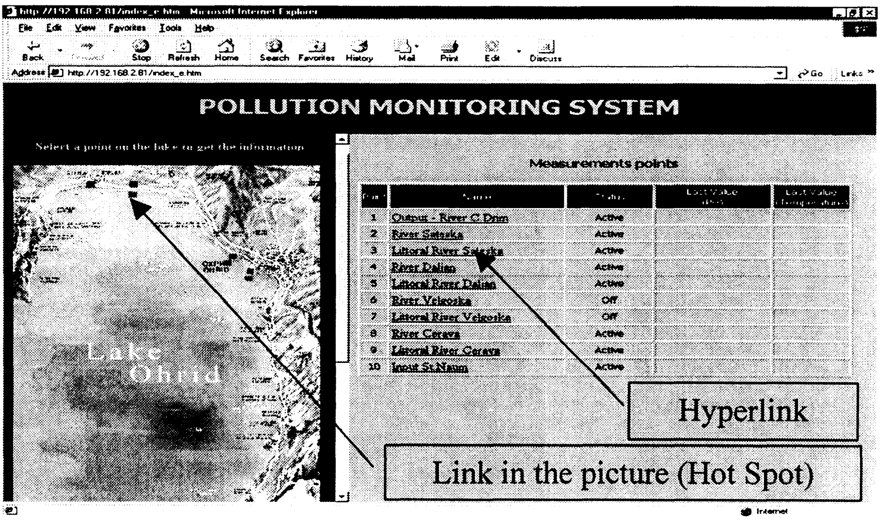

Fig.4 You can chose location by clicking on the picture or on the hyperlink

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After choosing the location and query from date to date, application will generate dinamicly from the database analitical and graphical presentation for all measured parameters. (Fig.5 and Fig.6).

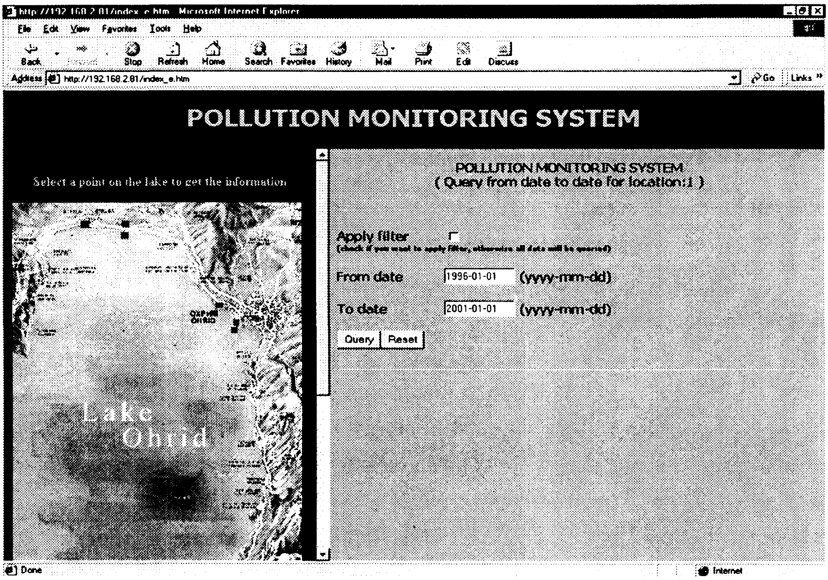

Fig.5. Query for the selected location (from date to date)

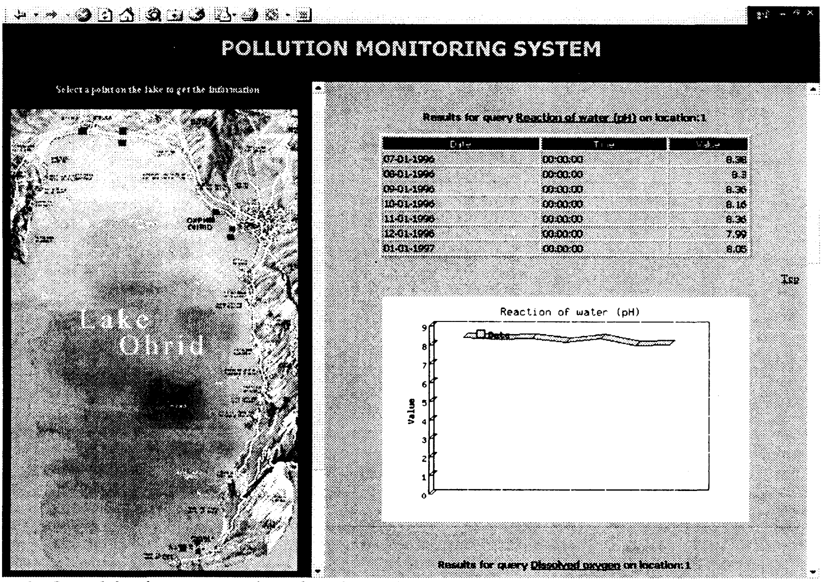

Fig.6. Graphical presentation for the selected location (from date to date) - for all measured parameters

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PHP Graph modul dinamicly create graphical presentation from DBMS for all available parameters. PHP3 WEB generator dinamicly read measured data and using HTML orders, web browser will display all presentation to the client.

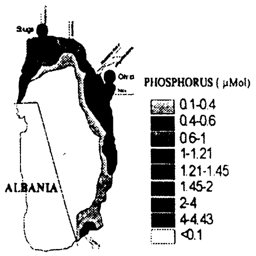

Fig 7.1

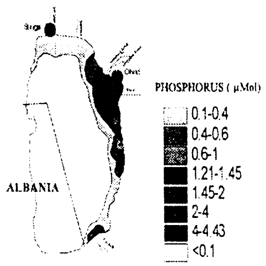

Fig 7.2

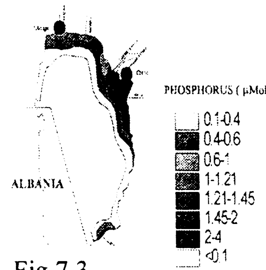

Fig 7.3

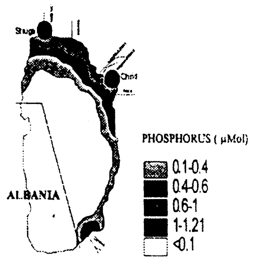

Fig 7.4

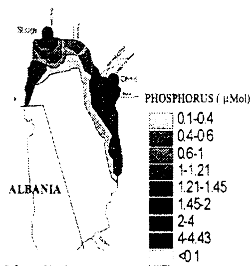

Fig 7.5

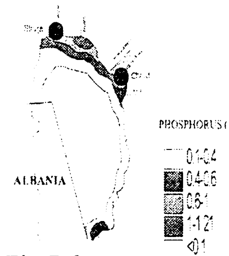

Fig 7.6

Fig.7. Graphical presentation for phosphorus concentration with GIS software

We have used selected data from PMS and ESRI GIS software for virtual modelling and visualization. Fig.7.1 shows present state of pollution of Lake Ohrid. Four main tributaries-rivers Sateska, Koselska, Velgoska and Cerava are shown a model of phosphorus pollution with value classification is presented. On Fig.7.2-7.6, the virtual models of the Lake Ohrid are presented. Fig.7.2 shows virtual model in the case when the river Sateska doesn't enter the Lake Ohrid, i.e. it is redirected or the river is totaly cleaned from the phosphorus. Fig.7.3, 7.4, and 7.5 shows virtual models in the case when the rivers Velgoska, Koselska and Cerava, do not enter the Lake Ohrid respectively. Fig.7.6 shows virtual models in the case when the rivers Velgoska and Koselska (together) are totally cleaned from the phosphorus.

The virtual model shows that if the influence of rivers Velgoska and Koselska are minimized, or if they are totally cleaned from phosphorus, the average pollution of the lake will be evidently decreased, especially in the litoral zone.

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4 Conclusion

In the paper, we present a Web-application for handling the data for pollution monitoring system. Data acquisition and analysis is performed by DBMS server and then presented in HTML format in regular pre-defined time intervals. Web server and corresponding software are used for this presentation. In this way the data and its analysis is performed on one place and they are available to any user having just a web browser.
Also using selected data from PMS and GIS software, virtual modelling and visualization of the pollution are presented.

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