EnviroInfo 2012: EnviroInfo Dessau 2012, Part 1: Core Application Areas

ICT activities for Air Quality Monitoring: An example of Network Stations of the City of Zagreb

Silvije Davila[1], Ivan Bešlić[1], Jadranka Pečar-Ilić[2] and Krešimir Šega[1]

Abstract

The most significant research and development activities concerning air quality assessment that is carried out by the Institute for Medical Research and Occupational Health (IMORH) according to the "Program to protect and improve air quality in the City of Zagreb" is shown. For the first time, information on air quality in the City of Zagreb is experimentally presented showing air quality indexes, easily understandable to the citizens. The model that we used to display the air quality index is CAQI model, which is the most common in the European Union and facilitates the international comparison of near real time air quality. In this paper, a proposal for near real-time presentation of air quality information for the City of Zagreb, using sensor data and Web GIS technology is elaborated. Presently, data are available only from four automated monitoring stations, but activities are carried out towards automated stations within local city network.

1. Introduction

1.1 Croatian air quality legislative framework

Air Protection Act (Official Gazette No. 130/11) sets up the objectives to protection and improvement air quality in the Republic of Croatia according to the requirements of CAFE directive. Air quality monitoring was started and preformed only on local level 50 years ago. Ministry of Environmental and Nature Protection is responsible today for air quality assessment in the entire state territory. Accordingly, Croatian government has established national air quality monitoring network 10 years ago. Air quality monitoring on national and local level has been adjusting according to the CAFE directive during last 7 years (Official Gazette, No. 61/08). New preliminary air quality assessment will be carried out in a period of next five years, especially at rural background monitoring stations. Revision of existing zones and agglomerations will be performed based on the results on this new assessment. Presently, air quality monitoring covers the measurement of the following pollutants: SO_2, NOx, PM10, PM2.5, O_3, CO, NH_3, H_2S, BTX, determination of heavy metals and PAH in PM10, as well as the meteorological parameters. Source apportionment (local and long range Tran's boundary pollution) is carried out based on the measured data results.

The Meteorological and Hydrological Service is responsible for air quality monitoring within the national network. Energy Research and Environmental Protection Institute (EKONERG) performs maintenance, calibration services and validation of the results. Croatian State National network consist of 11 automatic air quality monitoring stations in settlements and industrial zones and 12 new rural background monitoring stations.

Local air quality monitoring networks with the long tradition of the basic pollutant monitoring are organized across the country's territory. The representative bodies of local and regional governments are responsible for carrying out the assessment of air pollution levels in local networks. Air quality data are de-

[1] Institute for Medical Research and Occupational Health, Environmental Hygiene Unit, Ksaverska road 2, 10 001 Zagreb, Croatia. Email: sdavila@imi.hr

[2] Ruđer Bošković Institute, Division for Marine and Environmental Research, Bijenička road 54, 10 000 Zagreb, Croatia.

livered to Croatian Environment Agency (CEA) responsible for timely data collecting into Air Quality Information System (AQIS). AQIS makes an integral part of National Environmental Information System (Butuči/Mesić 2009), which has been developed and maintained in line with EU INSPIRE directive and SEIS principles (Hrebicek/Pillmann 2009).

1.2 Air quality monitoring in the City of Zagreb

Air quality monitoring in the City of Zagreb is performed at monitoring stations from two monitoring networks in order to cover the whole city area. Three automatic stations within national network are classified as traffic stations (Fig. 1).

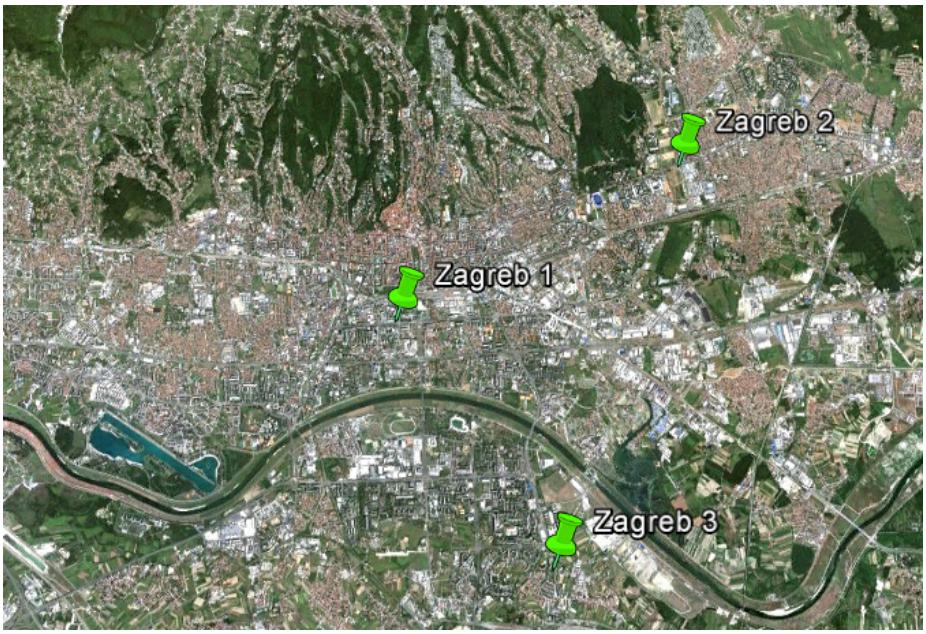

Figure 1
Automatic air quality monitoring stations within national network located in Zagreb City

Six monitoring stations within local network are classified as traffic, industrial or urban background stations (Fig. 2). The only automatic monitoring station within the local network is located at the Institute for Medical Research and Occupational Health (IMROH) and classified as urban background station. IMROH is responsible for the local network of the City of Zagreb following the scientific experience and development in air pollution field and maintaining the continuity of monitoring according to the "Program to protect and improve air quality in the City of Zagreb" (Mikulić et al. 2008). One of the most important objectives is to enable the citizen's right to be accurately informed on status of the ambient air quality at the location they live and work, in understandable way for everybody. IMORH has been accredited through EN 15025 for mass concentration determination of PM10 and PM2.5 particle fractions (EN 12341:1998 and EN 14907:2005), as well as for the determination of the following gases: ozone, nitrous oxide, sulphur dioxide and carbon monoxide (EN 14625:2005, EN 14211:2005, EN 14212:2005 and EN 14626:2005, respectively).

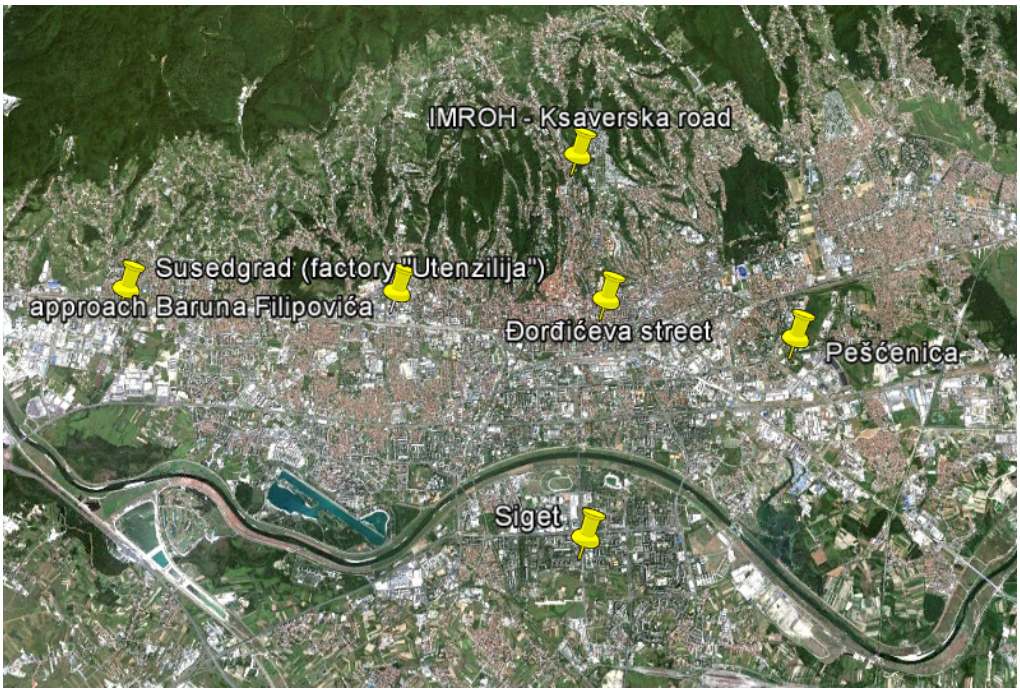

Figure 2
Air quality monitoring stations within local network of the Zagreb City

Since 2010, the specialized information system for presentation of air pollution information has been developing at the IMROH according to the EU and national air quality and information exchange legislation. At this point, two important functionalities are enabled in order to fulfill IMROH roles at the both national and local level (Davila/Bešlić/Pečar-Ilić/Šega 2011). The application IMI DEM Maker is developed independently to create Air Quality - DEM files, which entail setting up a file transfer to an information system for air quality of CEA. Web application for air quality monitoring from an automated station within local network (i.e. http://kvaliteta-zraka.imi.hr/index_eng.php) is a part of Institute's Web site available to different groups of users and citizens of Zagreb. The main goal is to develop more comprehensive geoportal and add the functionalities such as creation of an archive of pollutant concentrations for each monitored pollutant by days, introduce the air quality indicators and an air quality prediction model in combination with raster images of Zagreb.

Presently, the air quality information in the Republic of Croatia (as well as in the City of Zagreb) consists of raw monitoring data or corresponding categories of air quality for the past year, only, which is more suitable for air quality experts rather than general public.

In following paragraphs, we present a proposal based on the best practice guidelines and the methodology set up by the CITEAIR project (co-funded by first by INTERREG IIIC then INTERREG IVc). The main aspects of development process of the application system are explained, the main components of the system and information flows are presented. An example of interactive dynamic map with monitoring stations and corresponding hourly values of air quality indexes for the City of Zagreb is shown.

2. Air quality index

Air quality index had begun to develop 1960 in Toronto, Canada (Garcia/Colosio/Jamet 2002) for the purpose of informing the general population on air quality. In Europe air quality index first began to be used in France in 1995. Till year 2000, the 47 countries used air quality index. In order to determine the air quality index they used limit value prescribed by law, with combined of mathematical methods and restriction methods.

2.1 CAQI

CAQI model or Common Air Quality Index was created in the project CITEAIR (an INTEREG IIIc project, 2006). The index is designed for the purpose of comparing air quality in real time between European cities (van den Elshout et al. 2010, Hodges et al. 2005). In the early stages of the project they noted that many cities use other air quality indexes that are very difficult to compare. Because of that, they developed a new air quality index called CAQI.

CAQI has a scale from 1 to 100, where 1 is marked with the best air quality, while higher values are associated with concentrations mentioned in the European Air Quality Directive (Directive 2008/50/EC). Index is calculated using the grid shown in Table 1. For each pollutant the hour index is calculated. While the overall index for a given measuring site is defined by taking the worst of the calculated index.

Table 1
Pollutants and calculation grid for the CAQI
Source: van den Elshout and Leger, 2007

Index Class	**Grid**	**Traffic**				**City Background**					
		Mandatory			Auxiliary	Mandatory				Auxiliary	
		NO_2	PM_{10}		CO	NO_2	PM_{10}		O_3	CO	SO_2
			1 h	24 h			1 h	24 h			
Very Low	0	0	0	0	0	0	0	0	0	0	0
	25	50	25	12.5	5000	50	25	12.5	60	5000	50
Low	25	50	25	12.5	5001	50	25	12.5	60	5001	50
	50	100	50	25	7500	100	50	25	20	7500	100
Medi-um	50	100	50	25	7501	100	50	25	120	7501	100
	75	200	90	50	10000	200	90	50	180	10000	300
High	75	200	90	50	10001	200	90	50	180	10001	300
	100	400	180	100	20000	400	180	100	240	20000	500
Very high	>100	>400	>180	>100	>20000	>400	>180	>100	>240	>20000	>500

3. An Architecture of Web Application

Activity flow of the application system for display the air quality in the City of Zagreb is presented by Activity diagram of the Unified Modeling Language (UML) in Figure 3.

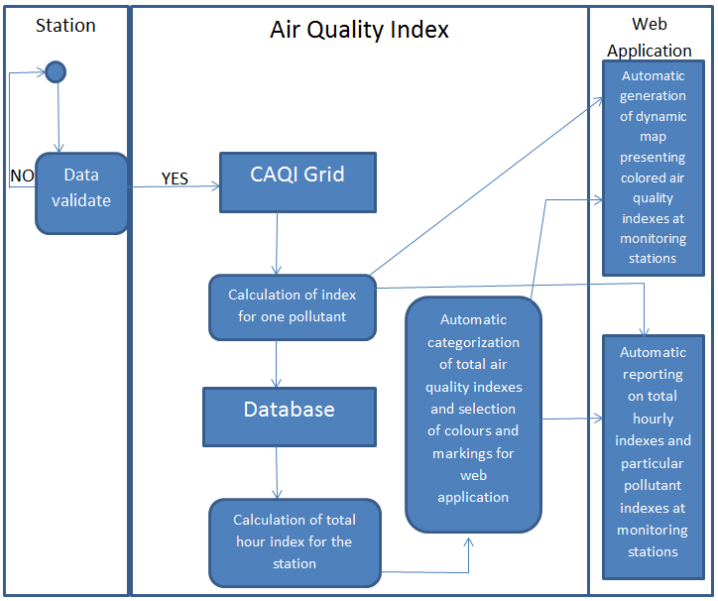

Figure 3
UML Activity Diagram of the System

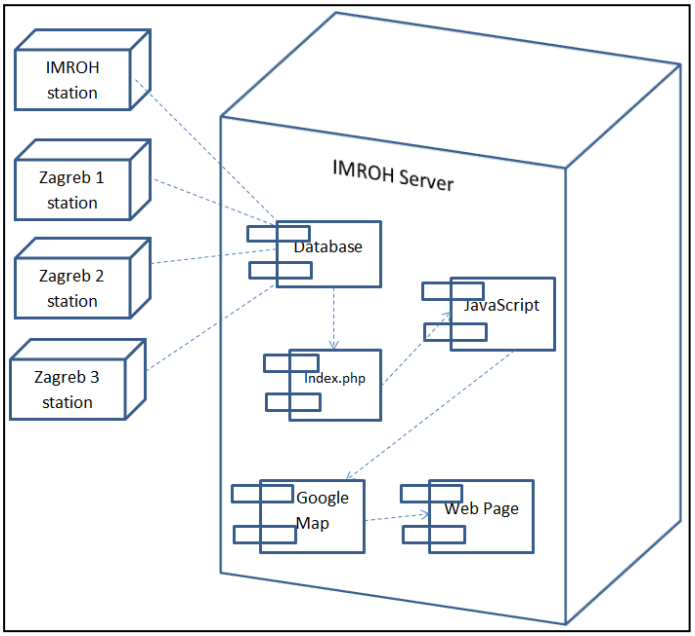

Figure 4
UML Component Diagram of the System

When downloading the data from monitoring stations, data is check whether it is validated or not. If data is not validated such data is not stored in the database. Data that passed the validation process is fed into the CAQI grid. With that grid air quality index for each pollutant from each monitoring station is automatically calculated using mathematic formula for calculating index. Air quality index for each pollutant is stored in a database, and then calculates the total hourly air quality index for each measuring site. After calculating a total air quality index, system automatically assigned a color and icon for a web application for each monitoring station. Web application automatically displays the report for hourly air quality index for a given monitoring station, and also automatically generates a dynamic map with markers of air quality index.

Organization and relationships of the components of application system for display the air quality in the City of Zagreb are shown by UML Component diagram in Figure 4. Data from local and national monitoring networks are collected in a database. The database contains the concentration of pollutants from all automatic station in Zagreb. Concentration data from the database are automatically converted to air quality index using php and JavaScript applications. When the air quality index for each pollutant is calculated, the overall air quality index for the measuring site is automatically assigned to the Air Quality Index Google map. These data are displayed on an experimental website which will be accessible by public in textual, numerical and in the form of a map.

4. Web application example

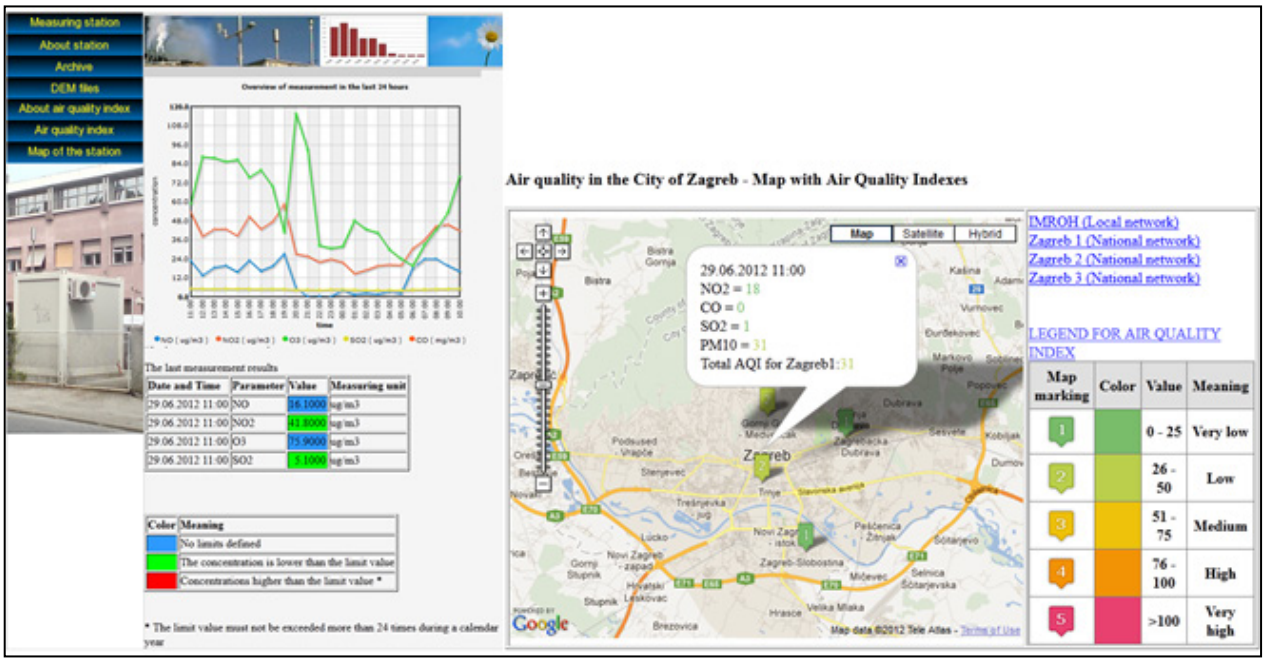

Figure 5
a) Web application of IMROH measuring station according Croatian Air Protection Act (left side)
b) Web application of Zagreb applying the CAQI methodology and in accordance with EU (right side)

Web application (Fig. 5a) for automatic monitoring station on IMROH (http://kvaliteta-zraka.imi.hr/index_eng.php) was done according the Croatian Air Protection Act. By the law we can only defined if the mass concentration of an hour pollutant is higher or lower than the legally permitted values.

Showing this data to the person who is not familiar with the Air Protection Act is completely incomprehensible. Therefore experimental Web application (Fig. 5b) of air quality in Zagreb (http://kvalitetazraka.imi.hr/aqi_experimental_eng.php) has been developed in accordance with European directives and applying CAQI methodology and proposed to the authorities of the Zagreb City. It shows interactive dynamic map of the City of Zagreb with the markings of automatic monitoring stations. The icons on the map are changed depending on the air quality index. By selecting individual monitoring station the details related to air quality index are showed. In this way, a person who is not familiar with the Air Protection Act can know how the air quality near the place where he is located is. Table 2 shows the hourly air quality index for each pollutant as well as total hourly air quality index for that location which is measured at national and local network stations (i.e. Zagreb 1, 2, 3 and IMROH, respectively) located in the Zagreb City.

Table 2
Total and components hour air quality indexes for automatic monitoring stations located in the Zagreb City (from 6th July 2012.)

Measuring site	Components	Concentration	Unit	AQI	Total AQI
Zagreb 1	NO_2	41	µg/m3	21	32
	CO	0	mg/m3	0	
	SO_2	0	µg/m3	0	
	PM10	32	µg/m3	32	
Zagreb 2	NO_2	27	µg/m3	14	20
	CO	0	mg/m3	0	
	SO_2	2	µg/m3	1	
	PM10	20	µg/m3	20	
Zagreb 3	NO_2	9	µg/m3	5	28
	CO	0	mg/m3	0	
	O_3	2	µg/m3	1	
	PM10	28	µg/m3	28	
IMROH	NO_2	48	µg/m3	24	39
	SO_2	5	mg/m3	3	
	O_3	92	µg/m3	39	

5. Conclusion

In this paper we present proposal for real-time presentation of air quality information for the City of Zagreb. The web application has been developed accordingly to the EU legislation and CAQI methodology.

Web application for monitor air quality for the City of Zagreb will be in the future a part of more comprehensive Web portal. We intend to develop new subsystems of IMROH's information system to completely fulfill recommendations set by EEA. For example, we will add the new functionalities such as an air quality prediction model in combination with raster images of the Zagreb City and trajectories.

Bibliography

Butuči, J., Mesić, H. (2009): Croatian Environment Information System Conceptual Model, Towards eEnvironment, Brno, pp. 153-158

Croatian Government (2008): Air Quality Protection and Improvement Plan of the Republic of Croatia for the period 2008-2011, Official Gazette, No. 61/08, Zagreb, pp. 141

Croatian Parliament (2011): Croatian Air Protection Act, Official Gazette No. 130/11, Zagreb (in Croatian)

Davila, S., Bešlić, I., Pečar-Ilić, J., Šega, K. (2011): An automated web-based system for air quality monitoring, 34 Int. Convention on ICT, Electronics and Microelectronics, IEEE Region 8, Opatija, Croatia, pp. 816-819

Garcia, J., Colosio, J., Jamet, P. (2002): Air Quality Indexes, EnviroInfo 2002, Wien, Austria

Hodges, N., van den Elshout, S., Heich. H.-J., Lad, C., Leger, K., Nussio, F. (2005): CITEAIR – Common Information to European Air, EnviroInfo 2005, Masaryk University Brno, pp. 518-522

Hrebicek, J. Pillmann, W. (2009): Shared Environmental Information System and Single Information Space in Europe for the Environment: Antipodes or Associates?, Towards eEnvironment, Brno, pp. 447-458

Mikulić, J. (et al.) (2008): Program to protect and improve air quality in the City of Zagreb, Zagreb, pp. 103, (in Croatian)

van den Elshout, S., Leger, K. (2007): A review of existing air quality indices and the proposal of a common alternative, Final version, in Component 3: Comparing Urban Air Quality Across Borders, CiteAir INTEREG III project, DCMR, Environmental Protection Agency Rijnmond, pp. 35

van den Elshout, S. (et al.) (2010): CAQI Air quality index, Citeair II 2010, Ljubljana, Slovenia