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Management and monitoring of air and water pollution by using GIS technology

Quản lý giám sát ô nhiễm môi trường không khí và nước bằng cách sử dụng công nghệ GIS

Research article

Ngo, Thanh Binh[1]*; Nguyen, Tuan Anh[2]; Vu, Ngoc Quy[1]; Chu, Thi Thu Ha[3]; Cao, Minh Quy[2]

[1]Faculty of Electrical and Electronic Engineering, University of Transport and Communications (UTC), Lang Thuong, Dong Da, Hanoi, Vietnam; [2]Institute of Environmental Science and Transportation, UTC, Lang Thuong, Dong Da, Hanoi, Vietnam; [3]Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Hanoi, Vietnam

The need for a green clean living environment is increasing today, with the boom of the socio-economic development, educational level. However, the environmental pollution becomes an alerted global issue due to the large amount of wastes discharged making this need to be not easily met at the moment. Greenhouse gas emission mainly from energy, transport and agricultural land use is causing climate change because of their long atmospheric lifetime and trapping the heat in the atmosphere. Harmful effects and damages caused by environment pollution and climate change are unpredictable. It was reported that every year millions of people die because of fine particles when exposing to air pollution and other millions die from water-born diseases. Management and monitoring of air and water pollution by using GIS technology is an effective method. The measured data can be obtained continuously, quickly and accurately at stations in any regions even with complex terrain. This helps reduce the required number of employees, manage automatically and continuously a large number of data.

Ngày nay nhu cầu về một môi trường sống xanh, sạch đang gia tăng, với sự bùng nổ của phát triển kinh tế - xã hội và trình độ dân trí. Tuy nhiên, ô nhiễm môi trường đang trở thành một vấn đề cảnh báo toàn cầu do số lượng lớn các chất thải được xả ra môi trường làm cho nhu cầu này không dễ dàng được đáp ứng tại thời điểm này. Phát thải khí nhà kính chủ yếu là từ sử dụng năng lượng, giao thông vận tải và đất nông nghiệp đang gây ra biến đổi khí hậu vì thời gian tồn tại của cúng dài và giữ nhiệt trong khí quyển. Các ảnh hưởng xấu và thiệt hại gây ra bởi ô nhiễm môi trường và biến đổi khí hậu là không thể đoán trước. Thông tin báo cáo chỉ ra rằng mỗi năm có hàng triệu người chết vì hít các hạt bụi mịn khi tiếp xúc với ô nhiễm không khí; và hàng triệu người khác chết vì bệnh do nước sinh ra. Quản lý và giám sát ô nhiễm không khí và nước bằng cách sử dụng công nghệ GIS là một phương pháp hiệu quả. Các dữ liệu đo có thể được lấy liên tục, nhanh chóng và chính xác tại các trạm ở bất kể khu vực nào, ngay cả nơi có địa hình phức tạp. Điều này giúp làm giảm số lượng lao động cần thiết, quản lý tự động và liên tục một số lượng lớn dữ liệu.

Keywords: Management and monitoring, air and water pollution, GIS

1. Introduction

Monitoring of atmosphere and water environment through air and water analysis to manage, control and treat the pollution issue in order to ensure the safety of people and the environment.

Today, with the boom of the socio-economic development, educational level, the need for a green clean living environment is increasing. However, this is no longer a need to be easily met because the environmental pollution becomes an alerted global issue due to the large amount of wastes discharged by the plants, factories, power industry, mining industry, cement industry, shipbuilding and other industrial sectors. The wastes can be biodegradable or can not be destroyed within the next few hundred years. It is evident that anthropogenic air pollution, both indoor air pollution and outdoor air

* Corresponding author
E-mail: ngobinh74@yahoo.com

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pollution, is one of the most important issues that affect development in the world. The World Health Organization (WHO) estimated that every year about 2.4 million people die prematurely because of fine particles when exposing to air pollution (WHO, 2002; WHO, 2006). The degradation of water quality caused by human activities has harmful effects on human and ecosystem health. In the developing countries every year three million people die from water-born diseases (IPCC, 2007).

The situation of global warming is evident due to the emission of air pollutants especially the greenhouse gases such as CO_2 and CH_4. These kinds of gases are causing climate change because of their long atmospheric lifetime and trapping the heat in the atmosphere. Global climate change affects human activities on land and the associated water run-of caused by change of precipitation patterns contributing to degraded water quality.

According to statistics, Vietnam has over 800 industrial establishments with about 70 export processing zones (central industrial areas). Industries' contribution to GDP is huge, but we have to take more environmental damage caused by industrial sectors. In addition to the generation of greenhouse gases, about 90% of industrial production facilities and most of industrial zones do not have waste water treatment plant.

With the actual pollution situation in Vietnam, we have to manage and monitor environmental pollutants in order to give warnings when the parameters exceed safe thresholds, and offer specific solutions to prevent environmental pollution. Especially, monitoring the pollution parameters by using GIS technology is of very concern because of advantages of this method such as automatically continuous management of huge data; saving working time and reduction of necessary labour staff as well as accessing easily to the data of each parameter at each place on the map.

2. Situation of environment monitoring in Vietnam

2.1 Atmosphere monitoring

The air continuous automatic monitoring focuses on environmental hot spots (e.g. key economic zones, near the roads, etc.) and environmentally sensitive areas. In Vietnam now there are 17 fixed stations and 2 mobile stations in the national network of environment monitoring. For the local network there are 13 fixed stations (EMC, 2012). For most of the production facilities and industrial zones, emission monitoring is done by semi-automatic method (sampling, storage and transport to the laboratory for analysis); or quick measurement of some parameters at the scene by using the handle equipments. However, a number of production facilities actively installed air automatic monitoring systems for pollution emission control and / or monitoring the effectiveness of the treatment system.

2.2 Water monitoring

The water continuous automatic monitoring is mainly located in the river basin, major river systems. There are 3 stations in operation in Vietnam for monitoring Nhue river, Red river and Mekong river; and 6 stations in installation (EMC, 2012). By August 2011, there were 118 of total 174 industrial zones went into construction and operation of central wastewater treatment plants. However, the majority of the industrial zones did not install, operate wastewater automatic monitoring system under Circular No. 48/2011/TT-BTNMT (Ministry of Natural Resources and Environment).

2.3 The necessity for environment monitoring

The air and water automatic monitoring systems contribute to identify changes in environmental quality (through measured parameters) continuously over time and space. It helps determine quickly, detect early problems of environmental quality and provides continuous, instantaneous, real-time data serving for environmental management and protection.

From the obtained data, the manager can give out timely warning and propose the appropriate measures to manage, control and protect the environment as well as identify the responsibilities of the production facilities / industrial zones and of the provinces / cities (for example: for inter-provincial river basins).

Depending on the location, type of production and sources of emissions to choose exactly the typical characteristic parameters that are representatives for monitoring location. Among the basic parameters selected to evaluate the atmosphere quality, the required parameters measured in the field include wind direction, wind speed, temperature, relative humidity, pressure, solar radiation. The other parameters according to MONRE (2011a) should be monitored such as SO_2, NO_2, NO_x, CO, O_3, dust, Pb. Frequency of background monitoring should be at least 1 time per month and of impact monitoring at least 6 times per year. For the water monitoring, based on the objectives of the monitoring program, the type of water source, use purpose, pollution source or receiving water sources, the parameters monitored can include pH, T^0, DO, EC, turbidity, TDS (parameters measured at the field). The other parameters guided by MONRE (2011b) consist of color, redox world (Eh or ORP), TSS, BOD_5, COD, NO_2^-, NO_3^-, NH_4^+, SO_4^{2-}, PO_4^{3-}, N_{total}, P_{total}, SiO_3, coliform, E.coli, fecal coli, CN^-, Cl^-, F^-, metals, heavy metals, etc. The frequency of background monitoring should be at least 1 time per month and of impact monitoring at least 1 time per quarter.

Up to now, the number of monitoring stations in Vietnam is small; failure to satisfy the requirements of providing information and data serving for management activities. The monitoring has not reflected spatially the overall quality of water and air yet and has not met 1/10 network planning requirements of the National Environmental Monitoring according to Decision 16/2007/QD-TTg

(Prime Minister of Vietnam). Besides, knowledge and experience for operating the system; checking, processing, approving and monitoring of data mining of continuously automatic monitoring are still limited (EMC, 2012). Environment monitoring in many places is still not cared appropriately. Measured data were little and even obtained once per year only (DNRE, 2011; IESE, 2011).

Design, development and improvement of the automatic monitoring system are very necessary to ensure the efficiency of environmental management and monitoring process. That is especially significant in the poor conditions of developing countries when the prices of imported equipments are usually very high due to the taxes and cost for long distance of transportation.

3. Design and application result of the monitoring system based on GIS technology

3.1 Design of monitoring system

Management and monitoring system of air and water pollution includes the equipments at the station and equipments in the center. Station equipments are electronic devices, using the appropriate sensors to measure environmental parameters such as: air parameters (S-Dust, NO_2, CO, SO_2) and water parameters (pH, DO, TSS, NH_3).

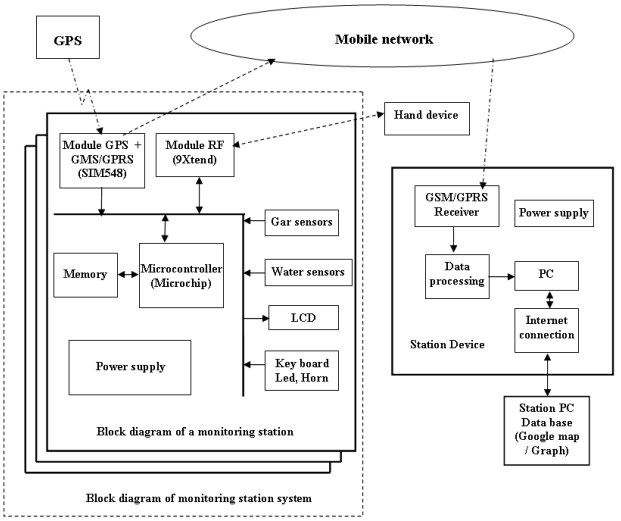


Figure 1. Block diagram of management and monitoring system of air and water pollution

Monitoring management software at the station was designed on GIS technology. WebGIS is a geographic information system operating in a computer network environment to integrate, distribute and transmit geographic information via the World Wide Web on the Internet (Thach, 2008).

The server system was connected to the internet and the applications installed on the server include: web server for receiving and handling the requirements of users; software and database (DB) of GIS support for functions of web server in implementing geographic information retrieval and browsing map.

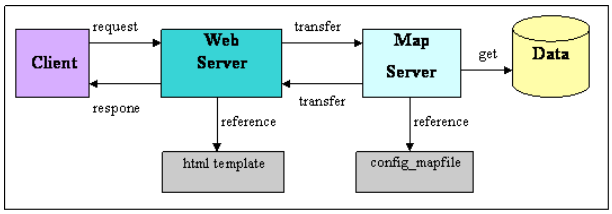


Figure 2. Block diagram of WebGIS

To use the system, users need to have a GPS device connected to the web server over the mobile network. This device sends the data about its location to the web server to enable the system to determine the user's location or the location of the object that the users need to monitor.

To get results from the system, users need at least one of the following devices: (1) PC, (2) personal digital assistance device (PDA) or (3) smart phone. These devices have the ability to connect to the internet. Users will use the web browser (or WAP) built in device to send requests and receive results.

Location information received from the GPS receiver will be processed by web server and commands GIS software to mark location on the map, then creates a copy of the map in the form of digital images. Web server will send the map as an image file to the user's device over the internet using the HTTP protocol. This map will be displayed on the user's device by web browser software (such as Internet Explorer). Simultaneously with sending an image to the map, the Web server sends the HTML pages and code scripts to create a graphic interacting with the user.

3.2 Application results of the monitoring system

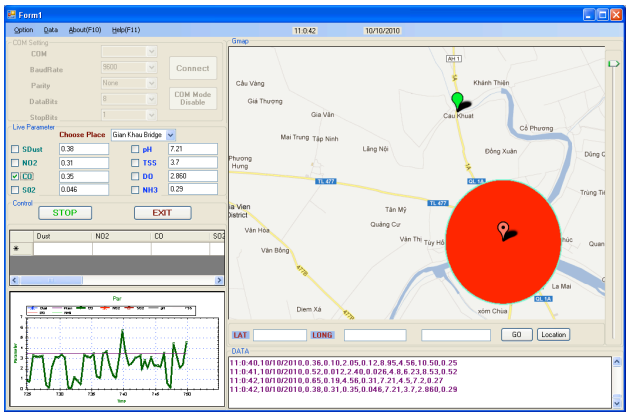
The parameters measured by using the sensors through the RF or GSM / GPRS communication will be transmitted to the user's device and saved in the table on Microsoft Access. The storage of data is very important for monitoring. The purpose of storage is to be able to access the data at any time, from that we can check and monitor the changes of the measured parameters over the time to provide analyses and conclusions about the environment status.

The system can operate in two methods: offline method (Writing data to the storage device, and then using these data to draw graphs); and online method (Transmitting data to the station to draw graph directly). On management monitoring screen, we follow these steps:

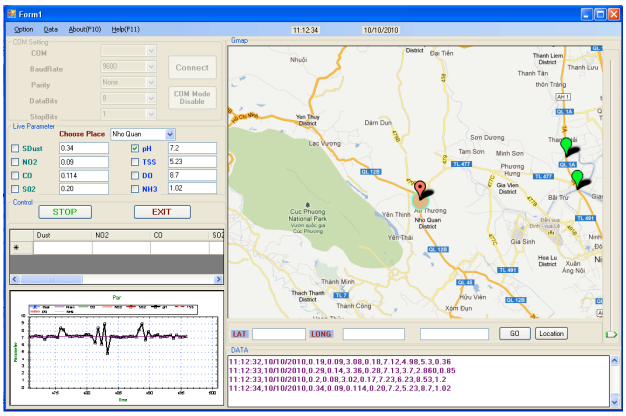
- Selecting the COM port (in online mode) or data file (in offline mode)
- Selecting area of the measuring station: Khuat bridge, Gian Khau bridge or Nho Quan
- Selecting the parameters required to observe: Air (S-Dust, NO_2, CO, SO_2), Water (pH, TSS, DO, NH_3)

Then, the users activate the display of an area by selecting test box named "Choose Place". After that, they activate the display of each parameter by selecting the appropriate check box. Finally, click on the Start button to run the system. The active place will change its color and be circled by a coloring circle. The changing of radius of this circle depends on values of measured data at that place. The color of the circle will change when these measured data exceed the standard limitation level. These measured data are also drawn on the graph with suitable scale and together with a horizontal line indicating the standard limitation. Data will be saved in database automatically. Through the visual display observed, supervisors can quickly grasp the variation of the parameters. Once the parameters increase or decrease outside the threshold levels dramatically, the supervisors can recognize and give out the warnings, as well as analyze, report and provide suitable solutions.

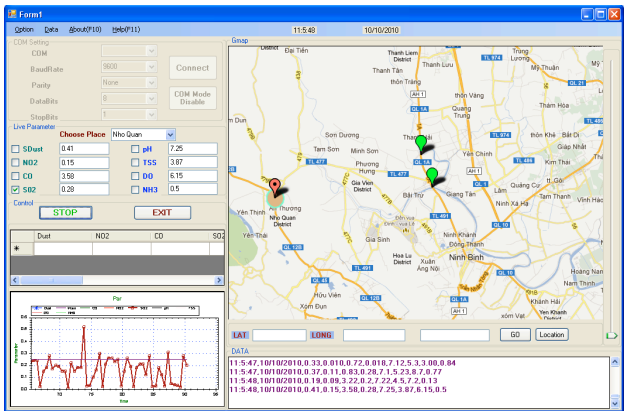
The results in this paper were obtained through running the system in offline mode with the measured parameters at three locations: Khuat bridge, Gian Khau bridge and Nho Quan of Ninh Binh province (DNRE, 2011). Environmental monitoring parameters at three locations, including Air (S-Dust, NO_2, CO, SO_2), Water (pH, TSS, DO, NH_3), are taken to the activities of offline mode and are shown in the following graphs:



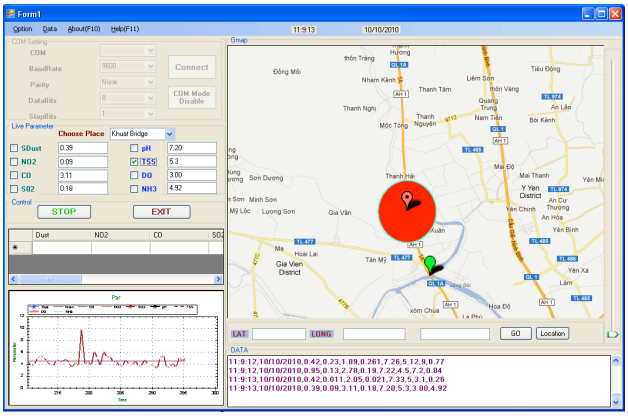
CO at Gian khau Bridge



pH at Nho Quan



SO_2 at Nho Quan



DO at Khuat bridge

Figure 3. Environmental monitoring parameters displayed on the map at the station

3.3 Advantages and disadvantages of the designed system

3.3.1 Disadvantages

In the online system, it is necessary to use GPRS / SMS for data communication over mobile networks. So for areas without mobile signal or at the period of time of losing signal, the online system will not receive data.

The received data may be error because of noise or loss of some pieces of data during transmitting and receiving process, so we need to develop programs to correct the signal.

Due to the automated performance and measurement, the online system is just in accordance with the operating parameters that have relatively large values. These parameters must be measured directly by sensors or automated electronic devices.

3.3.2 Advantages

This system was developed based on the GIS technology embedded with graphs that showed intuitively. Graphs used different colors corresponding to the selected parameters and by areas. They could be drawn from the parameters measured directly or taken from the file. The values were plotted and visually compared with a threshold, and also be recorded in the database.

Besides the direct management and supervision of the local station, the system can also connect all stations to receive information of the entire regional stations as well

as a management and monitoring center. Through the use of wireless communication methods, the system also solves problems caused by the complicated areas. For example, data can be obtained continuously, quickly and accurately at stations in regions with complex terrain such as on the mountains or on the sea. This helps reduce the number of employees, manage automatically and continuously a large number of data.

4. Conclusions

An entire environmental monitoring system can completely designed and manufactured in Vietnam with much lower price than imported equipments. All the measuring stations of environmental monitoring systems can be linked to a server to store data in the server. The information is transmitted to the local stations and to an integrated management institution as the Ministry of Natural Resources and Environment. Therefore, the suitable solutions for treatment of pollution will be fast provided when necessary.

Besides the advantage as monitoring function of a SCADA system, the designed system can be used for information advertisement that is especially useful for environment management and planning. The obtained data from monitoring process can be uploaded on internet in public for the purpose of environment co-management between civilians and the authorities. So the citizens will easily have information about the pollution sites, especially the people living near the pollution sources and pollution receiving places. This can help to prevent some plants, factories or industrial companies from discharging untreated wastes and wastewater to the environment.

5. References

[1] Dang, Q.T. 2008. The system offering services based on location. Transport and Communi-cations Science Journal, No. 27 (in Vietnamese).

[2] DNRE 2011. (Department of Natural Resources and Environment of Ninh Binh province) Report on the environmental status of Ninh Binh province in 2010, 137 pp. (in Vietnamese: Sở Tài nguyên Môi trường tỉnh Ninh Bình (2011) Báo cáo hiện trạng môi trường tỉnh Ninh Bình năm 2010, 137 tr.)

[3] EMC 2012. (Environmental Monitoring Center, Vietnam Environment Administration) Overview of automated monitoring system for managing air and water environment in Vietnam - Status, orientation and noticeable issues. (in Vietnamese: Trung tâm Quan trắc môi trường, Tổng cục Môi trường (2012) Tổng quan về hệ thống quan trắc tự động môi trường không khí và nước ở Việt Nam – Thực trạng, định hướng và những vấn đề cần lưu ý)

[4] IESE 2011. (Mainland station 1 at the Institute of Environmental Science and Engineering, National University of Civil Engineering) Report on the results of environmental monitoring and analysis of phase 2 in 2001 in the northern provinces and cities of Vietnam by the station of the impact the Red River Delta region (mainland station 1), 65 pp. (in Vietnamese: Trạm vùng đất liền 1 tại Viện Khoa học và kỹ thuật môi trường, Đại học Xây dựng (2011) Báo cáo kết quả quan trắc và phân tích môi trường đợt 2 năm 2001 các tỉnh và thành phố phía Bắc Việt Nam của trạm vùng tác động đồng bằng sông Hồng (Trạm vùng đất liền 1), 65 tr.)

[5] IPCC 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovern-mental Panel on Climate Change, 996 pp.

[6] MapInfo Corporation, 2005. MapXtreme ® DEVELOPER GUIDE, http://www.mapinfo.com

[7] MONRE 2011a. (Ministry of Natural Resources and Environment) CIRCULAR - Defining technical process for monitoring surrounding air environment and noise (in Vietnamese: Bộ Tài Nguyên và Môi Trường (2011a) THÔNG TƯ - Quy định quy trình kỹ thuật quan trắc môi trường không khí xung quanh và tiếng ồn)

[8] MONRE 2011b. (Ministry of Natural Resources and Environment) CIRCULAR - Defining technical process for monitoring continental surface water environment (in Vietnamese: Bộ Tài Nguyên và Môi Trường (2011b) THÔNG TƯ - Quy định quy trình kỹ thuật quan trắc môi trường nước mặt lục địa)

[9] Open Geospatial Consortium 2006. Inc., Corrigen-dum for the OpenGIS® Web Feature Service (WFS) implementation specification 04-095, http://www.opengeospatial.org

[10] Open Geospatial Consortium 2006. Inc., Open-GIS® Web Map Server Implementation Specifica-tion, http://www.opengeospatial.org

[11] Steiniger, S., Neun, M., Edwardes, A. 2005. Foundations of Location Based Services, CartouCHe1 - Lecture Notes on LBS, Vol. 1.0

[12] UNEP 2007. (United Nations Environment Pro-gramme) Global Environment Outlook GEO-4, 540 pp.

[13] UNEP 2012. (United Nations Environment Pro-gramme) Global Environmental Outlook GEO-5, 528 pp.

[14] WHO 2002. The World Health Report 2002. Reduc-ing risks, promoting healthy life, 248 pp.

[15] WHO 2006. Fuel for life: Household energy and health, 42 pp.