ROLE OF INFORMATION TECHNOLOGY IN AUTOMATED MONITORING OF WASTEWATER FROM HEALTHCARE ESTABLISHMENTS

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Abstract: There are some important water and wastewater treatment challenges such as: stringent quality requirement, stringent regulation, need for 100% reliability, increased responsibility to public, limited budget. All these require increased frequency of monitoring, a need for immediate reporting, a rapid communication and an emergency response. The need for decision-support tools for wastewater management is becoming more acute, and due to the risk involved, these tools are necessarily complex. Therefore such tools need to be incorporated in automated monitoring systems based on user-friendly software. In this paper, we aim at presenting the most important objectives and features that must be fulfilled by a software tool used in wastewater management of a healthcare establishment and the methods used in the development and implementation of a specific monitoring system

Key Words: water quality, wastewater management, software tool

1. INTRODUCTION

Wastewater is defined as water whose properties have been changed by domestic, industrial, agricultural or other use and other water discharged with such water in dry weather (sewage) and also as water from precipitation which runs off and is collected from built-up and hard-surfaced areas (rainwater). Liquids discharged and collected from facilities for the treatment, storage or dumping of waste are also classed as sewage. Wastewater, whether untreated or after purification in a treatment plant, almost always reaches a body of water or is used as service water (from which further requirements result). Bodies of water comprise surface waters, coastal waters and groundwater. Under adverse circumstances, some of the microorganisms or germs (*including pathogenic bacteria, fungi, viruses and protozoa*) contained in wastewater can cause and spread diseases among animals and humans.

Wastewater from health-care establishments is of a similar quality as the urban wastewater, but may also contain various potentially hazardous components, such:

- microbiological pathogens *(contaminated wastewater produced by patients*);
- hazardous chemicals from cleaning and disinfecting operations;

- pharmaceuticals from hospital pharmacies and from the various wards, including antibiotics and genotoxic drugs;
- radioactive isotopes discharged into sewers by oncology departments;

Discharge of untreated or inadequately treated wastewater to the environment will inevitably pose major health risks. Toxic effects of any chemical pollutants contained in wastewater on the active bacteria of the sewage purification process may give rise to additional hazards.

The need for decision-support tools for wastewater management is growing more acute, and due to the risk involved, these tools are necessarily complex. Therefore, such tools need to be incorporated in automated monitoring systems based on user-friendly software. The software should be designed so as to be useful to any potential users, as such users are not likely to have all, the expertise needed in order to interpret and implement the information. The development of expert systems-based decision-support tools is believed to be a way of obtaining the required decision support, even though the knowledge contained in the software is of a routine nature.

Several papers have been reported in the specialized literature to describe different attempts of applying dedicated software tools in water and waste water management or of applying control system for activated sludge processes.

In this paper, we intend to present the most important objectives and features that must be fulfilled by a software tool used in wastewater management of a healthcare establishment and the methods used in the development and implementation of a specific monitoring system.

2. PROCESS DESCRIPTION

The basic principle underlying effective wastewater management is a strict limit on the discharge of hazardous liquids to sewers. In countries that do not experience epidemics of enteric disease and that are not endemic for intestinal helminthiasis, it is acceptable to discharge the sewage of health-care establishments to municipal sewers without pretreatment, provided that the following requirements are met:

• the municipal sewers are connected to efficiently operated sewage treatment plants that ensure at least 95% removal of bacteria;

• the sludge resulting from sewage treatment is subjected to anaerobic digestion, leaving no more than one helminthes egg per liter in the digested sludge;

• the waste management system of the health-care establishment maintains high standards, ensuring the absence of significant quantities of toxic chemicals, pharmaceuticals, radionuclide, cytotoxic drugs, and antibiotics in the discharged sewage;

• excreta from patients being treated with cytotoxic drugs may be collected separately and adequately treated (as for other cytotoxic waste).

Many hospitals, in particular those that are not connected to any municipal treatment plant, have their own sewage treatment plants. Efficient on-site treatment of hospital sewage should include the following operations:

• *Primary treatment*

• *Secondary biological purification*. Most helminthes will settle in the sludge resulting from secondary purification, together with 90–95% of bacteria and a significant percentage of viruses; the secondary effluent will thus be almost free of helminthes, but will still include infective concentrations of bacteria and viruses.

• *Tertiary treatment*. The secondary effluent will probably contain at least 20 mg/liter suspended organic matter, which is too high for efficient chlorine disinfection. It should therefore be subjected to a tertiary treatment, such as lagooning or rapid sand filtration to produce a tertiary effluent with a much reduced content of suspended organic matter.
• *Chlorine disinfection*. To achieve pathogen concentrations comparable to those found in natural waters, the tertiary effluent will be subjected to chlorine disinfection.
Sludge treatment. The sludge from the sewage treatment plant requires anaerobic digestion to ensure thermal elimination of most pathogens. Alternatively, it may be dried in natural drying beds and then incinerated together with solid infectious health-care waste.

3. ROLE OF INFORMATION TECHNOLOGY IN WATER AND WASTEWATER MONITORING

3.1. Water Quality Monitoring

Monitoring is defined by the International Organization for Standardization (ISO) as: "the programmed process of sampling, measurement and subsequent recording or signaling, or both, of various water characteristics, often with the aim of assessing conformity to specified objectives". This general definition can be differentiated into three types of monitoring activities that distinguish between long-term, short-term and continuous monitoring programs as follows:

- *Monitoring* is the long-term, standardized measurement and observation of the aquatic environment in order to define status and trends.
- *Surveys* are finite duration, intensive programs to measure and observe the quality of the aquatic environment for a specific purpose.
- *Surveillance* is continuous, specific measurement and observation for the purpose of water quality management and operational activities.

Water quality monitoring and assessment can be conducted from a number of different perspectives which may combine the following goals in different ways:

- Uses of water. Does water meet user requirements for quantity and quality? (For example, with respect to meeting use-defined standards.)
- Influences on water quality from direct use or from other human activities or natural processes. What are these influences?
- Impacts on water quality (e.g. water as a medium for pollutant transport and exposure).
- Control and regulation of water quality. What is the capacity of water to assimilate pollutants? Are standards met? Are control strategies and management action appropriate and effective?
- How does water quality differ geographically in relation to uses and quality influences?
- How have past trends in water quality, influences and policies led to the present status?
- What factors in present water quality and in the past, present and planned activities, give an insight into future trends? What will these be?
- How does water quality influence other parts of the environment

There are some important water and ***wastewater treatment challenges*** such as: stringent quality requirement, stringent regulation, need for 100% reliability, increased responsibility to public, limited budget, **a**nd also there are the ***management challenges***: effective performance measurement, continuous improvement, effective asset utilization and overall cost minimization. All these, require increased frequency of monitoring, a need for immediate reporting, a rapid communication and an emergency response.

3.2. Application of Information Technology

The whole system of general water quality monitoring and particular wastewater monitoring is aimed at the generation of reliable data, i.e. data that accurately reflect the actual status of the variables which influence water quality. It is acknowledged that simply generating good data is not enough to meet objectives. The data must be processed and presented in a manner that aids understanding of the spatial and temporal patterns in water quality, taking into consideration the natural processes and characteristics of a water body, and that allows the impact of human activities to be understood and the consequences of management action to be predicted. The information should provide the user with the understanding necessary to meet the objectives behind the monitoring program.

To this purpose , ***the application of information technology*** refers to:

- creating the central resource of data;
- creating the frame for the instantaneous access to all levels of users;
- effective performance measurement;
- sharing of knowledge to minimize the cost;

and requires the integration of information from: SCADA – process control information; sources and treatment plants - water quality data; monitoring labs -water quality data; asset and equipment information; financial information.

The objectives of an information system used in water and wastewater monitoring are: easy handling by a variety of users; easy configuring; scalable to support large number of data points; security in order to protect sensitive information; ability to collect data from different sources (e.g. real time information from SCADA, labs, plant, etc. *see Fig.1*); verification of data reliability; integration of data-critical analysis; rapid access to calculated results (tabular, graphical); provide effective tools to improve efficiency and reduce cost.

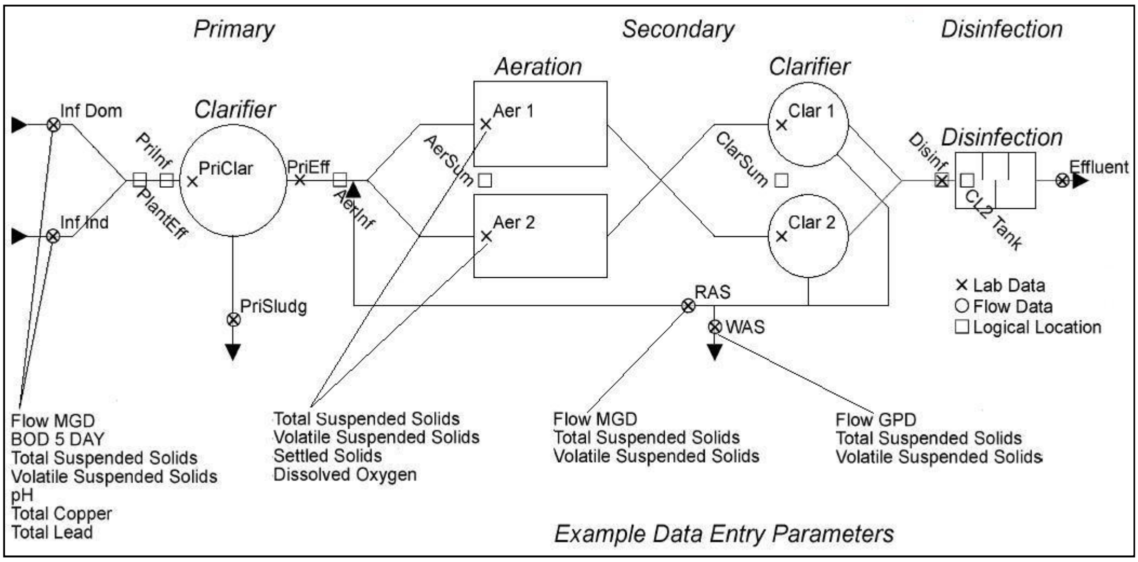

Fig.1. Information data from wastewater treatment process

3.3. Features for Water and Wastewater Management Software Tool

The main features involved in the development of a wastewater management software tool are:

- multilevel hierarchies;
- one-time data entry;
- consolidation of operation, performance and cost data;
- creating time based graphs and charts at all levels and flexible reporting useful to different levels of management : operator-unit process level; team-leader- (inter-process level); healthcare unit (plant) management level.

The data consolidation have to be based on:

- measurement from on-line instruments and SCADA (e.g. –hourly average, daily average, minimum, maximum)
- results from laboratory analyses (e.g. water quality, critical analysis such as coli forms, cryptosporidium, giardia,etc);
- treatment plant performance (treatment efficiency)
- assessment of the establishment operating conditions (units in operation, operating capacity)
- cost summary (operating cost, cost/unit of water; chemicals /unit of water, energy /unit of water, etc)

Since the computer software used in data handling and management falls into three main categories:

- Statistical software which processes numerical data and performs statistical tests and analyses.
- Spreadsheets which handle both numerical data and text, and usually include powerful graphical and statistical capabilities (thus overlapping with the purely statistical software).
- Database software which is designed to manage the input, editing and retrieval of numerical data and text. There are no in-built statistical or graphical capabilities, but the power of the programming language allows the skilled user enormous scope for data manipulation, sorting and display

it is an ideal situation if all these three software categories can be used together in a complementary fashion. Nevertheless, it is essential that the eventual statistical methods to be applied are taken into account fully in the original monitoring program design. This should help to ensure that the data produced are adequate for the statistical techniques which are to be applied

4. SAMPLE FUNCTIONS OF DEVELOPED "*MONAPAT*"– WASTEWATER MONITORING SOFTWARE TOOL

4.1. Multiple hierarchy architecture

The team of IPA Cluj Subsidiary is developing a software monitoring tool, *MONAPAT*- dedicated to wastewater management from healthcare establishments, based on multilevel hierarchy as it is shown in the fig.2.

4.2. Graphical Drill down Capability and Historical Reports

The software product is designed to use the information technology facilities offered by the graphical software in order to create the frame for wastewater monitoring. This involves the use of a dedicated friendly GUI based on drill down capabilities. The historical reports are based on time-based graphs and charts *(Fig.2)*

4.3. Data handling based on Database structures

The scope and nature of computerized data-handling processes will be dictated by the objectives of the water quality ad wastewater monitoring program. Generally speaking, however, a database offers the best means of handling large quantities of data

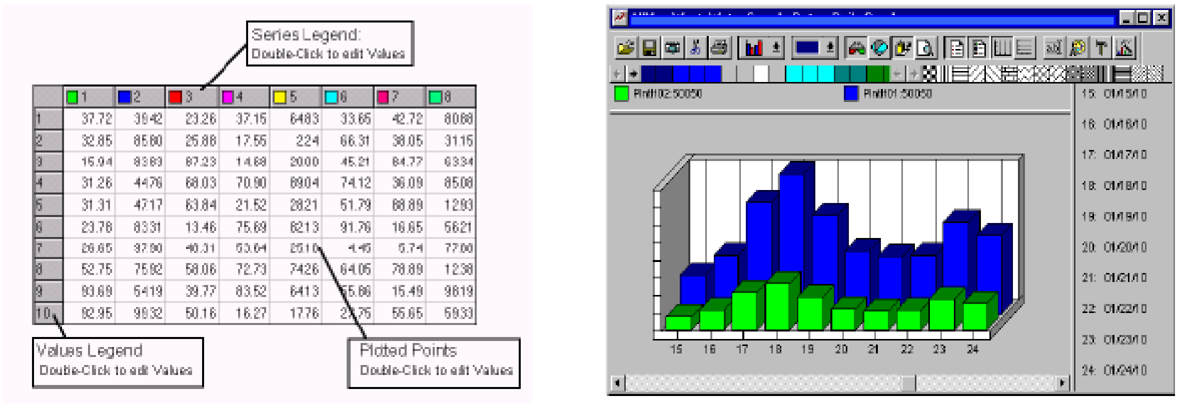

Fig.2.

and it should be capable of exporting data in formats that are accepted by all good statistical, spreadsheet and GIS packages

The greatest advantages of the computerized database are ease of manipulation, ease of retrieval and, particularly, ease of dissemination of data to all interested parties. It is the later that constitutes one of the main objectives of the water quality monitoring program, securing to computerized databases their enormous advantage

5. CONCLUSION

The solutions presented above for the use of information technology in wastewater monitoring and the main functions for the proposed MONAPAT software tool were developed in the frame of MONAPAT project financed by VIASAN Romanian National Research&Development Program. The future development aims at including fuzzy reasoning in wastewater treatment process monitoring.

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