DEVELOPING AN INTEGRATED AUTOMATIC CONTROL SYSTEM FOR WASTEWATER TREATMENT IMPROVEMENT

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Abstract
Modern wastewater treatment is a complex process, which involves several treatment steps in order to obtain quality indicators with a high performance, established by environmental regulations for treated effluent. Optimal wastewater treatment plant management is concerned with trying to obtain good wastewater treatment efficiency in condition of maintaining process stability.
In rapid environmental monitoring, the traditional system of analytical control became inefficient. Nowadays , taking into account major constraints such as water characteristics, effluent quality and costs of each operation, the use of Artificial-Intelligence (AI) systems seems to be necessary in order to obtain better results in wastewater management.
Authors presents some contributions focused on the optimisation of complex process related to wastewater treatment plants through an integrated automated system for process parameters monitoring and control in municipal wastewater treatment plant.
The paper presents the architecture of the proposed system which integrates different reasoning modules, with additional modularity and independence, as a first step for implementing an automatic control system.

Keywords: *wastewater treatment, process parameters control*, *process automation*

1. INTRODUCTION

Environmental systems are very complex and have some characteristics which make their control difficult: they evolve in time, are characterized by interactions between physical–chemical and biological processes and, very often, are periodic in time. Because their complexity and the interdisciplinarity of many environmental problems, specialists suggest that their suitable management cannot be based on a single technique. Wastewater Treatment Plants (WWTP) are clear examples of complex processes which need an integrated approach in order to implement a control system [1,5].
Wastewater treatment plants (WWTPs) receive water from the anthropogenic system of sewers, they process it, and finally they deliver this water to a natural surface water.
Like other environmental and biotechnological processes, WWTP are complex systems, involving many interactions between different processes, e.g. chemical or biological reactions, kinetics, catalysis, transport phenomena, separations, etc[2].
The successful management of these systems requires multi-disciplinary approaches and expertise from different scientific fields.
Optimal wastewater treatment plant management is concerned with trying to obtain good wastewater treatment efficiency in condition of maintaining process stability.
Reducing the level of pollution of the inflow water is the main goal in a wastewater treatment plant (WWTP). This means to remove, within certain limits, the pollutants in the water before to its discharge to the natural environment. This can be done in a number of different ways, corresponding to different kinds of WWTP.
A typical wastewater treatment plant usually includes a primary treatment and a secondary treatment to remove organic matter and suspended solids from wastewater. Primary treatment is designed to physically remove solid material from the incoming wastewater. Coarse particles are removed by screens or reduced in size by grinding devices. Inorganic solids are removed in grit catchers and many of

the organic suspended solids are removed by sedimentation [2].
The primary treatment removes almost one-half of the suspended solids in the raw wastewater. Secondary treatment usually consists of a biological conversion of dissolved and colloidal organic compounds into stabilized, low-energy compounds and new biomass cells, caused by a very diversified group of microorganisms, in the presence of oxygen.
In a wastewater treatment plant, which has biological step, the major challenge is to find out the current status of the process [5].
A biological process is not known well enough and the head of the plant must treat a lot of information. Sometimes, the human operator can not deal with all that information. Current developments in control systems offer opportunities for dealing with complex systems in an integrated manner by considering qualitative and quantitative aspects simultaneously. Artificial Intelligence can help by providing efficient solutions to complex problems involving both quantitative and qualitative information as well as spatial and temporal aspects [5].
The WWTP with biological step that use activated sludge process is perhaps the most widely-used process for the removal the pollutants in the wastewater.
The activated sludge process is highly controllable, and its operation can be adjusted in response to a wide range of conditions. The main problem consists of the difficult to control the process. The plant operations require qualified and experienced personnel 24 hours a day.

2. THE AUTOMATIC SYSTEM FOR PARAMETERS CONTROL OF WASTEWATER TREATMENT PLANT

Although progress in control engineering, computer technology, and process sensors has enabled automatic control improvement, integrated operation of WWTP is still far from being solved. The number of measured variables in a WWTP is increasing and the need and possibility to control the process is becoming greater[1, 2].
The application of computer technology to control and supervision of technological processes in a WWTP has lead to a spectacular increase in the information acquired by these

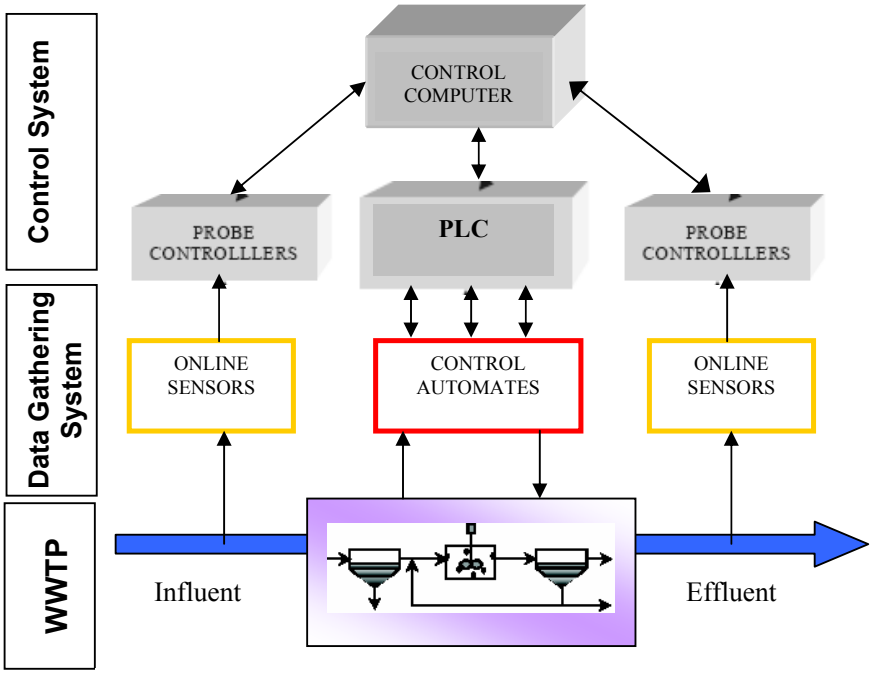

Figure 1. Architecture of the Control System.

systems. The complexity of these systems, due to the number of biological processes implicated, makes necessary the development of reliable on-line instrumentation [5].
Monitoring of the components of wastewater treatment processes is an important feature in order to assure its control, particularly when biological processes are involved.
The architecture of a system for automatic control of wastewater processes is presented in figure 1.
Actual trends in process control are determining an increase in complexity at each control level. Each mechanical unit of the plant (pumps, level detectors, nipping valves, etc) is controlled by a PLC(Programmable Logic Controller), that allows to automate all those elements. In the PLC program, the operation failure detection and corrective actions are included. This is the first control level. Every reactor of the pilot plant has in-line sensors (dissolved oxygen, pH, ORP, temperature) connected to probe controllers [3].
A control and monitoring computer supervises the PLC. This computer also acquires data from the probe controllers and it controls the manipulation of the pneumatic control valves of every reactor.
Real–time monitoring of the process implies using of on-line transducers. The placement of sensors for measuring the mainly parameters is essentially both for monitoring the whole purifying process and for regulation of some parameters, which are important for obtaining a high quality of purified water.

3. MATERIAL AND METHODS

The elements used to develop an automatic control system go from analytical tools to software tools, going through databases and an informatics environment. The materials that are necessarily can be shortly presented as follows:

- Computers and networking equipments
- Programmable Logic Controllers (PLC)
- On-line sensors
- Software tools (databases, inference engine programs, programmed control mechanisms, programmed external software interface routines.

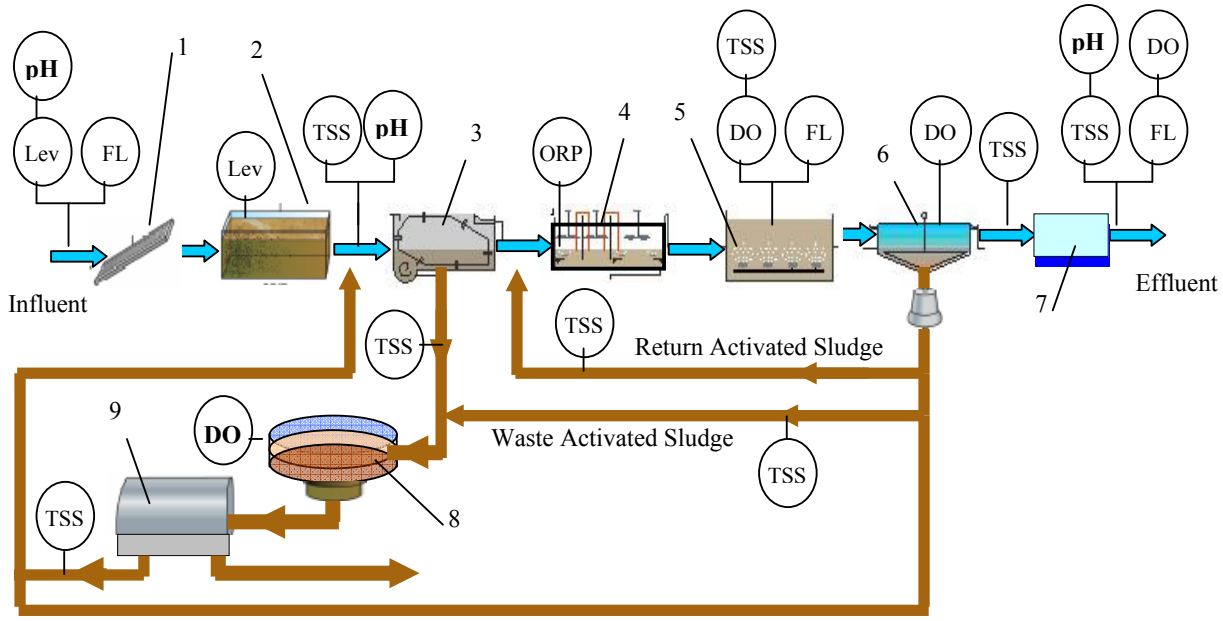

Figure 2-Typical Wastewater Treatment Plant Plug Flow Design
1-Bar Screen; 2-Grit chamber; 3-Primary Settler; 4-Anaerobic Reactor; 5-Aerobic Basin; 6-Secondarily settler; 7-Clorination; 8-Thickening Clarifier; 9-Dewatering Unit.

Lev – Level/Pressure Sensor; **FL** – Flow Sensor; **pH** – pH Sensor ; **TSS** – Total Suspended Solids Sensor; **DO** – Dissolved Oxigen Sensor; **ORP** – Redox (ORP) Sensor

Location of sensors on the flow of wastewater treatment is particularly important in obtaining accurate data that can be used in the monitoring and control of processes .

Criteria of choice of representative sections or points for the measurement and data collection must take into account[3]:

- Location of the sections in close proximity to points of measurement of flow in order to correlate the qualitative with quantitative data
- It must be chosen those sections that are found in essential changes of water quality
- Establishment of sections to follow how the quality of water required to meet specific regulations.

In figure 2 is presented a schema for location of a minimum number of sensors that are necessary for monitoring of process parameters in a typical municipal WWTP.

Depending on the complexity of controlled processes, type of sensors can be extended, to increase the level of information sent to the second level of the control system:

- solid suspension concentration(TSS)
- temperature
- pH
- Level (Lev)
- Wastewater Flow
- Water pressure
- Air pressure
- Organic matter and chemical oxigen demand (COD)
- Total ammonium concentration($NH4^+$)
- Nitrate concentration(NO3)
- Total phosporus (PO_4)
- Dissolved oxigen (DO)

The control system contains also sensors for command of the pumping station for recirculated sludge and for monitoring of air pump parameters (flow, pressure), which are necessary both in biological step and for aeration process in grease separator.

4. CONCLUSIONS

Developing and implementing of an automatic monitoring and control system is an important step in transformation of classical system, based on analytic control, in a system adaptable to different problems that could appear in a WWTP. The capacity to deal with these problems is useful to control abnormal situations and to maintain legal restrictions in the effluent. In addition, an automatic control system is able to avoid the appearance of some situations that could cause long term problems. The on-line features of the proposed system are very important taking into account problem of energy-saving, which can be realized by implementing of particular loops control for reducing operation costs(for example, control of dissolved oxygen can be used for manipulation of aeration pumps). The other important aspect of the proposed system is the wastewater plant capability of being remotely controlled via a complex data communication network over the internet. The system proposed in the paper represent a first stage for future researches, which will include contributions for developing an expert system for supervising of wastewater treatment plants.

5. REFERENCES

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