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Parameters Monitoring for Process Control in Municipal Wastewater Treatment Plant

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Abstract

Modern wastewater treatment is a complex process, which includes several treatment steps before the water is released to the recipient. The traditional system of analytical control became inefficient actual conditions for environmental monitoring. The paper presents some researches focused on the development of a system for parameters process monitoring in municipal wastewater treatment plants, as a first step for implementing an automatic control system.

Key words: *wastewater treatment, process parameters, monitoring system*, *process automation*

Introduction

The wastewater treatment process is part of the water cycle and it has a direct relation with other water systems or reservoirs. Wastewater treatment plants (WWTPs) receive water from the anthropogenic system of sewers, they process it, and finally they deliver this water to a natural reservoir (a river).

The main objectives in wastewater-treatment research are:
- knowing better the relevant characteristics of the wastewater,
- refraining the contaminated water from reaching the natural environment.

In a wastewater treatment plant (WWTP), the main goal is to reduce the level of pollution of the inflow water, that is to remove, within certain limits, abnormal amounts of pollutants in the water prior 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.

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 much diversified group of microorganisms, in the presence of oxygen. This mixture of

microorganisms (living biomass) together with inorganic as well as organic particles contained in the suspended solids constitutes what is known as activated sludge. This mixture is kept moving in wastewater by stirring done by aerators, turbines or rotators, which simultaneously supply the required oxygen for the biological reactions. A biological reactor followed by a secondary settler or clarifier constitutes the activated sludge process, which is the most well known process of secondary treatment because it is also the most widely used.

Two of the main challenges in the area of general water-management are to protect the water bodies and to provide high quality water in sufficient quantity at affordable costs.

In order to achieve these goals, multidisciplinary research-efforts and actions are necessary.

Architecture of the WWTP Control System

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 systems. The complexity of these systems, due to the number of biological processes implicated, makes necessary the development of reliable on-line instrumentation.

Monitoring of the components of wastewater treatment processes is an important feature in order to assure its control, particularly when simultaneous organic matter, nitrogen and phosphorus removal are involved.

Actual trends in process control are determining an increase in complexity at each control level. Utilization of automatic analyzers, industrial controllers, PLC (Programmable Logic Controller) and industrial computers is continuously increasing.

The architecture of a system for automatic control of wastewater processes is presented below in figure 1.

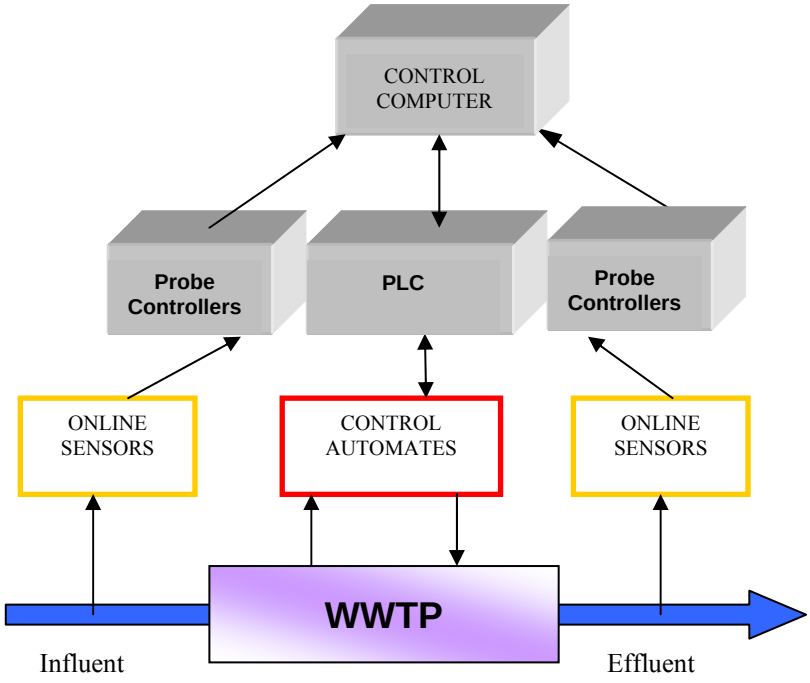

Fig. 1. Architecture of the control system.

Each mechanical unit of the plant (pumps, level detectors, nipping valves, etc) is controlled by a PLC, 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.

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.

Sensors Placement for Monitoring of Specific Wastewater Parameters

The purpose of monitoring is to obtain representative data, repeatable, reliable, consistent and comparable. These characteristics depend on the measures applied for quality control and quality data achieve. 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:

- 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 choosen 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.

Some of the parameters are measured only for the purpose of monitoring, and others both for monitoring and for an automatic control of the processes.

The main paramepetrs that are measured in the proposed schema are:

In the mechanical step:

- In the admission zone of wastewater - The wastewater flow;
- In the grit zone - a level sensor for measuring the level difference of water in order to command the grit cleaner;
- For aerated sand settler is monitored:
  - flow of supplied air
  - pressure of supplied air pH- on output line;
- Pumping station - a level sensor in pumping station, which allows the command to start / stop pumps, depending on the level.

At the output of the equalization basin. Equalization basin is required in any WWTP, with the role to equalize the flow and concentrations so that wastewater enter to the WWTP with the most constant features. Out of this basin is measured parameters that characterize the composition and concentration of main pollutants of wastewater. Parameters that are necessary to be monitored are:

- pH,
- Temperature,
- Solid suspension concentration,

- Organic matter and chemical oxigen demand,
- Total ammonium concentration(NH4),
- Nitrate concentration(NO3),
- Total phosporus (PO4),
- Dissolved oxigen;

For primary settler:

- Flow of admission wastewater;
- Sludge level for command to start / stop of sludge rejection pump, depending on the level;
- Solid suspension concentration of sludge that are evacuated from the settler. This sensor allows command to start/stop of sludge rejection pump, so that sludge that is sent to the sludge house have a small water concentration;
- Level of evacuated sludge;
- Turbidity, before and after primary settler.

On the output of primary settler are measured parameters that are necessary for biological treatment: organic matter concentration, ammonium concentration, phosfate concentration.

In the biological step:

The biological step in the analized WWTP contains: an anaerob basin having role in biological phosphor removing from wastewater, a bioreactor, which has an anoxic zone for predenitrifying and an oxic zone for carbon release and for nitrifying process, a pumping station for recirculated sludge and for sludge in excess and a pump station for aeration of bioreactor.

In the biological stage of WWTP will be monitored the following parameters:

- Solid suspension concentration;
- Organic matter and chemical oxigen demand;
- Total ammonium concentration(NH_4);
- Nitrate concentration(NO_3);
- Total phosporus (PO_4);
- Dissolved oxigen.

For the secondary settler have to be monitored the effluent parameters:

- solid suspension concentration,
- temperature,
- total ammonium concentration,
- nitrate concentration,
- total phosporus,
- dissolved oxigen,
- pH.

The monitoring 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.

In figure 2 is presented a schema for location of sensors for monitoring of process parameters in the Targoviste South municipal WWTP.

From an economic point of view an optimisation of the treatment processes can be made only by a better knowing of the real processes. Implementing of an automatic monitoring system can lead to a better use of the existing treatment capacities at the WWTP and to lower treatment costs.

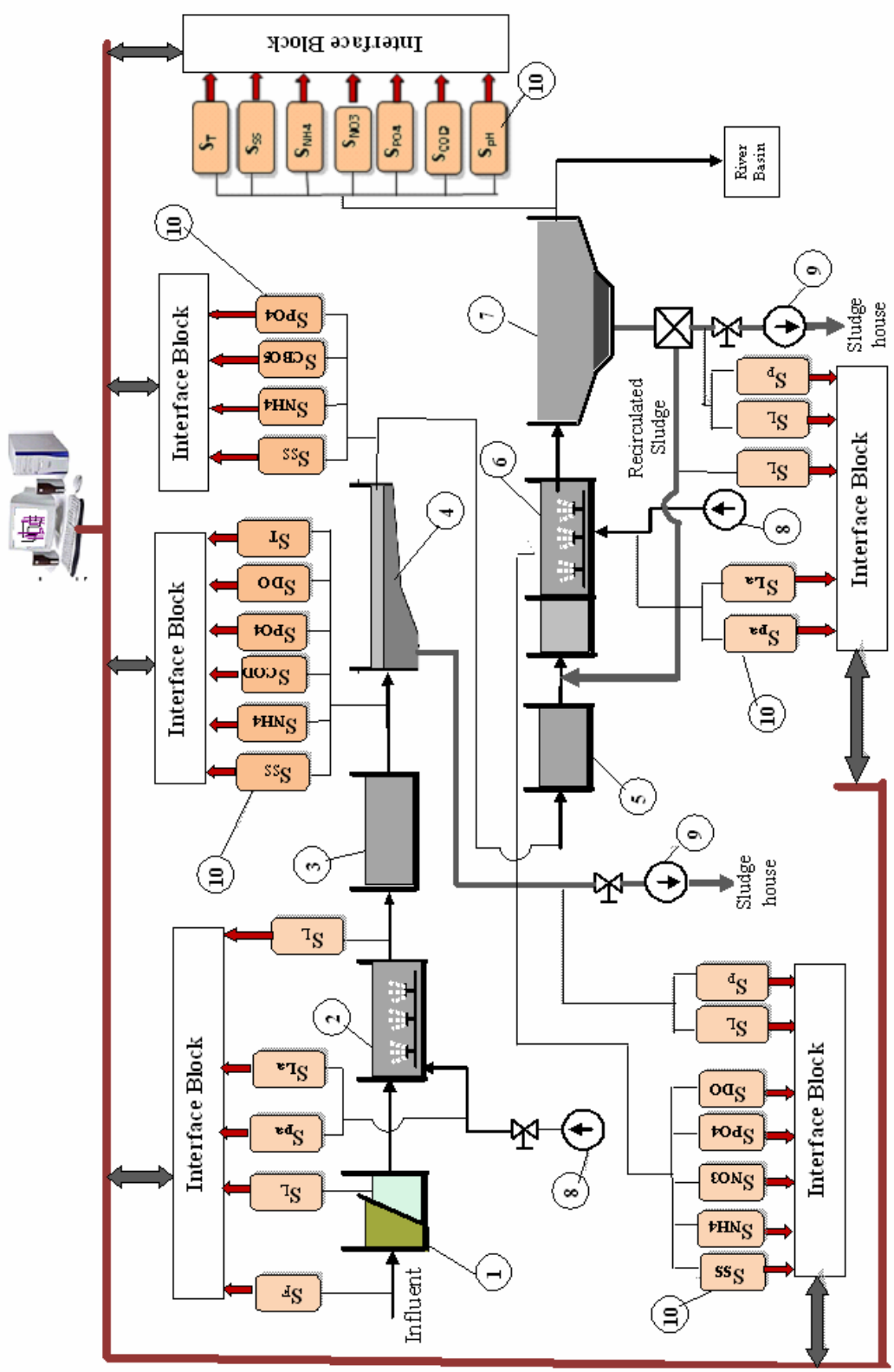

Fig.2. Sensors placement in a WWTP: 1-Grit chamber; 2-Aerated grease separator; 3-Equalization basin; 4- Primary clarifier; 5-Anaerob basin; 6-Anoxic/aerob basin; 7-Secondary settler; 8-Air pump; 9-Sludge pump; 10- Sensors.

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 represents a first stage for future researches, which will include contributions for developing an expert system for supervising of wastewater treatment plants.

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Monitorizarea parametrilor pentru controlului proceselor în staţii de epurare a apelor uzate municipale

Rezumat

Epurarea modernă a apelor uzate municipale reprezintă un process complex, care include anumite etape ale procesului de epurare, înainte de deversarea apelor în emisar. Sistemul tradiţional de analiză a calităţii parametrilor efluentului a devenit ineficient în acualele condiţii impuse de monitorizarea calităţii mediului. Lucrarea prezintă cercetări orientate în direcţia dezvoltării unui sistem pentru monitorizarea parametrilor de proces la staţiile de epurare a apelor uzate municipale ca primă etapă în implementarea unui sistem pentru controlul automat.