ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering

Tome XII [2014] – Fascicule 4 [November]
ISSN: 1584-2673 [CD-Rom, online]

a free-access multidisciplinary publication
of the Faculty of Engineering Hunedoara

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MEASUREMENTS IN SCADA SYSTEM USED AT A WASTEWATER TREATMENT PLANT

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Abstract: This paper reports on the design and implementation of a software platform for a wastewater treatment plant for advanced control testing and data quality assessment. The platform can be integrated within an existing control structure, namely the plant SCADA system, with the purpose of providing tools for the implementation and testing of sophisticated control systems and data quality analysis for plant wide operation. The platform is being implemented and tested at a utility's wastewater treatment plant.
Keywords: Wastewater treatment plant, programmable logic controller, supervisory control and data acquisition, human-machine interface, Remote Terminal Units

1. INTRODUCTION

Wastewater treatment processes (WWTP) can be considered as the largest industry in terms of treated mass of raw materials. In the European Community, for instance, a daily wastewater volume of approximately $40x10^6$ m^3 has to be processed [13].

Distribution network SCADA includes not only the models and methods of data acquisition and supervisory control but the models and methods of power network topology [6,10,14].

With the expansion and market-oriented operation of the power network, the operating and failure modes begin to increase so does the data needed to be monitored and analyzed. Especially when devices are running down or under emergency condition the analysis and decision-making tasks are so pressing and heavy that the operator often can't accomplish them perfectly. Therefore, they have to depend on the efficient SCADA [4,5,9].

SCADA systems can be found in critical infrastructures such as power plants and power grid systems, water, oil and gas distribution systems, building monitoring (e.g., airports, railway stations), production systems for food, cars, ships and other products [7,8,9,12].

Acronym for supervisory control and data acquisition, a computer system for gathering and analyzing real time data, SCADA platforms are used to monitor and manage a plant or equipment in industries like telecommunications, water and waste control, energy, oil and gas refining and transportation [1,2,11].

A SCADA system gathers information from a range of processes, transfers the information back to a central site, alerting the home station when an event has occurred, carrying out necessary analysis and control, such as determining if the event is critical, and displaying the information in a logical and organized fashion [8,12].

SCADA platforms can be relatively simple, such as one that monitors environmental conditions of a small office building, or incredibly complex, such as a system that monitors all of the activity in a nuclear power plant or the activity of a municipal water system [1].

In fact, most control actions are performed automatically by remote terminal unit (RTU) or by programmable logic controllers (PLC). For example, a PLC may control the flow of cooling water through part of an industrial process, but the SCADA system may allow operators to change the

set points for the flow, and enable alarm conditions, such as loss of flow and high temperature, to be displayed and recorded [10].
SCADA systems became popular to arise the efficient monitoring and control of distributed remote equipments. Today SCADA systems include operator-level software applications for viewing, supervising and troubleshooting local machines and process activities. Powerful software technologies are used for controlling and monitoring equipments in easy-to-use web-based applications, e.g., platforms: PCS7 – Siemens, CX-Supervisor – Omron, Genesis 32 – ICONIX [3].
SCADA encompasses the collecting of information transferring to the central site, carrying out any necessary analysis and control, and then displaying that information on a number of operator screens or displays. The required control actions are then conveyed back to the process [3].
The introduction of SCADA systems in the process industry has facilitated the control and monitoring of processes with several hundreds and even thousands of control loops. However, it is only in the last decade or so, with effluent quality standards becoming increasingly stringent, that large-scale urban wastewater treatment plants have been equipped with similar supervisory control systems [2].
This paper reports on the design and implementation of a software platform, at the SCADA level, which provides tools for advanced data quality management and control testing [2].
SCADA systems can be used at any water or wastewater system to integrate various processes and monitoring Information [1].
In water and wastewater applications, SCADA is often applied to link remote and/or local sensing units to a central monitoring location, from which coordinated responses to monitoring data can be initiated. Waste Water Treatment Plants (WWTPs) are complex dynamic systems that are difficult to manage and that require long-term expertise and constant monitoring for efficient operation. SCADA system is commonly used in WWTP for the following applications [1]:

- ✓ provide data for process modelling and energy use optimization;
- ✓ provide immediate detection of problems through diagnostic displays, enabling quick intervention for fast resolutions;
- ✓ predictive system for seasonal flow and wet weather;
- ✓ reduce the energy use and costs associated with aeration in biological processes;
- ✓ improve the settling characteristics of the biomass;
- ✓ overview screen showing the overall status of the system;
- ✓ alarm summary screen showing all the acknowledged in-alarms, unacknowledged in-alarms;
- ✓ alarm history screen with selectable start and end date;
- ✓ trend screen for each important parameter of process sensors showing the real-time and historical data with timeline;
- ✓ report package.

2. TECHNOLOGICAL FLOW OF WASTEWATER TREATMENT PLANT FROM BRAD MUNICIPALITY

Technological flow for wastewater treatment waste consists of the following:

A. Mechanical treatment stage is composed of:
   - ✓ The installation of an automatic sieve with rare holes;
   - ✓ Raw water pumping station;
   - ✓ Compact module mechanical cleaning-gratings, un-sanding, aerated fat separator;
   - ✓ Primary deck settler Imhoff type.

B. Biological cleaning stage consists of:
   - ✓ De-nitrification basins;
   - ✓ Nitrification/de-nitrification basin;
   - ✓ Nitrification basins;
   - ✓ Pumping station for external activated sludge;

- ✓ Pumping station for domestic activated sludge recirculation;
- ✓ Secondary settler;
- ✓ Control and service module wastewater treatment plant;
- ✓ Measurement parameters water purified.

C. Stage of sludge treatment composed of:

- ✓ Automatic pump station excess sludge;
- ✓ Stabilisation basins, sludge thickening, and primary and excess sludge;
- ✓ Stabilized sludge drying beds;
- ✓ Mixing mud pool;
- ✓ Mobile dewatering sludge.

The dirty water browse through the following sequence of sewage treatment plant:

a. Pre-wastewater treatment -mechanical gear-the stage where solid materials by removing oil, sieve fats, sand and primary decantation.
b. Biological wastewater treatment-stage II-phase in which the processes of nitrification, un-nitrification, oxidation of organic carbon based secondary decantation.
c. Sludge-processing primary and excess sludge is extracted from the primary settling vessel in six stabilization basins where besides the thickening and stabilization of anaerobic sludge for cold. The six basins have a cumulative volume of 1350 m^3.

3. DESCRIPTION OF THE OPERATION OF WASTEWATER TREATMENT PLANT

The dirty water from the sewage network flows through gravitational system with automatic sieves with rare holes (e = 30 mm), housed in a compartment of the former un-sanding. In the other compartment is going to mount a grill manual intervention for grills. The exhaust note is in a container with a capacity of 1 m^3. Raw sewage flows then in gravitational existing pumping station. From here is pumped by means of three submersible pump combined wastewater treatment plant mechanics.

For measuring and limiting flow submersible pumps are equipped with frequency converters and controlled by means of an electromagnetic flow meter mounted on the discharge pipe of the combined mechanical treatment plants. In the combined mechanical wastewater treatment plant, the first phase is effluent with a sieves installations with 4 mm for hollow. Material detained is discharged into a container of 1 m^3 through a snail that dehydration and its compaction up to 40% solid substance. Mountainous water then passes through an un-sanding separator aerated where are retained in a proportion of not less than 95% (Q_{max}) all particles larger than 0.2 mm.

The sand is collected, classified and transported inside a container. Fats are also automatically collected and pumped into a container of 1,1 m^3. The compact module mechanical wastewater treatment plant, effluent flows and un-sand located in the gravitational settling vessel type Imhoff the existing primary consisting of two basins. In this primary settler is pumped and excess sludge. For circumventing the settling vessel there is a bypass channel.

After mechanical treatment stage, sewage flows in the gravitational two de-nitrification basins equipped with mixers (activated sludge homogenisation mixers re-circulated air with waste water and decanted avoiding fouling watersheds). De-nitrification tanks of sewage flows into a pool of nitrification/de-nitrification equipped with a mixer as well as with fine bubble aeration. This pool can be used for both the increase in volume of de-nitrification and nitrification volume increase where appropriate. The process is automated with the help of a sensor for measuring dissolved oxygen, ammonia sensor and a sensor for nitrates.

Of nitrification/de-nitrification basin water catchment in nitrification equipped with aeration devices with fine bubbles. Here is the removal of organic and carbon-based process of nitrification. After passage through activated sludge basins, water purification works reach the settling vessel. After the whole technological flow of WWTP effluent meets from the qualitative point of view the conditions and may be spilled in natural emissary, Crişul Alb river.

The mixture of primary and excess sludge is extracted from the primary settling vessel in the six existing pools where in addition to thickening and stabilization of anaerobic sludge for cold. The six basins have a cumulative volume 1350 m^3. The daily production of sludge is 53 m^3, resulting in a storage time of 24 days. After this period can be dried mechanically by means of a mobile dehydration unit stops at a concentration of at least 22%. It is first homogenized in a basin of homogenization with a volume of 75 m^3. Alternatively it can evacuate the stabilized sludge by hydrostatic pressure in drying beds where they will achieve a concentration of more than 30% can be stored on an ecological residual of the operator.

4. CONTROL & AUTOMATION OF WASTEWATER TREATMENT PLANT WASTEWATER

In principle, the command module and automation will ensure the monitoring and control of technological process and will support the operator by simplifying the mass balances such as that of solids in suspension. The control, operation and protection of various equipment (such as pumps of any type and destination, blowers, air compressors, electric motors in general) will be carried out by means of a PLC communication networks at fixed point on the infrastructure of electrical wiring and installation of remote-controlled terminal units (RTU) to the SCADA system, which will be installed in the building for administrative processing and registration but also for the automation and remote control of the technological cycle. Local electrical panels will be fitted with the man/machine interface with keys and buttons, to allow the operator to manually intervene and take control.

The time during which the engine has been started and/or off will be logged along with the total running time. When the pumps (and engines in general) are mounted in parallel with backup equipment, the system allows the automatic cyclic permutation of the unit. It will also take into account the following requirements:

- ✓ All pumps will be protected against dry operation, through judicious placement of pressure level or through a system of measure in the level;
- ✓ Level sensors or measure the level of systems will be referred to as pumps whose operation is determined by the level of water in the water retention structures (pools);
- ✓ The flow rate shall be measured and recorded continuously in the following locations:-the entry in the combined treatment plant, pipeline mechanical displacer to group the water supply pump, with electromagnetic flow meter;
- ✓ On leaving the station with purge flow meter Parshall.

Other measurements:

- ✓ at the entrance to the station: pH, temperature, parameters of quality;
- ✓ Aeration tanks: dissolved oxygen, suspended solids;
- ✓ On leaving the station: pH, NO_2, NO_3, NH_4, turbidity, parameters of quality.

5. THE APPLICATION OF SURVEILLANCE, MONITORING AND CONTROL OF THE COMPUTER

Software system for supervision of WWTP wastewater from Brad municipality enable the monitoring of water purification technology, allowing the following:

- ✓ The operation of functional blocks and parameters measured;
- ✓ Tracking the conditions of functioning of the installations;
- ✓ Starting, stopping, and installation of the units in accordance with the prescribed rules;
- ✓ Develop analysis for main parameters measured.

The data received from the acquisition are visualized in the Siemens WinCC flexible. The application of visualization will be organized on several levels:

- ✓ Overall Level-viewing window with system components with important global parameters;
- ✓ Detailed-Level viewing Windows with detailing of components separately with important parameters.

The windows contain basic information, functional schema with animation and colours appropriate to the different modes of operation, quick buttons and Windows for alarms and events. For interactive mode of operation will use dialog boxes and buttons.

The various animation states allow parts of the installation:

- ✓ View key local/remote/distance;
- ✓ Animate in different colours running conditions;
- ✓ Animating with flash in red in an emergency (e.g., thermal protection, etc.).

Measures will be shown on the display screens in accordance with customer specifications (e.g.: oxygen level in the system with the possibility of prescribing oxygen alarm levels LL, L, H, HH).

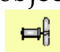
Trends of the measured quantities is done either in the historic trends, either online, on trend graphs with the organization predefined maximum 8 trends on a graphics surface. Historic trends will keep at least 1 month. The application will allow viewing and displaying the hours of operation of the units active in the system. The visualization and management of alarms and events.

Alarms and events will be categorized on several levels:

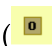
- ✓ critical damage that requires stopping the plant or personal assistance (obligation of confirmation);
- ✓ informative events that do not necessarily require staff intervention (requires confirmation).

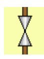
Critical alarms appear on images and animated technology indicating their source.

The common elements are graphics and animations for each component of the application. The machines in the installation are represented graphically and represent essential elements. Quick-acting valves, valves and functional valves are represented separately on each screen. Measurements (temperature, pressure, level, oxygen level, power, etc....) and the actuators (motors, valves, adjustments of sizes and functional parameters) are represented separately on viewing screens and Windows application control. They are defined by the standard shapes and colours, jokes specific to each mode of exploitation.

Engines, pumps, and fan coolers are the actuator through control of an electric motor. The representation of these symbols are used in engineering, the shape and colour of the Stroke object specifying the nature: motor: , Sewage pump: , Mud pump: , Air blower: , Mixer: , Dispenser: 

The fill colour of the symbol representing its status: • off: • Green: switched on • Red: fault condition they can be under remote operation.

They may be in operation within (), local () or isolated () According to the indicator of employment. The control window allows for starting and stopping the engine speed adjustment, possibly for engines with frequency converter.

The representation of mechanized and engineering symbols are used, the shape and colour of the Stroke object specifying the nature: mechanical: catches, steel , Electric power valves: .

Colour animation of the valve is as follows:

- ✓ inanimate mechanical operated valves for gray;
- ✓ green symbol to the symbol of the actuator electrically operated valves in case of completely open valve;
- ✓ red symbol for the actuator to the power-operated valves in case of mechanized closed completely;
- ✓ concentric green with red symbol for the actuator to the power-operated valves in the valve which is located in a transitional position or intermediate position;
- ✓ blinking yellow symbol for actuator symbol at power-operated valves in case of error or damage.

The overview is a general representation of the technology. She views the major components of the equipment and technological flow through tubing. It contains for each active component of the plant, as an indicator of the corresponding animated component operation (engine, splat or unified symbol for pumps, blowers, valves), and a signpost for the operation (L, D, a).

This screen from fig.1 provides high level information to the operator and the current status of all the major components [1].

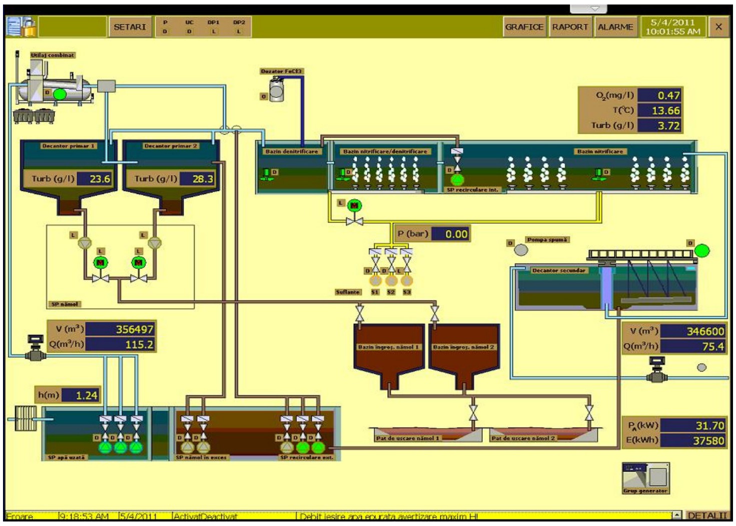


Fig. 1. The main overview screen of SCADA system

Direct or indirect measurements with the purpose of adjusting analogue or prescribing the application manifests itself in the same way as the standard items that are part of a control panel, adjustments and command for an installation or a technological parameter.

Adjusting measurements appear in boxes, coupled with control of the control element.

1. the label size adjuster.
2. Bar-graph measured value:
✓ actual or percentage;
✓ appears in form, is obtained by bar-graph read the measured value from the technology.
3. adjust the Set point Value:
✓ Cursor or real interest rates;
✓ After setting the desired quantity indicate the PID or hysteresis;
✓ You can change the click using the bar-graph's mouse.
4. the measured value Display:
✓ real or a percentage.
5. Display:
✓ Set point can be changed by typing followed by Enter.
6. Setting limit values (fig. 2):
✓ value crash LL: the critical value of the lower limit;
✓ fault it value: value warning lower limit;
✓ crash valuable h: warning value upper limit;
✓ crash valuable HH: the critical value of the upper limit.

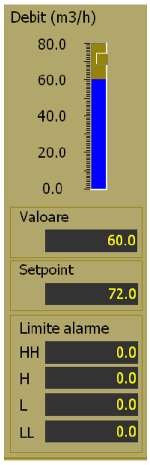


Fig.2. A pump flow monitoring

Setting limit values can be changed only with the permission of the administrator.

1. Name tag with the name of the engine;
2. The control panel of the engine that contains informative system PLACE switch: local/distant/DIST isolated 0, START button and STOP button;
3. Engine Information Panel that contains (fig.3): a percentage displayed speed if the engine operates on a frequency converter, Adder, number of starts, control of repeated restarts, the next date of the last revision, maintenance and electrical coupling of the motor if you can work in many types of drives (Star delta converter, directly).

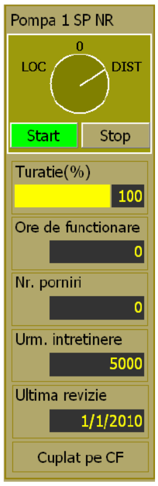


Fig. 3. The monitoring functions a pump

Example of command group motors is presenting in fig.4.

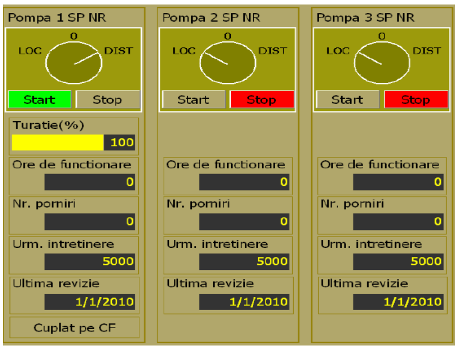


Fig. 4 Engine group box has controls for each engine separately

6. MONITORING OF PROCESS PARAMETERS

The application allows you to view graphs and trends in real time and from the archive. Graphic button opens the chart selection menu. Display real-time trends and historic is done in a similar manner.

The trend on the y-axis contains the sizes and units of measure in the colour of the line graph and the x-axis the time. In the background of the window control buttons appear like Media player for the axis of time respectively for increasing or decreasing sequence x-axis. Trends you can print by clicking the print button in the upper right corner of the screen. Close the window with the X button in the upper right corner of the screen.

It will present, in fig.5-10, some of the graphs that you can view by using the application by pressing the button Graphic history over a period of 3 days and over a longer period of time.

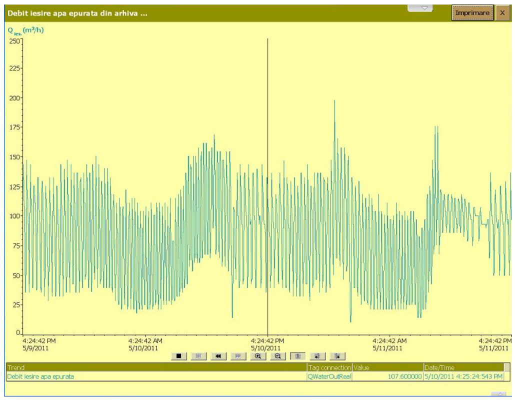


Fig. 5. The flow of purified water output

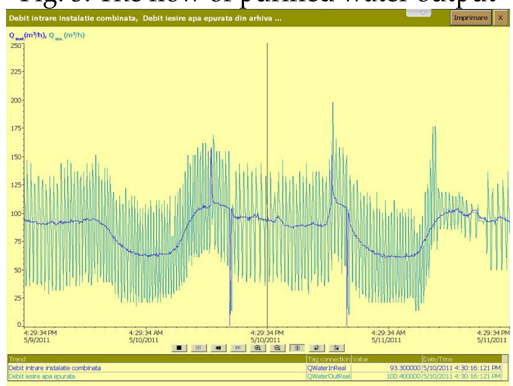


Fig. 6. Input flow in combined plant and output flow of purified water

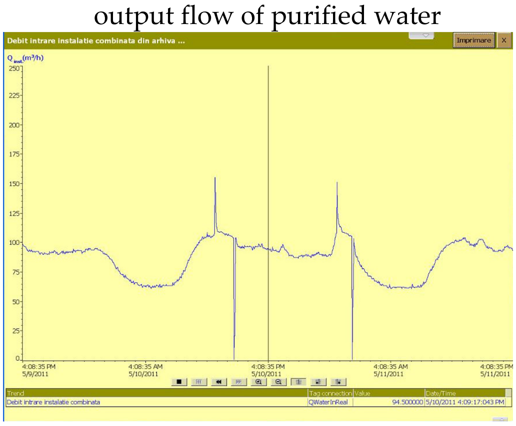


Fig. 7. Input flow in combined system

Flow variations in treatment plants result in the speed jumps that disrupts the flow regime. Instability of flow velocities is especially harmful in the tailings ponds, where large flow velocities in effluent suspended materials or even already deposited materials.

Uniform flow and composition wastewater is done in pools of smoothing in series or shunt with the sewage collector and allows for sizing the treatment plant flows. In smoothing the wastewater in the ponds of smoothing, with shapes and sizes adapted to each case, processing may take place between the various chemical pollutants from these waters, such as neutralization reactions, oxygenation, precipitation or biochemical processes, all leading to a disclaimer of the stage. Waste waters, regardless of source, presents variations in flow and composition of time, due to non-uniformity of water consumption, the quantities of water removed from the process and contents in pollutants. The presence of multiple sources of staple, with different periodicity, determines the disordered flow variations and composition of wastewater.

These flows are affected and the degree of recirculation of water and sanitation systems and rainfall regime. Flow variations are always accompanied and variations of the concentrations of polluting substances. Concentrations of pollutants are determined by specific discharges of water per unit of the product, as well as evacuation of unwanted materials.

In wastewater treatment, the results depend on the stability of the incoming regime uniformity of wastewater treatment system.

By controlling the water level in the tank is kept constant relative (fig. 9). The level of oxygen in the nitrification zone are kept within the limits laid down (fig.10).

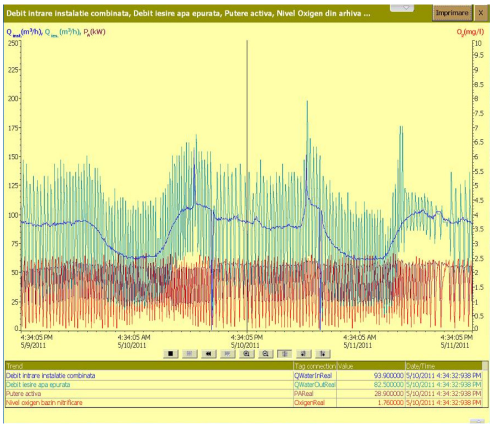


Fig. 8. The flow of input and output, the active power and the oxygen level in the catchment area of nitrification

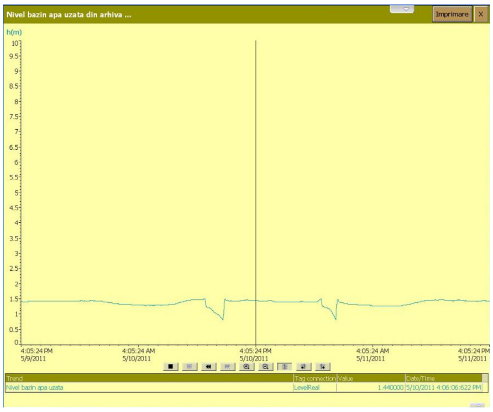


Fig. 9. The water level in the basin of the water supply

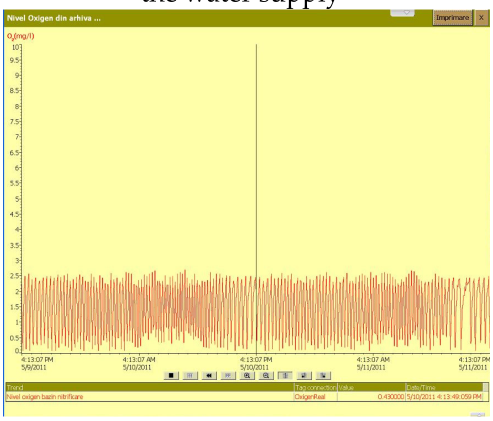


Fig. 10. The oxygen level in the catchment area of nitrification

7. CONCLUSION

SCADA systems have been developed in addition to systems for automation of various activities. With the development of PCs DROP interfaces were made with the help of specialized programs. Even so a good period of time were viewed as closed systems, which are exclusively designed to record and monitor the process data. At the time of such a system was strictly tied to the lifetime of the plant. Any refurbishment led to the redesign and rebuilding of the SCADA system.

Automation and SCADA systems for wastewater treatment plant offers the following advantages:

- ✓ support for maintenance work;
- ✓ provides a mode of operation in the automatic mode;
- ✓ ensure a optimum operating mode in the event of damage;
- ✓ increase the life of the equipment and machinery through appropriate operation;
- ✓ decrease the number of requests and the necessary interventions in the WWTP;
- ✓ provides operators a easy operation;
- ✓ monitoring and control of remote station.

SCADA system at the WWTP monitors the following parameters:

- ✓ the status of machinery (on, off, fault);
- ✓ the absorbed power of the machinery;
- ✓ effluent flow (flow);
- ✓ biological excess sludge flow (electromagnetic flow meter);
- ✓ external recirculation flow active sludge taken from flow recirculation pumps, fitted with converter;
- ✓ internal recirculation flow active sludge taken from flow recirculation pumps, fitted with converter;
- ✓ dissolved oxygen concentration in the aeration basin;
- ✓ the flow of phosphorus precipitation reagent;
- ✓ the level in the vessel storage phosphor precipitation reagent;
- ✓ influential flow;
- ✓ concentration of activated sludge nitrification basin;
- ✓ concentrations of NH_4 and NO_3 at the exit of the station;
- ✓ number of hours working machines;
- ✓ number of hours operates machinery to revisions.

Centralized control system is designed for the following functions:

- ✓ communication and the exchange of data between the automation system, and always strive for automation;
- ✓ data acquisition process and condition of the equipment.
- ✓ operating in automatic mode;
- ✓ control of wastewater treatment plant/process;
- ✓ man-machine-interface supervision and monitoring;

- ✓ management of alarms;
- ✓ optimization programs;
- ✓ drawing trend lines;
- ✓ historical archive of events;
- ✓ communication with the operator;
- ✓ overseeing the system;
- ✓ documentation of the system.

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