EOLI
Efficient Operation of Urban Wastewater Treatment Plants

Deliverable D1.6
Documentation for the implementation, the tuning and the use of the FDI and supervision systems

WP1. Process experiments
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I. INTRODUCTION

This document presents the necessary information for the implementation and the tuning of both the diagnosis and the supervision systems that have been developed within the framework of EOLI.

The systems described here above concern both the diagnosis modules and the supervision modules. In order to maximize the exchange of data and knowledge between the South American partners and the European ones, and regarding the specificity of the two lab-scale processes chosen to test and validate the EOLI system (an SBR treating toxic compounds in the lab of the Mexican partner and an SBR performing nutrient removal at the LBE, Narbonne, France), it was decided to test and validate the diagnosis system (sensor fault detection) on the Mexican plant and the supervision system on the LBE SBR. It is why the documentation for each of these modules are clearly separated in the two following sections.

II. IMPLEMENTATION OF THE DIAGNOSIS SYSTEM

In order to have a basic set of safety features some monitoring routines were integrated inside the real-time BioReC (BioReactor Control) software reported in WP5 for the automation of the field-pilot SBR at UNAM. They was written using the LABVIEW high level software and interfaced with the process I/O Beckhoff modules via the MODBUS open protocol. This part of the document explains such features and how the operator can use it.

II.1 Hardware basic supervision

This feature allows monitoring the ON/OFF actuator status and even detect some of the actuator malfunctions. The electrical hardware was designed in such a way that each actuator does have an overload protection relay. Their status may be read by the BioReC. There are two supervision features embedded in the BioReC using this hardware property:

II.1.1 Actuator command and status report

Each time the controller system transmits a command to the actuator to change its state, a report is issued to the online-events file (see “Data Format for EOLI-SBR-UNAM” document for explanation on the data format of the report). If the actuator does indeed change its state as expected, at this moment another report is issued to the operator. This feature is implemented for the following actuators: AirBlower, Stirrer, Influent pump, Effluent pump, and Purge valve.

II.1.2 Actuator error detection

If the actuator fails to respond to the command issued by the controller (except if Manual operation mode is selected) for more than 10 seconds then an alarm is issued to the operator and a report is issued to the online-events file. This feature is implemented for the following actuators: Influent pump, Effluent pump

II.2 Process limits

This feature allows monitoring some of the continuous variables in order to detect limits transgressions. Each time a limit alarm is detected a report is issued to the online-events file, an alarm is issued to the operator and, if necessary, a control action is taken in order to prevent the condition causing the alarm to put the SBR in danger. There are 3 basic supervision features embedded:

II.2.1. Oxygen limitation

When filling in EDTOC mode, if the dissolved oxygen goes below a preprogrammed threshold limit (OxígenoMínimoAceptable), an "oxygen limitation" condition is declared and the control is forced to go in to a "wait" state, thus suspending the filling while such an alarm condition persists.

II.2.2. Inhibition

When filling in EDTOC mode, if the dissolved oxygen goes above a preprogrammed threshold limit (called Oxígeno Máximo Inhibición in Spanish) for more than 10 minutes, a "possible inhibition" condition is declared and the controller is forced to go in to a "wait" state, thus suspending the filling while such an alarm condition persists.

II.2.3.Acidification

If pH crosses a preprogrammed low limit (pH.Mínimo) then an "acidification" status is detected.

II.3 Reaction time limits

This feature allows supervising the time it takes for a reaction to finish normally. If the reaction is not finished within a preprogrammed time lapse (ReacciónMáx.minutos) then the controller aborts the reaction, an alarm is issued, and a report is made to the online-events file.

II.4 Graphic User Interface, GUI

If an alarm condition is detected then a report is issued and filled. These reports are also available at the real-time GUI, at the bottom, as a text buffer. See an example below.

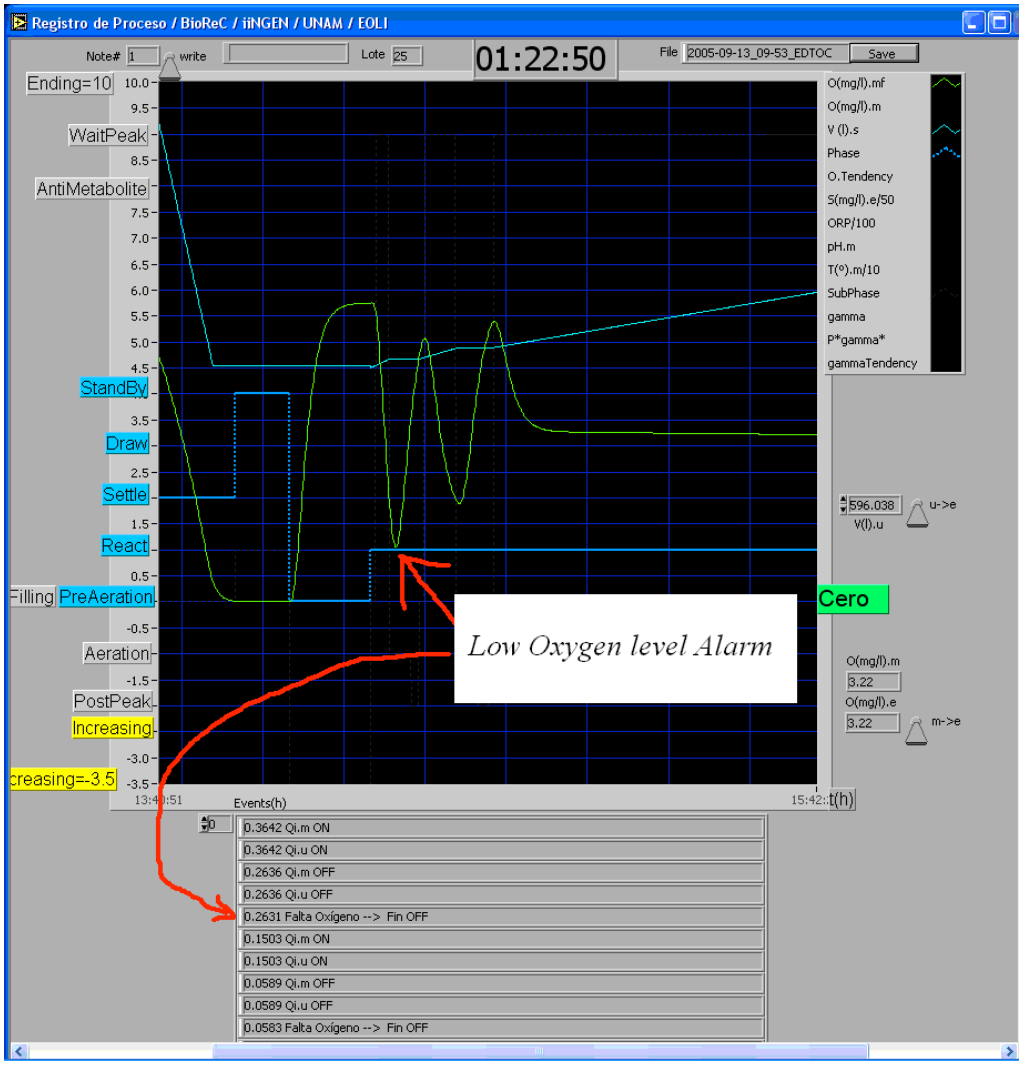

Figure II.1 Window of the Monitoring System

III. IMPLEMENTATION OF THE SUPERVISION SYSTEM

The structure of the system is "open" in the sense any new module can easily be implemented on the system. It is the responsibility of the user to verify a priori that any new module does not interfere with a running module. The independence of the system is based on the fact that a central interface manages any new volume. A module is a matlab function for which a set of inputs and ouputs have been defined. The central interface regularly reads the needed variable values into the local database (see the deliverable D7.1 and D8.1 for the global structure of the integrated EOLI system) and send the required variables to all the modules inventoried in the interface.

Because the module are totally independent from the SPES system (the are only communicating though regular readings and writings of the local database content, the implementation of a module (whatever its objective) is straightforward and includes only three steps :

- Declaration of the module within the central interface;

- Definition of the needed inputs (these inputs will be regularly read by the running central matlab interface and send on a regular timely basis to the module);
- Definition of the computed outputs.

Prior to these steps, the user should be aware of the facts that its modules must use data that are existing in the database. In addition, the operator must proceed with a consistency test: he should have verified before implementing its module that this last does not interfere with existing running modules. In particular, it is required that an actuator is not controlled by several modules at the same time!

The tunings of the system depend on the parameters of the algorithms used in the different modules. In the framework of the EOLI system, a very limited number of tuning parameters have been used and a system based on a plug-and-play basis has been preferred.

The supervision system that allows one to evaluate the amount of organic matter degraded during the aerobic phase of the treatment cycle at the LBE-INRA pilot plant has been described in the deliverable D1.5. Here below, we describe the use of the EOLI supervision system developed for the instrumentation case #2 (the use of the system in the case of a basic instrumentation (called case #1) is described in deliverables D7.1 to D7.4). In the Figure 3.1, the main window of the graphical interface is presented.

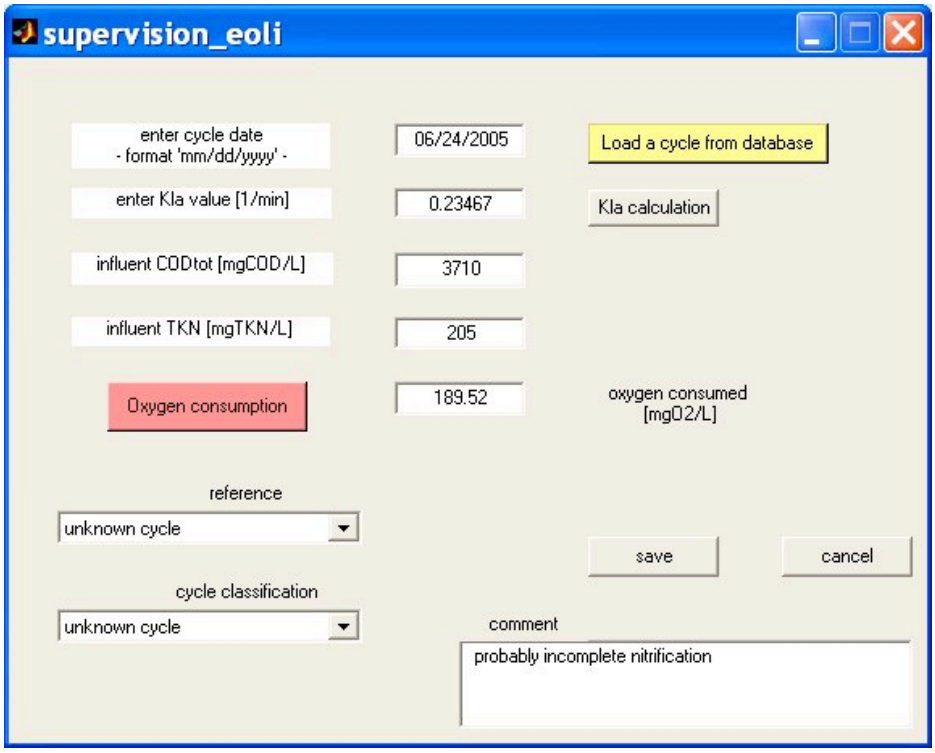

Figure III.1 : Graphical interface of the Supervision system

In the first box on the left the user should introduce the date of the cycle to analyze (at the moment the system allows the calculation only for the first of the two daily cycles performed). Then a value of K_La is required to perform the calculation of the oxygen consumed in the aerobic phase. The value can be entered manually by the operator, for instance if he performed off-line K_La measures, or it can be calculated automatically by the system, by pressing the grey button "K_La calculation". In this case the software performs a query on the database, extracts dissolved oxygen data from the "K_La measurement phase", and

returns the value of K_La after the calculation. A window opens at pushing the button, showing two graphs: the DO evolution during K_La measure and the logarithmic curve y =log (O_2sat- O_2) with its fitting polynomial curve. In such a way the operator can easily evaluate the quality of the K_La measure and decide to utilize or not the last measure performed.

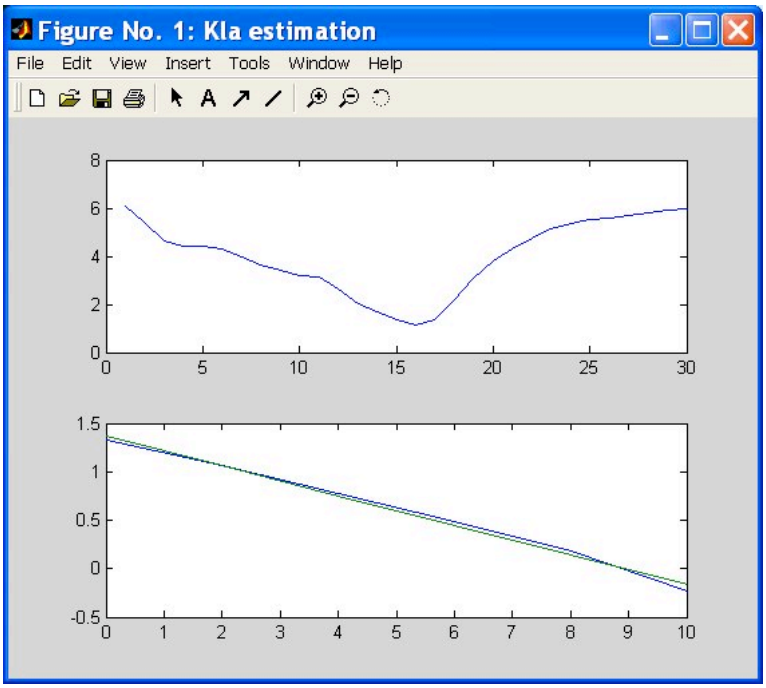

Figure III.2 : example of a K_La measure (above) and the relative fitting of the experimental data (under)

Then the operator can enter values of COD_{tot} and TKN of the influent if they are available; data can be provided by off-line analysis and/or by on-line instrumentation. For instance the hardware sensor TITAAN could provide influent's TKN estimations. Then by pushing the red button "Oxygen consumption", the system returns the amount of oxygen that has been used for the depletion of organic matter and the oxidation of nitrogen during the aerobic phase. In the Figure 3.3 is reported the oxygen profile during the aerobic phase and the calculated curve that simulate the oxygen saturation of the reactor in endogenous conditions: the oxygen consumption is simply calculated by subtracting from the area below the second curve, the area below the first one.

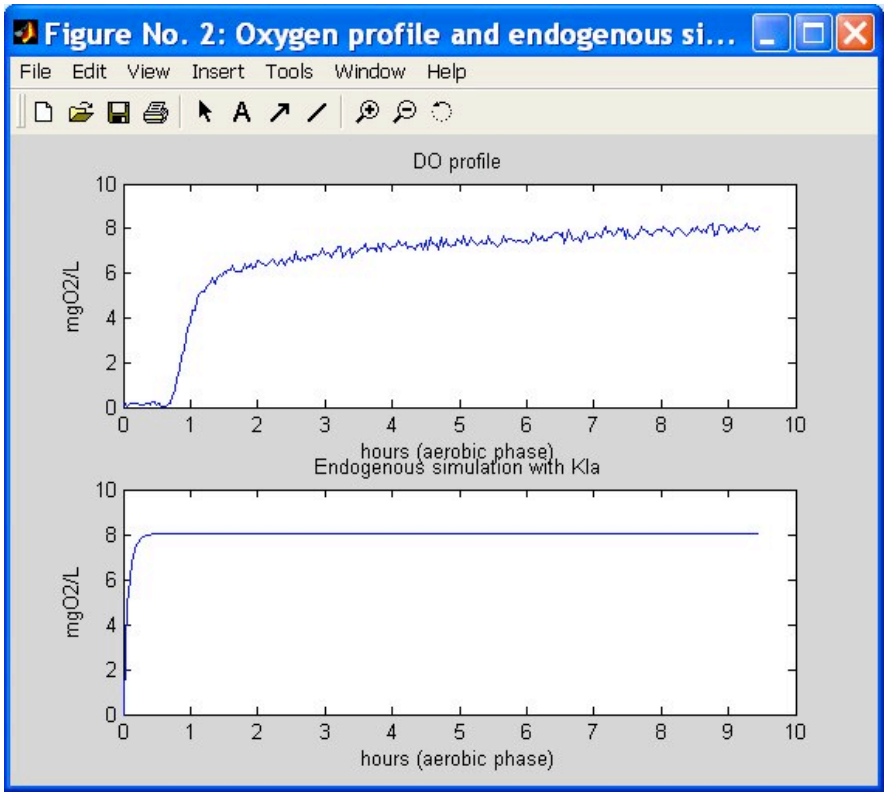

Figure III.3 : Oxygen profile in aerobic phase (above) and simulated re-aeration curve (below)

In the next release of the software we will include a tool that performs automatically the oxygen and nitrogen mass balance reported in the EOLI Deliverable 1.5.

In the main panel it is also possible to enter a comment about the cycle that it's going to be analyzed (under on the right of the window) and to enter a synthetic remark, for instance: COD overload, TKN under load, standard cycle, etc.