Replication of the **art-ICA** controllers for improving the eco-efficiency and sustainability of nutrient removal wastewater treatment plants.

# Layman´s Report

**www.artICA4nr.eu**

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Co-funded by the Eco-innovation Initiative of the European Union

## 1. Efficiency challenges in Waste Water Treatment Plants (WWTP)

Despite the progress made in recent years, a large percentage of **W**aste**W**ater **T**reatment **P**lants (WWTPs) in Europe and in the rest of the world are still being operated below optimum achievable performance.

This underperformance becomes apparent in the form of treated water discharges that are not compliant with water quality standards as well as low efficiencies in terms of energy consumption. In this context, the full automatic intelligent **art-ICA** controllers are a novel advanced control solution for biological nutrient removal WWTPs that, when applied, immediately lead to significant improvements in terms of the quality of the treated water combined with important savings in electricity consumption, up to 25%, and a similar reduction of greenhouse gases, due to a more stable biological process.

The use of art-ICA controllers will have an important impact on the environment and on the sustainable exploitation of WWTP, since it is known that WWTP have a high energy consumption (6 GWh for a typical plant of 200.000 HE (Habitants Equivalent)). In general is considered that the WWTP energy consumption can represent up to 3% of the national energy consumption, and expected improvements of 25% due to art-ICA can have a high impact on environment and sustainability expressed in less CO2 emissions.

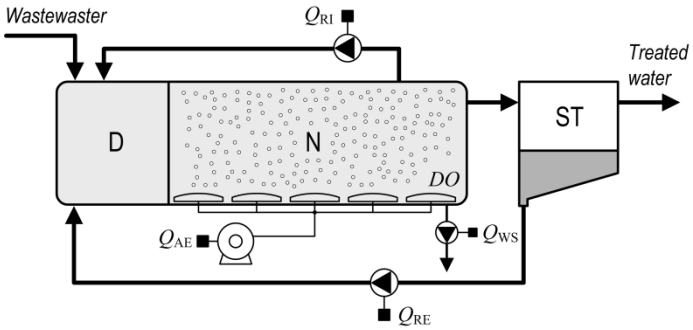
## 2. How does art-ICA work?

Unlike other control solutions, the **art-ICA** controllers rely on multivariable control techniques, with the objective of controlling all the main actuators of the biological process in an integrated way by considering their interactions. The integrated approach of this strategy, makes the **art-ICA** controllers able to manage the trade-offs between water quality and energy costs with great effectiveness.

The art-ICA controllers are an advanced process control solution that combines online sensors with control technology to automatically optimize the operation of WWTPs. It implements three controllers, where each one is in charge of keeping the following three critical process variables close to predefined set-points:

1. The Total Mass of Suspended Solids (TMSS) in the biological treatment;
2. The concentration of Nitrates (NO3-N) at the end of the denitrification zone;
3. The Ammonium (NH4-N) in the last aerated tank.

Each controller works by calculating and applying via algorithms the optimimum setpoints to the three most relevant actuators in conventional Biological Nutrient Removal (BNR) systems (see Figure), namely, the sludge surplus pump (QWS), the internal recycling pump ($Q_{RI}$) and the external air supply ($Q_{AE}$).




The **art-ICA** controllers have been developed for application to pre-denitrification / nitrification plant designs (also known as conventional BNR systems), which represents the most common type of plant-layout found in full-scale BNR WWTPs in Spain, Portugal and the European Union.

It is well known that the way the above actuators are operated, completely determines the performance of these systems and, more specifically, the quality of the treated effluent and the energy consumed in the treatment. The flow and composition of wastewaters generally present unavoidable large and permanent fluctuations that require real-time adaptation of the actuators in order to optimize the biological treatment.

## 3. How to implement art-ICA?

The **art-ICA** controllers are implemented very easily by integrating a windows based PC in the existing automation architecture, reading directly the process data so that the algorithms can calculate in real time the new setpoints to be sent to the Plant PLC or SCADA. It comes together with a process scoreboard with plant performance monitoring functions and data analysis techniques ready for detailed process analysis with emphasis on the biological part.

At the same time, if wanted, the complete solution (controllers and process scoreboard) can be implemented as a service by sending all the process data to the private cloud of MSIGrupo where the algorithms will calculate the optimum setpoints which are sent back in a secure way to the plant. MSI´s process consultants will provide continuous follow up, alarm management, finetuning, optimization so that the customer´s plant is in optimum conditions all the time even when nobody is there.

In terms of pricing, it must be remarked the flexibility to accommodate the specific needs of customers offering a product pricing for local installations or a shared risk model when a project is set up with MSI´s process consultants.

## 4. European Added value

Installation of art-ICA becomes economically interesting for medium sized plants (and bigger) which are plants above a size of 50,000 HE (habitant equivalent). According to market studies, the number of European WWTPs in which the **art-ICA** controllers can be installed are 163 in Spain and 1300 in Europe. This represents 32 million or 225 million HE (habitants equivalent) respectively, good for a yearly energy consumption of 7.000 GWh in Europe. A conservative 10% energy consumption improvement with a market penetration of 1% will lead to 7 GWh less energy consumed, every year. So the implementation of advanced controllers as art-ICA will have a major impact on environment and sustainability, improving directly the operations and maintenance of the plants.

It is also important to state that art-ICA will lower the Nutrient discharges into nature thanks to better effluent quality, complying the effluent regulation. This is especially interesting for the main European Countries which discharge in rivers with increasing effluent quality restrictions. Additionally, in this project has been proven also that the improved stability of the biological process will reduce the impact on the greenhouse effect due to the reduction of gas emissions, highly aggressive for the greenhouse effect.

## 5. The project Artica4nr

So, the main goal of this artica4nr (art-ICA controllers for nutrient removal) project is to promote the introduction of the art-ICA controllers in the market and to quantify the real benefits in a numerical way since the market is characterized by the following barriers :

- The wastewater sector is, in general, reluctant to incorporate new solutions that are not fully consolidated in the market;
- The return on investment associated with the costs of implementing art-ICA controllers are still considered relatively expensive or not reliable enough for wastewater operators.

The artica4nr project aims to overcome the above barriers through further replication of the art-ICA controllers in three WWTPs in Spain and Portugal :

- The Navarrosillos WWTP (Spain): 113.000 HE
- The Velilla de San Antonio WWTP (Spain): 123.000 HE
- The Chelas WWTP (Portugal): 210.000 HE
- The Castelo Branco WWTP (Portugal) : 95.000 HE

In these three replications, the performance of the art-ICA controllers will be monitored and its benefits will be quantified through environmental as well as economic indicators. Equally important, lessons learnt during the implementation of art-ICA in these three plants will be gathered to produce commercial content that will support the presentation of the art-ICA controllers at targeted conferences, seminars and workshops with operators and managers of WWTPs in Spain and Portugal and on international fairs. This material will be made available on the project website.

Partners of artICA4nr :

Research center, acts as Project coordinator and contributes with the scientific follow up of the results of the plants.

Owner of the art-ICA controllers and process Scoreboard. In charge of implementation and follow up of the art-ICA solution in the different plants.

Owner of two WWTP plants where art-ICA will be installed and contributes by giving feedback on the performance of art-ICA in their plants and by results diffusion in Spain.

University deeply involved in implementing art-ICA in plants of Portugal and realizing the environmental impact due to art-ICA.

Owner of the 2 WWTP plants in Portugal and contributes by giving feedback on the performance of art-ICA in their plants and by results diffusion in Portugal.

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