

Real-Time Expert Control of a Pilot WWTP with Nitrogen and Phosphorus Removal

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In the present work, the design and implementation of a multilevel distributed control system is shown. This control system is applied to a pilot WWTP with biological removal of organic matter, nitrogen and phosphorus. The operation scheme is based on an A2/O system (Anaerobic, anoxic, oxic) and includes organic matter removal, nitrification/denitrification, and Enhanced Biological Phosphorous Removal (EBPR).

The pilot plant is formed by four independent reactors and a settler. It has a total volume of 150 L and treats about 500 L per day. The pilot plant is fully automated and configurable from the control system. The control and monitoring system is based on two different computers. One is in charge of three automatic analysers of phosphate, ammonium, and nitrate and nitrite [1], in addition to an automatic sampling system. The other computer controls the plant, monitoring three probe controllers and supervising a PLC programmed for the actuation over the mechanical elements of the plant.

The expert system (ES) developed in G2 [2], which runs in a Sun workstation, is on the top of the system architecture. The ES is fed with in-line data (pH, T, DO, ORP, aeration and flows) and on-line data (NO_3^- , NO_2^- , NH_4^+ and PO_4^{3-}) generated by the two computers. These data is sent to the ES using a TCP/IP connection through an Ethernet network. Qualitative data (odours, colours, microbiological observations data) and discrete data from off-line analyses (COD, TSS, VSS, TKN, and SVI) are sent to the ES using a form page in WWW.

The ES systematises the knowledge about the process being based on the existing scientific knowledge and the practice acquired in our particular system. All this knowledge is structured through a whole of rules and procedures for each subsystem of the pilot plant, co-ordinated with a supervisory agent. The knowledge base has been validated on the pilot plant, showing an excellent performance to manage the pilot WWTP. The system developed detects and controls all the wrong and special operations, as for example: pump failure, feeding problems, probes malfunctioning, analysers control and maintenance, etc.

The main achievement of this prototype is a versatile framework able to deal with different plant configurations, based on object-oriented paradigm and rule-based reasoning. The on-line feature is an important innovation of this system, particularly for data monitoring and supervisor control. In our system, different control strategies can be implemented for activated sludge control of carbon, nitrogen, and phosphorus removal with different plant configurations. In addition, the developed KBES can be adapted to a new plant in a short time because of object-oriented design.

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[1] Gabriel, D., Baeza, J., Valero, F., Lafuente, J., *Anal. Chim. Acta*, **359**, 173-183. (1998).

[2] Gensym G2 Reference Manual Version 4.0. (1995). Gensym Corporation, Cambridge, MA, USA.