ENERGY$^+$: AB PROCESS PILOT PLANT

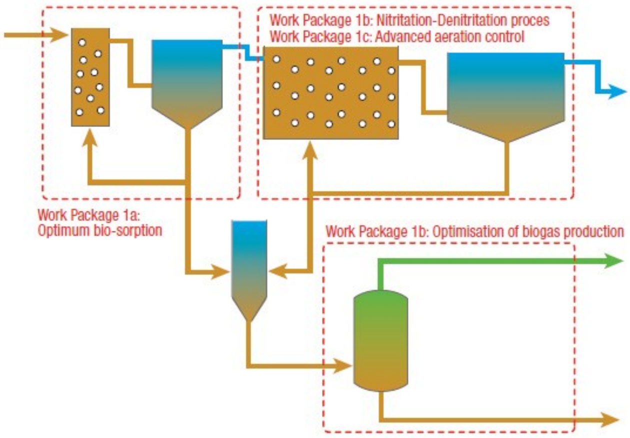
A novel integrated concept for retrofitting and optimising existing wastewater treatment plants to make them energy self-sufficient

Electricity used for wastewater treatment plants (WWTP) contributes to approximately 2% of the total electricity consumption in the industrialised world. Global warming, rising energy prices, and increased urbanisation mean a more effective approach to increasing the energy efficiency of large centralised wastewater treatment plants is needed. Energy self-sufficiency in a municipal wastewater treatment plant is a reality in just a few plants around the world. These plants focus on minimising energy demands throughout the entire plant. Coupling innovative design and treatment concepts has resulted in decreasing energy consumption and increasing energy production.

TOWARDS ENERGY SELF-SUFFICIENCY

At DHI, we have adopted a novel concept for improving the energy self-sufficiency of wastewater treatment plants by combining international best practices and further improvements through our research activities on key elements of the system. Our innovative approach can be used to retrofit existing treatment plants in Singapore, where our study was conducted, and abroad. In the Energy+ project, a 50 m^3 pilot plant operates with the AB process concept to treat real wastewater in Singapore.

The first step towards energy self-sufficiency focuses on the early entrapment of organic material during the biosorption process (A-stage). In this stage, biomass is recycled and used to improve organic material removal at short retention time.



High rate organic material entrapment in biosorption process (A-stage) with nutrient removal in controlled nitritation-denitritation process (B-stage) to achieve maximum biogas production © Singapore's Public Utilities Board (PUB) in 'Innovation in Water Singapore', July 2012, page 26.

CLIENT

- Wastewater treatment plants
- Public utility companies
- Municipal councils

CHALLENGE

In wastewater treatment plants, the need to achieve:

- a high rate of organic material removal in municipal wastewater pre-treatment process
- energy self-sufficiency without compromising final effluent quality

SOLUTION

Innovative wastewater treatment process involving:

- two-stage activated sludge with biosorption (A-stage) for early high-rate organic entrapment resulting in increased yields of biogas production via anaerobic digestion
- advanced aeration control (B-stage) for reduced aeration demand via DIMS.CORE

VALUE

- Reduction in overall energy demand
- Increase in energy production
- Tailored advanced aeration control to meet nutrient discharge requirement
- Compact process that reduces WWTP footprints

SOFTWARE USED

DIMS.CORE

THE TECHNOLOGY IN USE

Our technology results in an improvement in the removal of organic material compared to Primary Settling Treatment (PST), a conventional pre-treatment process prior to Biological Nutrient Removal (BNR) process. Carbon Oxygen Demand (COD) removal improved from an average of 37% in PST mode to 55% in A-stage mode. Total nitrogen was removed at a rate of 20% in A-stage mode compared to 8% in PST mode. A significant improvement in effluent solids concentration after A-stage is easily identified with typical average total suspended solids (TSS) concentration at 40 - 60 mg/L while typical TSS concentration in effluent PST is above 100 mg/L. Higher removal rates in A-Stage increases the amount of sludge collected to feed the anaerobic digester for improved biogas production.

In A-Stage, high removal rates of organic material with reduced energy consumption can be achieved by minimising carbon mineralisation and the effects of diurnal solid concentration. With good online database management and tailored real-time control via DHI's DIMS.CORE software, process controls such as low Dissolved Oxygen (DO) aeration and constant mixed liquor suspended solid control are able to achieve optimum removal. Such real-time controls can be designed and applied in full-scale operation with low capital cost.

DECREASING ENERGY DEMAND

The major factor of energy demand in BNR process is the aeration supplied for aerobic nitrification process. This is up to 45% of total energy demand in WWTP. In reality, many of the plant's operation may have not been optimised to reduce aeration demand. Taking this into consideration, we explored two strategies to reduce aeration demand in the context of Singapore: a novel process of nitritation-denitritation (N-DN) via nitrite shunt in B-stage and various advanced aeration control strategies.

In nitrite shunt, ammonium is only oxidised to nitrite instead of nitrate and after it is denitrified. Compared to conventional N-DN process, the advantages of this process, coupled with A-Stage, include:

- 40% lower carbon source requirement
- 25% lower oxygen consumption for aerobic nitrification
- 30-40% reduction of reactor volume
- higher denitrification rate

Singapore's high water temperature is favourable for biomass activity. As such, B-Stage can be realised by running the process with short SRT and low DO, resulting in energy savings.

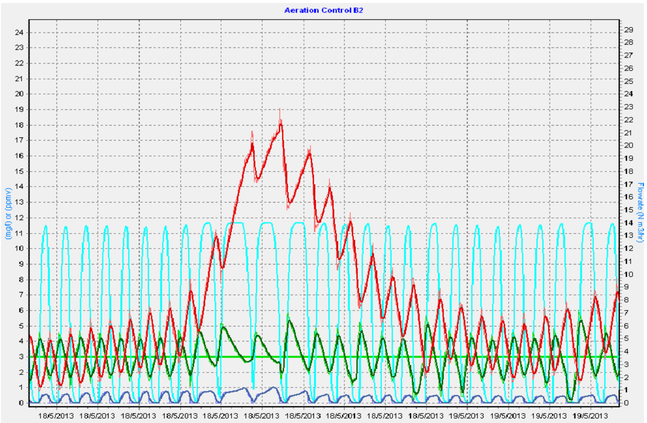
BENEFITS

The benefits of our innovative wastewater treatment process include:

- reduction in overall energy demand and increase in energy production in wastewater treatment plant
- proof of AB process concept in warm climate
- operational know-how of AB process in the context of Singapore's wastewater
- reduction of physical footprint in BNR process by nitrogen removal shortcut

AERATION CONTROL STRATEGIES

Different aeration control strategies were designed and tested with DIMS.CORE to achieve aeration savings in AB process. Aeration controls that employ basic Proportional Integral Derivative (PID) controllers such as ammonium set point controllers and nitrogen ratio set point controllers are the primary controllers used. However more advanced controls such as PID controllers with low DO supervision and intermittent aeration to promote Simultaneous Nitritation Denitritation (SND) process are able to further reduce aeration demand. Using these various controls, aeration saving in the nutrient removal process varies between 40 to 80% compared to the full-scale plant's process – without compromising effluent quality.



Real time advanced aeration control by DIMS.CORE in B-Stage with ammonium set-point at 3 mg/L (PID control with low DO supervision running at intermittent mode). This type of control is effective in reducing energy consumption while maintaining ammonium discharge limit. Ammonium (dark green), Ammonium set-point (light green), Nitrate (red), Aeration flow Rate (light blue), and DO (Blue) © DHI: DIMS.CORE

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