ELAN® technology: a step forward in the quest for energy self-sufficiency in WWTP

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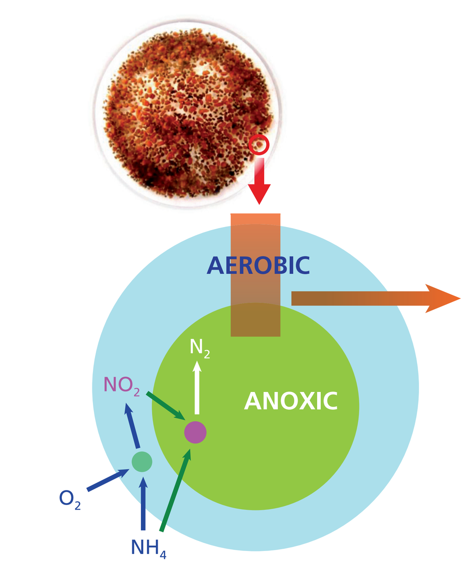
PAST (1914-2014): High energy demanding WWTP

- ✓ Activated Sludge (AS) is the most applied process in Wastewater Treatment Plants (WWTP).
- ✗ AS uses 0.5 - 1.4 kWh/m^3 of treated wastewater when nitrogen removal is required[1].
- ✗ AS does not make profit of the energy contained in the organic matter: 4 kWh/kg $COD_{removed}$[2].

Fig 1. ELAN® process, which performs autotrophic nitrogen removal in a single granular biomass sequencing batch reactor (SBR),[4] developed by **FCC Aqualia** with the know-how of the University of Santiago de Compostela (USC).

Pilot plant

ELAN® PROCESS



Autotrophic nitrogen removal processes

FISH picture of a cryosectioned slice of granule (bar = 75 µm)

PRESENT: Energy autarky in WWTP, ELAN® in the sludge line

- ✓ Wastewater treatment is shifting to anaerobic processes in order to profit from the potential energy production: 1 kWh/m^3 of treated wastewater, considering a production of 250 L/(p.e. d) and 60 g BOD5/(p.e. d).
- ✓ Anammox processes allow removing nitrogen with less oxygen requirements due to the partial nitrification of half of the ammonium to nitrite and no organic matter need for denitrification.
- ✓ The **ELAN**® process (Fig 1), applied in the sludge line (Fig 2), is already a mature technology that brings WWTP closer to energy autarky[3].
- ✓ The **ELAN**® process applied for treating the digester supernatant (around 20% of the N load in municipal WWTPs) remove 0.5 - 1.0 kg N/(m^3 d).

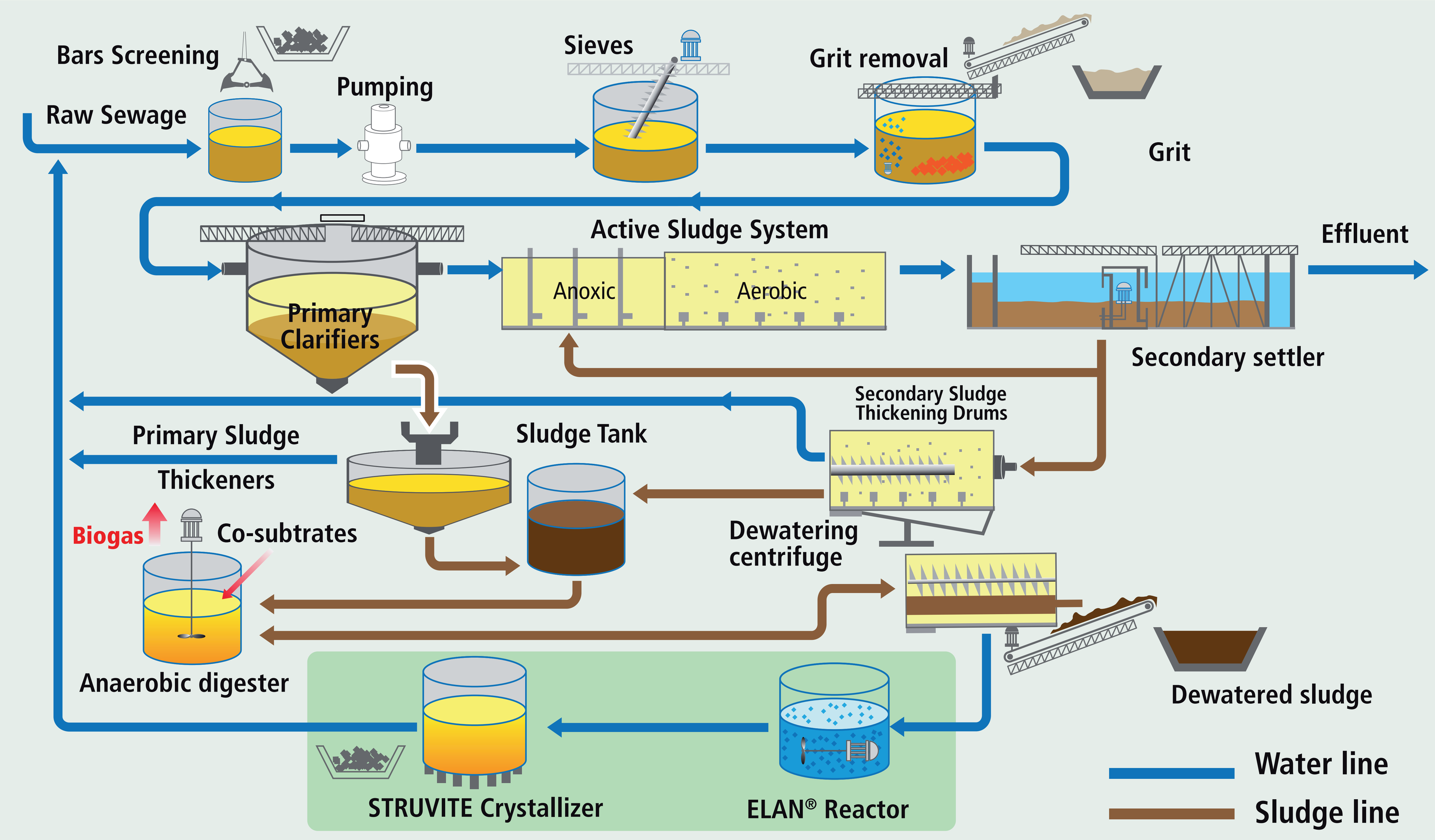


Fig 2. Schematic representations of the improved municipal WWTP, with the inclusion of ELAN® process treating the nitrogen in the sludge line and phosphorus reclamation by means of struvite precipitation.

FUTURE: Energy producers, ELAN® in the water line

- ✓ The next step and challenge will be the direct application of the anaerobic digestion process in the main stream followed by the **ELAN**® process (Fig 3).
- ✓ This treatment strategy will transform municipal and industrial WWTP from energy consumers to energy producers.
- ✓ Laboratory and pilot plant scale experiments (Fig 4) are being performed in order to test the **ELAN**® process applied to the water line of the WWTPs.

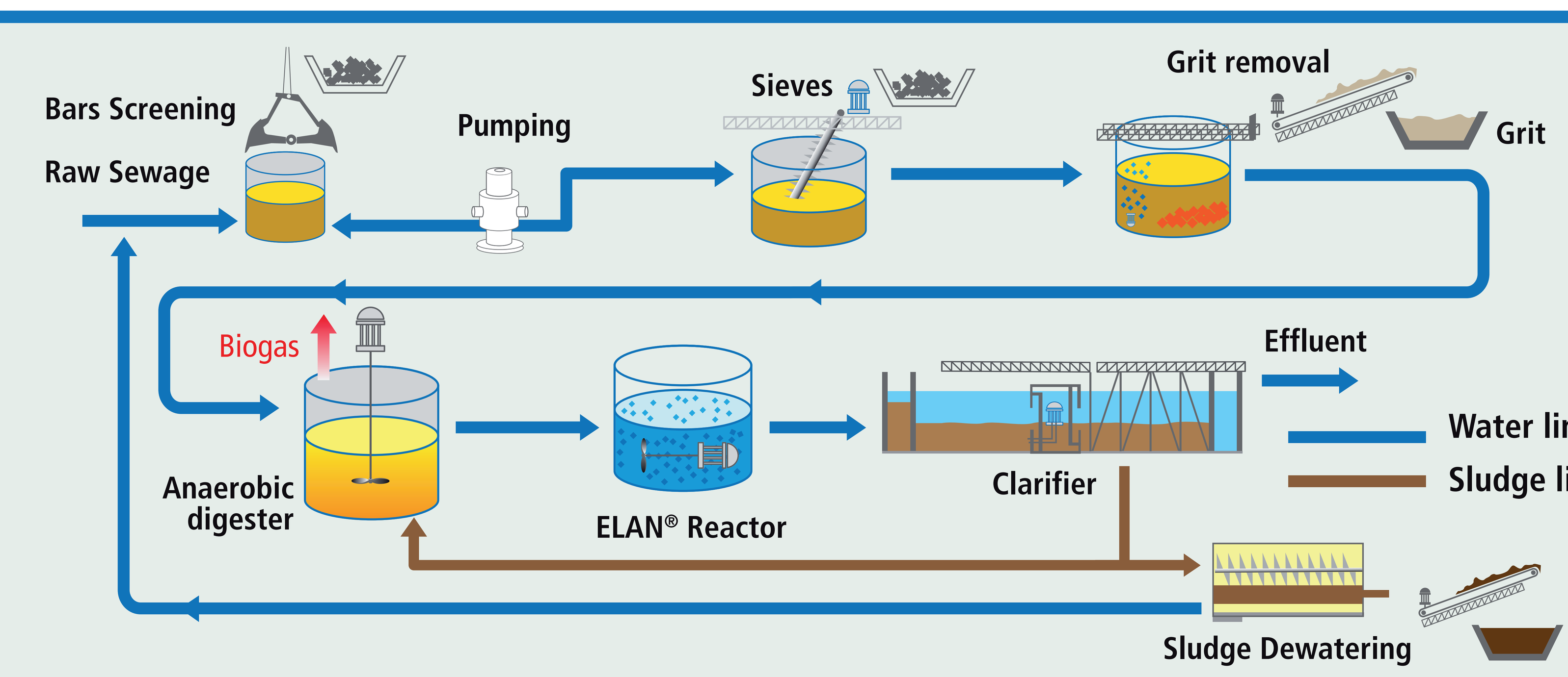


Fig 3. Schematic representations of next generation WWTP: The WWTP of the future for industrial or municipal wastewater. ELAN® process treating the N in the main line.

RESEARCH: ELAN® IN THE WATER LINE

Three factors should be fulfilled to operate an **ELAN**® system in the water line of a WWTP, coping with the low ammonia concentration and low temperatures of the municipal wastewaters: 1) to achieve a high biomass retention; 2) to achieve an equilibrium between the Ammonia Oxidizing Bacteria (AOB) and Anammox activities within the granule and 3) to avoid the Nitrite Oxidizing Bacteria (NOB) development in the biomass.

MATERIALS AND METHODS

Table 1. Operational conditions of the ELAN® reactors, R1 (lab-scale) and R2 (pilot-scale), used to treat the wastewater from the main line of the WWTP.

Parameter	Lab-scale (R1)	Pilot plant scale (R2)
Temperature (ºC)	15	15-22
Volume (L)	4	600
Ammonia (mg NH_4^+-N/L)	50	20-50
Biomass (g VSS/L)	10	2

Lab-scale (R1)

Pilot plant scale (R2)

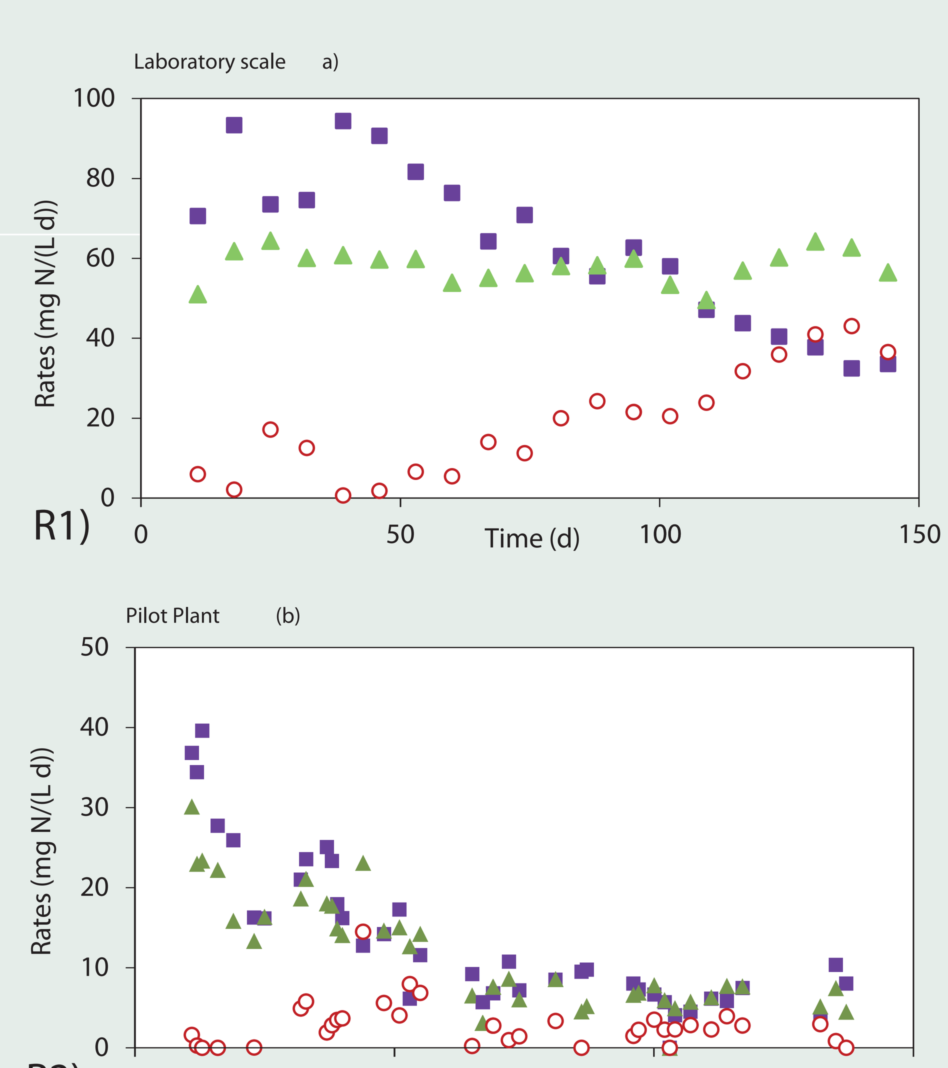


Fig 4. Nitrogen removal rate (ANR, ■) ammonia oxidizingrate (AOR, ▲) and nitrite oxidizingrate (NOR, ○) in mg N/(L d), in the laboratory scale reactor (R1) and in the pilot scale ractor (R2).

DISCUSSION AND CONCLUSIONS

- ✗ A progressive decrease in the nitrogen removal rate was observed at long term in both reactors (Fig 4).
- ✗ This detrimental evolution could be related to the low dissolved oxygen (DO) concentrations required to avoid nitrite oxidation:
  - ✗ Low DO might weaken the aerobic layers of the granular sludge (Fig 1), mainly AOB.→ The share of aerobic volume in the granule increases. →The development of NOB, the competition with AOB, and the inhibition of anammox bacteria were observed.
- ✓ Specific anammox activity batch experiments revealed that the maximum N removal capacity of the biomass remained stable during the whole reactor operation. →Anammox potential of the granules was not reduced.
- ✓ Granular biomass and SBR operation guaranteed the biomass retention.→ No significant variations in the biomass concentration were registered in both reactors.
- ► A robust control strategy to avoid nitrite oxidation is a key factor in order to ensure the stability of the autotrophic nitrogen removal process in the mainstream of a municipal WWTP.

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