
# Environmental Technology Verification of the Full Scale Short-Cut Enhanced Nutrients Abatement (SCENA) Process

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**Abstract:** This work reports the long-term operation of the Short-Cut Enhanced Nutrients Abatement (SCENA) for the treatment of anaerobic reject water. SCENA process adopted the via-nitrite pathway for an efficient nitrogen removal combined with the on-site VFAs production through acidogenic fermentation of sewage sludge. The system was operated for more than 450 days, where the applied vNLR was maintained between 0.50 to 0.66 kgN/m$^3$ day, while the average removal efficiency was stable at around 82% (average). Currently, the energy consumption for nitrogen removal (kWh/kgN removed) and related $N_2O$ emissions (g$N_2O$-N/kgN removed) are the performance claims target under evaluation to achieve the Environmental Technology Verification (ETV), which will establish the environmental added value of the process through independent assessment.

**Keywords**: Environmental technology verification; short-cut enhanced nutrient abatement (SCENA); external carbon source; SBR; Horizon 2020 – Smart-Plant

During the last decade, the environmental regulations are increasingly stringent, so the wastewater treatment plant (WWTP) should improve the effluent quality at affordable cost. In WWTPs, the sidestream treatment of the reject water from the sewage sludge digestion represents a suitable option to meet efficiently the effluent standard limits for nitrogen and phosphorus. The aerobic reject water can increase the nitrogen load to the mainstream biological treatment by 20-25 %, which may lead to an increase in air supply, and thus the energy demand. To minimize these negative economic and environmental impacts, the reject water from anaerobic digester should be treated with proper technology separately before it is recycled to the headworks of the WWTPs. On the other hand, the penetration of innovative technologies into the market could be helped by standard assessment of the environmental performance claims through Environmental Technology Verification (ETV pilot program, 2018). Within the EU framework program Horizon 2020, the Smart-Plant project (https://www.smart-plant.eu/) aims the development, implementation and validation through the ETV of the first full scale Short-Cut Enhance Nutrients Abatetment (SCENA, Renzi et al., 2015) in Carbonera WWTP (Treviso, North of Italy) for the via-nitrite treatment of anaerobic reject water. Specifically, the system adopted the on-site production Volatile Fatty Acids (VFAs) as carbon source by controlled fermentation of sewage sludge (Longo et al., 2015; Frison et al., 2016).

In this work, the long-term operation of the SCENA system and the monitoring period to evaluate the performance claims for the ETV are described. SCENA process operated continuously for around 450 days and 3 different periods were identified and described below (Table 1.1):

**Table 1.1** Description of the periods during the operation

| Period | Description |
|---|---|
| Period 1 | Start-up of the process (first 20 days) and achieving the design operating conditions; |
| Days 233-282 | Interruption of the sludge line due to not ordinary maintenance. During these days, the anaerobic reject water was not available; |
| Period 2 | Recovered of the design operating conditions after the interruption of the sludge line; |
| Period 3 | Monitoring of the energy consumption and $N_2O$ for the evaluation of the performance claims valid for the Environmental Technology Verification (https://ec.europa.eu/environment/ecoap/etv_en) |

Briefly, the fermented sludge is dewatered by a screw-press and the liquid stored in 20 $m^3$ of tank, while the anaerobic reject water is stored into a storage tank of 90 $m^3$ and then used as feeding for the SBR. The latter has a working volume of 70 $m^3$ and it was designed to treat up to 42 kgN/day. The aerobic conditions were accomplished by a volumetric blower (power installed 11 kW) combined with porous membrane disk in the bottom for fine bubbles distribution. During the anaerobic/anoxic conditions the biomass was kept suspended by a mixer having 1.5 kW of installed power. The length of the aeration phase and the carbon source dosage were controlled by conductivity real-time measurements, while the length of the anoxic phase was set on a timely basis. The typical cycles of the SBR consisted on the following ranges: feeding: 8-10 min; anaerobic: 60-90 min; aerobic: 180-260 min; anoxic: 50-60 min.

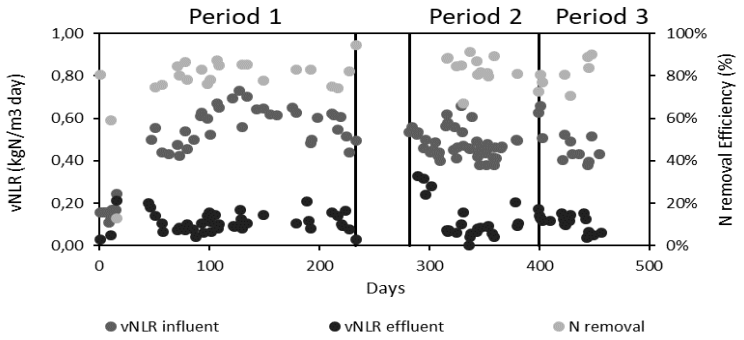


**Figure 1.1** Performances under long-term period of the SCENA process.

In the steady conditions, according with the nitrogen content in the reject water, the vNLR varied between 0.50 to 0.66 (kgN/$m^3$ day) with an average nitrogen removal efficiency of 82%. On the other hand, in period 1 the vNLR increased up to 0.73 kgN/$m^3$ day without significantly affecting the nitrogen removal efficiency. Preliminary assessment during the ETV monitoring period (Period 3) resulted that the observed energy consumption for nitrogen removal (including the VFAs production) accounted for 5-6 kWh/kgN removed. The latter was mainly affected by the nitrogen concentration of the reject water. On the other hand, the analysed $N_2O$ emitted during the aerobic phase (data not shown) was quantified around 15 g$N_2O$-N/kgN removed.

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