Short-Cut Enhanced Phosphorus and PHA Recovery from real sieved wastewater:

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Abstract
Wastewater treatment is a growing segment of the water industry, from which the recovery of valuable resources could make more efficient the water sector. In this regard, the Horizon 2020 project SMART-plant aims the upgrading of existing WWTPs by the integration of novel Smartechs for the biological carbon upgrading (as PHAs), phosphorus and cellulose fibers recovery and the implementation of innovative energy-efficient biotechnologies. Among the others, in this work is presented the pilot Smartech 5 which accomplishes the Short-Cut Enhanced Phosphorus and PHA recovery (S.C.E.P.P.H.A.R.) in the sidestream of the anaerobic digestion. The pilot S.C.E.P.P.H.A.R. system is just started up at the municipal WWTP of Carbonera (Treviso, North of Italy) and the preliminary results showed a PHA-bioplastic production of around 1.0 kgPHA/day using real cellulosic primary sludge from sieved wastewater as carbon source.

Keywords
S.C.E.P.P.H.A.R., bioplastics, phosphorus, Smart-Plant, Horizon 2020

Introduction

Municipal wastewater treatment plants consume large quantity of energy and valuable materials to comply with the standards for discharge. The possibility to recover resources from Water Resource Recovery Facilities (WRRF) represent the new challenge and an opportunity for water utilities from an environmental, economic and ecological point of view. Until now, the main type of resource gained from the wastewater was methane from the anaerobic digestion of sewage sludge (Verstraete et al 2014), although existing WWTP could offer also cellulose, short and medium-chain carboxylic acids, phosphorus and polyhydroxyalkanoates (PHAs, bioplastics) with potentially higher economical values in the market.

In this scenario, the SMART-Plant project in the framework of Horizon 2020, aims to validate and to address to the market a portfolio of SMARTechnologies (Smartechs) that, singularly or combined, can be integrated in existing wastewater treatment plants and give the added value towards efficient wastewater-based biorefineries. In this work, the preliminary results of the big pilot plant for Short-Cut Enhanced Phosphorus and PHA Recovery (S.C.E.P.P.H.A.R.) by the use sieved wastewater are shown. The latter adopts a novel approach to integrate the sidestream biological nitrogen removal via-nitrite from the anaerobic supernatant of sewage sludge with the selection of PHA storing biomass.

Material and Methods

The main units of the S.C.E.P.P.H.A.R. are the following:

Sieving of wastewater (Figure 1a) using a dynamic belt filter (SF1000 (Salnses Filter, Norway) at around 30 m^3/h (range 30-54 m^3/h) through a pore size of 360 μm (Figure 2a). The resulted cellulosic primary slugde (CPS) is characterized by a concentration of 40-45 gTSS/L

Volatile Fatty Acids (VFAs) production and solid/liquid separation (Figure 1b and c). The fermentation for VFAs production unit has 2.6 m^3 of working volume (4-5 days of HRT) while the S/L separation is performed using a ceramic membrane system (Sepra, Italy).

Nitritation (Figure 1d). Daily, around 3.5 m^3 of anaerobic supernatant is fed into a SBR (N-SBR) with a 1.4 m^3 of working volume (Figure 2d). Here, the oxidation of ammonia is accomplished at relatively high volumetric nitrogen loading rate (vNLR, 1.4-1.6 kgN/m^3 per day) and pH between 7.8-8 by the addition of NaOH. The SRT is mantained stable at 12 days.

Selection of PHA storing biomass (Figure 1d) The selection of PHA storing biomass is carried out in a SBR (S-SBR) with a 2.9 m^3 of working volume (~~Figure 2d~~) which accomplished feast and famine regime using VFAs from the CPS permeate under aerobic and anoxic conditions respectively, operating at 5 days of SRT. Then, the treated effluent is discharged in the mainline.

Accumulation PHA reactor (Figure 1d). The selected PHA biomass growth in the S-SBR where used as inoculum in the aerobic accumulation reactor (A-SBR) with a 1 m^3 of working volume (Figure 2d). The increase of the PHA content in the biomass is accomplish in 5-6 hours using VFAs from real CPS permeate as carbon source. After 5-6 hours of accumulation, the activity of the biomass is automatically quenched by the addition of (10 mg/L). The produced PHAs were extracted, purified and then quantified gravimetrically in order to evaluate the PHA production yields.

Figure 1 (a) Salsnes Filter SF1000 for the sieving of wastewater; (b) fermentation unit for the production of VFAs; (c) ceramic membrane for the solid/liquid separation and crystallizer for P-salts production; (d) Units in SBRs-modules for nitritation, PHA storing biomass selection and PHA accumulation.

MAIN RESULTS

The VFAs production from CPS fermentation was around 0.45-0.50 $gCOD_{VFAs}/gTVS_{fed}$ where relevant amount of phosphates were released in a range of 80-110 mgP/L. The phosphates could be recovered up to 85% as struvite, according with 250-300 grams/days. The latter will be characterized and analysed in the coming period to assess the purity and the quality as fertilizer. During around 4 months of operations, the SCEPPHAR system performed a nitrogen removal efficiency around 85%, while the observed feast to famine ratio in the S-SBR decreased to less than 0.15 min/min, indicating a good selection of the PHA storing biomass. The observed biomass growth was 0.27 gMLVSS/gCOD fed which was able to accumulate up to 53% (dry matter) of PHA in the biomass cells in the A-SBR. The PHA productivity obtained was 0.8-1.2 kgPHA/day, which corresponded to a potential PHA production of around 1.0 kgPHA/capita year.

ACKNOWLEDGEMENTS

This study was carried out within the framework of the “SMART-Plant” Innovation Action which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690323.

REFERENCES

Willy Verstraete. 2014 State of the Art Compendium Report on Resource Recovery from Water. IWA Resource Recovery Cluster.
Nicola Frison, Evina Katsou, Simos Malamis, Adrian Oehmen, Francesco Fatone (2015). Development of a Novel Process Integrating the Treatment of Sludge Reject Water and the Production of Polyhydroxyalkanoates (PHAs). Environ. Sci. Technol., 49 (18), pp 10877–10885