Demonstration of resource recovery from wastewater and related cross-sectorial value chain within Horizon2020 SMART-Plant

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The lack scale-up and long-term demonstration in real environment of eco-innovative resource recovery and reuse solutions is one of the main barriers for circular economy principles in wastewater systems management. Within this context, since 2016 the Horizon2020 SMART-Plant Innovation Action (www.smart-plant.eu) is delivering scaled-up solutions in n.6 existing wastewater treatment plants (WWTPs) with the aim to recover and recycle chemicals and nutrients in an energy- and carbon efficient way. In those Water Resource Recovery Facility (WRRFs), besides $CaPO_4$ and struvite, more than 400 kg per week of clean cellulose fibres or cellulosic sludge (Crutchik et al., 2018), more than 1 kg polyhydroxyalkanoates (PHA) per day are to produce sludge-wood-plastic bio-composites, fertilizer and biofertilizers, biomass fuel, sludge-added mortars and cement.
In order to achieve 10-50% energy efficiency, via-nitrite pathways for nitrogen removal and P and PHA recovery was coupled in SCENA (Short-Cut Enhanced Nitrogen Abatement) (Longo et al., 2017) and SCEPPHAR (Short-Cut Enhanced Phosphorus and PHA Recovery) (Frison et al., 2015). Results showed that around 5.5 kWh are necessary per kg nitrogen removed and around 1 kgPHA/capita per year can be recovered, respectively.
Experimental analyses of greenhouse gas (GHG) emissions and carbon footprint have demonstrated 15 gN_2O per kg N removed. These results are even under validation within the EU Environmental Technology Verification (ETV) program to prove the reliability of the claims and help technology purchasers identify innovations that suit their needs. This will be the first ETV application on a biological wastewater treatment process for resource recovery.
Recovered cellulose, PHA, PHA-rich sludge, $CaPO_4$ and struvite are then post-processed to produce bio-composite in an industrial extruder, to produce (after bio-drying process) biomass fuel having 3940 kcal/kg calorific value, and or to be added to mortars to increase lightness, flexural strength and hygrometric properties. Moreover, the agronomic properties of P rich sludge are under investigation in real field for maize growth.
Biochemical and physical processes were modelled by modifying Activated Sludge Models (ASMs) or Anaerobic Digestion Models (ADMs) and implemented in a Decision Support System (by using Open Modelica and Python), where a superstructure allow to simulate scenarios and support engineers to integrate existing WWTPs with the eco-innovative technologies developed within SMART-Plant.
Finally, economic and financial assessment of the novel technologies and products is under implementation considering current and future market scenario and regulatory barriers that are refraining the radical change from WWTPs to WRRFs.

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