Intensive treatment of waste effluents and conversion into useful sustainable outputs: biogas, nutrients and water- Life Infusion project

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ABSTRACT

The world has an enormous waste challenge 1.3 billion tons of municipal solid waste (MSW) are generated globally per year, and it is expected to almost double to about 2.2 by 2025. Although efficient waste treatment systems currently exist, the management of certain liquid fractions remains an environmental challenge, requiring the development of new sustainable and circular economy-oriented treatment to go along with green transition.

It is in this framework in which the LIFE INFUSION project was born, co-funded by the European Commission under the LIFE Programme, aiming to recover high-added-value resources such as energy, nutrients and water from various liquid wastewater effluents of municipal origin. In this way, it seeks to contribute to the creation of future biorefineries, closing the loop between waste and resources, while simultaneously reducing the environmental, social and economic impacts of municipal waste management.

The most innovative part of the INFUSION solution is based on the combined use of technologies that have only been tested at the laboratory scale, either individually or in completely different sectors. Specifically, the demonstrative pilot (treating 6 m^3/d) is made up of four different and interrelated treatment units to carry out the total treatment of the liquid digestate of the organic fraction municipal solid waste (OFMSW) treatment. These four units can work independently of the rest, so this document presents the results obtained in each of the units individually, and the result of the joint process.

- Stripping process: a two-step physico-chemical process recovering nitrogen as ammonium nitrate. This ammonium salt can be used as biofertilizer in agriculture.

- Thermophilic anaerobic membrane bioreactor (tAnMBR): a biological process that reduces the organic matter content of wastewater and converts it into biogas. The bioreactor operates at a temperature of 55 °C, for this reason, sanitized purge can also be used in agriculture.

- Membrane contactors: extract residual ammonia from the tAnMBR to recover it as ammonium salt using a hydrophobic membrane. Ammonium sulphate is obtained from this phase, which can also be used as biofertilizer in agriculture.

- Regenerated membranes: using regenerated reverse osmosis membranes from other processes; reclaimed water obtained is suitable for crop fertigation and aquaculture.

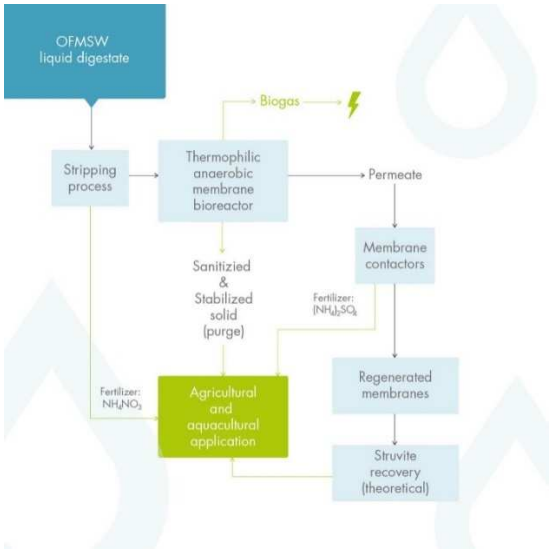

Figure 1. General demonstrative pilot process outline

Figure 2. Demonstration pilot located in Ecoparc 2 (Barcelona)

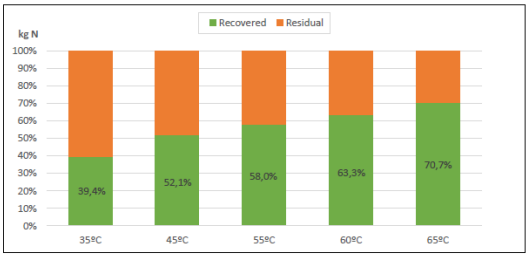

Figure 3. Recovered and residual nitrogen in relation operating to the kg of nitrogen fed in each period

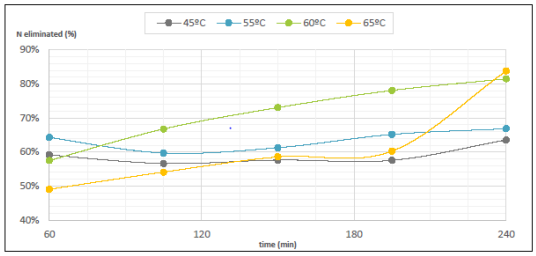

Figure 4. Stripping performances at different temperatures

In conclusion, the Stripping process has turned out to be very useful in the recovery of ammonium nitrogen contained in the leachates at different temperatures tested, reaching from almost 40% recovery at 35ºC, to more than 70% at 65°C. For temperatures of 45°C and above, recovery was even higher than the KPI set in the project of 50% for the stripping process and membrane contactors combined.

Regarding the tAnMBR, during the one year operation, the feeding had an average COD concentration of 20.2 g/L and a 76% COD removal was achieved. The OLR fed ranged from 0.4 up to 1.3 kg COD/(m^3 d) with solids content of 30-39 g/L. The biogas production ratios ranged from 1.8 to 3.0 m^3 biogas/m^3 treated water with a 66% methane content.

Membrane contactor unit. Despite not being able to operate the membrane contactor unit for long periods, it has been possible to verify its performance in the elimination and recovery of ammonium nitrogen depending on the initial regulation pH and the number of cycles. It has been demonstrated that at high pH, yields higher than the KPI set in the project of 50% recovery of ammonium nitrogen between the stripping and membrane contactor processes are achieved.

On the other hand, pH adjustments before and after the membrane contactors are the main factor hindering the Reverses Osmosis operation because of the associated conductivity increase in the water. To avoid this issue, the use of the stripping unit after the anaerobic reactor instead of the membrane contactors will be investigated.

Different effluents from tAnMBR (*purge*, *regenerated water* and *whole digestate from tAnMBR*) have been tested for growing horticultural species, including ornamentals. It has been demonstrated that the use of such products, once properly diluted, are able to sustain plant production of the tested species. Therefore, the use of the obtained effluents in horticulture could be feasible alternatives to the use of synthetic fertilizers and part of the clean water needed for irrigation; these results should be taken into consideration in a threating framework of resource scarcity (raw materials and water), particularly in the Mediterranean area.