Revalorization of sewage sludge and other organic wastes by co-digestion

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Abstract
Resource recovery from wastewater has gained high attention in recent years for reducing environmental impacts of human activity and improving profitability of waste management. Conversion of organic matter into energy or biochemical compounds and recovery of nutrients are the most promising routes for resource recovery. During wastewater treatment, sewage sludge is digested anaerobically for the production of biogas, but this is not always a very economically feasible process. To improve feasibility, sludge can be co-digested with other organic wastes to produce intermediate products of higher value such as volatile fatty acids or increase biogas production. The focus of this research is to achieve a higher valorization of waste streams through co-digestion.

Introduction

Wastewater contains several resources that can be recovered or converted into valuable products or energy to close the resource loop and increase the economic feasibility of wastewater treatment (Verstraete *et al*. 2016). Municipal wastewater is commonly treated by activated sludge systems with high energy consumption for aeration, but conventional wastewater treatment plants (WWTP) do not achieve their maximum potential to recover carbon sources or other valuable resources from wastewater.

Anaerobic digestion is a well-known and environmentally friendly technology that has also been applied for the treatment of sewage sludge (SS) for years, but an interesting alternative is the combination of sewage sludge with other organic wastes such as the organic fraction of municipal solid waste (OFMSW) or fish waste in co-digestion, which can improve the efficiency of the process. In addition, sewage sludge can be converted in other value-added products such as organic acids and other chemicals.

Activated sludge systems are the most common for wastewater treatment, in which organic matter of the wastewater is oxidized and the residual sewage sludge is treated by anaerobic digestion. Improvement of biogas production through this process has been shown by co-digestion of sewage sludge with organic waste due to a synergistic effect (Xie *et* al. 2017). Co-digestion can overcome problems related to single substrate digestion such as the lack of micronutrients or imbalanced C/N ratio. Sewage sludge from wastewater plants has been successfully co-digested with different organic wastes such as food waste (Koch *et al.* 2016).

Not only improvement of biogas production by co-digestion can increase economic feasibility of a wastewater plant but also by valorization of intermediate products of the anaerobic digestion process. Anaerobic digestion takes place in four different stages, from hydrolysis to methane production; volatile fatty acids (VFAs) are intermediate products that can be used as precursors to produce different bioproducts such as bioplastics (Ben *et al.* 2016). Different organic wastes have been used to produce VFAs such as tuna waste (Bermúdez-Penabad *et al*. 2017) and food waste (Wang *et al*. 2014).

The focus of this research is to achieve higher valorization of sewage sludge through addition of different organic wastes, fish sludge in Norway and OFMSW in Denmark, for the production of biogas and other intermediate products. This will be studied with different ratios of organic wastes in order to optimize the co-digestion of the substrates.

Materials and methods

Organic waste from both Denmark and Norway were used for this project. Primary, secondary and digested sewage sludge were supplied by Biofos Avedøre WWTP, Copenhagen, Denmark. Samples of OFMSW were collected from the waste receiving plant of HCS, Glostrup, Denmark. OFMSW samples were pretreated at HCS by shredding and mixing with rain water.

Sewage sludge was also collected from Bergen Rådalen Biogas plant and IVAR Grødaland WWTP in Norway. Fish sludge samples were supplied by different fish farms: Preline AS, in Skien and Lerøy Vest AS, in Bekkjarvik, Norway.

Samples were chemically characterized in terms of pH, TS (Total Solids), VS (Volatile Solids), total COD (Chemical Oxygen Demand), total N and total P according to standard methods. Fish sludge samples were also analyzed for heavy metals content. Further characterization of the substrates will be performed

Results and discussion

The main results of the chemical characterization of the samples from Denmark and Norway are presented in Table 1. It can be observed that sewage sludge from Denmark contains lower TS content than sludge from Norway, while the organic wastes have a similar TS and VS content.

Table 1. Characteristics of sewage sludge, OFMSW and fish sludge.

		COD g/kg	TS %	VS %	pH	Total N g/kg	Total P g/kg
	Primary sludge	44.1	3.3	2.8	5.8	1.1	1.0
Denmark	Secondary Sludge	24.6	2.6	1.9	6.4	1.5	2.3
	OFMSW	181.2	14.5	12.9	4.8	3.6	2.6
	Preline AS Fish sludge	n.a.	13.4	12.3	5.6	7.6	1.3
Norway	Lerøy Vest AS Fish sludge	n.a.	10.4	9.2	4.7	5.1	0.9
	Grødaland SS	n.a.	8.1	6.6	5.3	2.0	1.0
	Bergen sewage SS	n.a.	4.8	3.5	7.1	2.2	0.7

The first approach to study the co-digestion of different organic wastes with sewage sludge is the chemical characterization of the substrates, that may vary depending on the region and time of collection. It is then crucial to analyse different parameters such as COD, total N or total P in order to define the chemical characteristics of the organic wastes and optimize their utilization for waste revalorization.

Conclusions

Combination of organic wastes such as OFMSW and fish waste with sewage sludge in co-digestion is a promising approach in order to optimize feasibility of sludge treatment in WWTPs, but the first step is the proper chemical characterization. This will be further studied in this project in order to optimize biogas and other possible bioproducts production by co-digestion of the waste streams.

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