Assessment of a full-scale anaerobic co-digestion plant: A multi-component substrates analysis by using ORWARE

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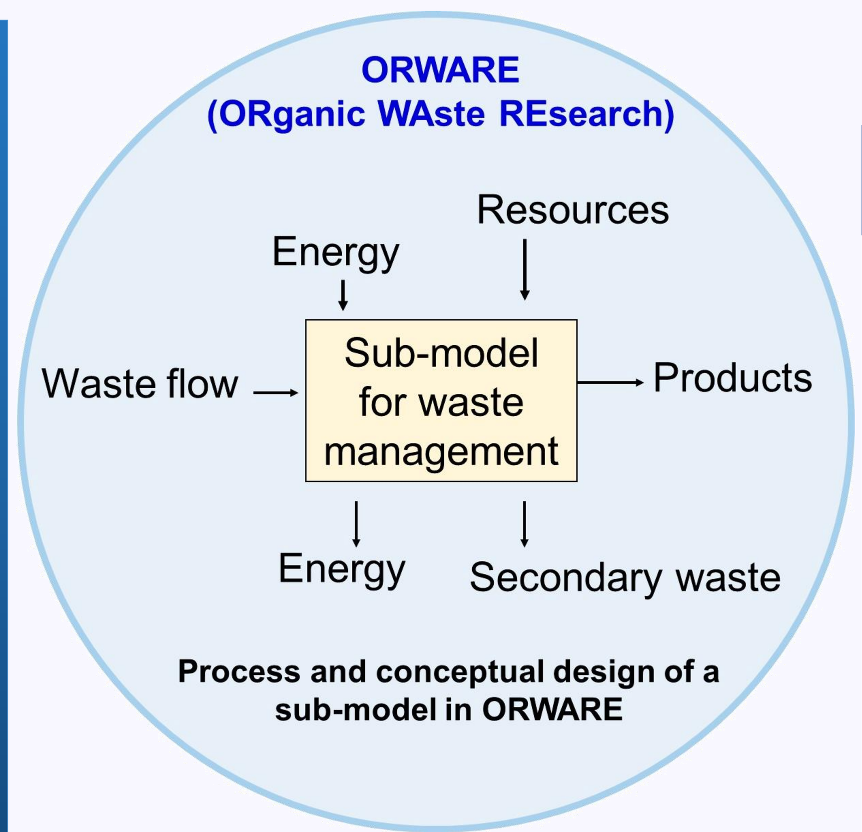
Introduction & methods

The feedstock supply for the anaerobic digestion (AD) process should be sustainable with respect to its environmental impacts. In Sweden, horse manure (HM) is generated in large quantities and it has the possibility to be used as a feedstock.

Digestate, rich in nitrogen (N), phosphorous (P) and potassium (K), can be used as organic fertilizer. It decreases the environmental impact from conventional fertilization, giving circularity to the process [1].

The aim of this study is to investigate how different substrates or combinations of these would influence the AD, and to assess, through the ORWARE model, methane and digestate from a full-scale AD where different feedstocks including HM are co-digested.



Different scenarios, Table 1, were analyzed by using the ORWARE model.

Table 1. Different feedstocks and scenarios analyzed.

Feedstock	Scenario A	Scenario B	Scenario C	Scenario D
Food waste (Biowaste)	77%	77%	77%	0%
Green Waste	19%	0%	0%	0%
FS/GS	4%	4%	4%	4%
Horse Manure	0%	14.3%	14.3%	72%
Wood chips (bedding)	0%	4.7%	0%	24%
Straw (bedding)	0%	0%	4.7%	0%

FS/GS= Food slurry/grease sludge

The analyzed biogas plant is located in Gävle, Sweden, and corresponds to a solid-state anaerobic digestion (SS-AD) process under thermophilic conditions with 36 days of hydraulic retention time (HRT) and 27% total solids (TS).

Results & Discussion

The simulation results in Table 2, show that by substituting green waste (GW) for HM in scenarios B and C, the co-digestion has an increase in methane production as well as energy turnover with negligible changes in electricity and heat consumption.

Table 2. Simulation results for the energy assessment and some operational parameters.

Parameter/Scenarios	A	B	C	D
Biomethane (MJ/$t_{treated\ waste}$)	3,570	**3,730**	**3,677**	2,455
Electricity consumption (MJ/$t_{treated\ waste}$)	-61	-61	-61	-72
Heat consumption (MJ/$t_{treated\ waste}$)	-352	-353	-352	-436
Energy turnover (MJ/$t_{treated\ waste}$)	3,156	**3,316**	3,264	1,947
Recirculation flow (t/year)	1,275	1,372	1,328	1,334
Fresh water for dilution (L/t_{waste})	4.4	**0**	**0**	304

Increasing the dry organic matter content inside the reactor will increase the amount of fresh water needed to adjust the TS of the process, leading to higher consumption of heat required to raise the desired temperature (scenario D).

The fresh water input for scenarios B and C can decrease to zero since HM has less %TS than that of GW. This represents a benefit in terms of having a more sustainable process, by reducing the input resources.

The analyzed nutrients in the digestate were N, P, K, and biological-C.

According to restrictions for spreading the digestate[2], scenarios B and D could have an excess of N when spreading the liquid fraction.

Liq. Fract. of scenario B has the major analyzed nutrients.

The main contribution of P is found to be the solid fraction of scenario D.

The nutrients application would fit according to the restrictions for scenario B if direct application of the digestate, no separating its fractions, is done.

Not doing any post-treatment could be beneficial in maintaining or increasing the energy turnover.

The solid fraction of digestate ranged from 1,641 to 7,035 t/year while the liquid fraction comprised between 10,021 to 10,856 t/year with respect all scenarios.

Conclusions

By substituting GW with HM+bedding, both scenarios B and C proposes an increase in biomethane yield without significant change in heat/electricity consumption as compared to scenario A. Digestion of only HM+bedding, scenario D, does not improve the process compared to scenarios A and B. The liquid fraction of scenario B contributes with the biggest increase in all the analyzed nutrients. The liquid fraction of scenarios B and D could present an excess of N according to the restrictions in the Swedish SCPR 120 certification. If the solid/liquid separation is avoided, nutrient concentrations in all scenarios, except scenario D, would be in line with the regulation implying a possible benefit for the process in terms of energy turnover.

[1] Głowacka, B. Szostak, R. Klebaniuk, Effect of biogas digestate and mineral fertilisation on the soil properties and yield and nutritional value of switchgrass forage, Agronomy. 10 (2020) 1–22. doi:10.3390/agronomy10040490. [2] Avfall Sverige, Certification rules for digestate, Borås, Sweden, 2007.