Optimizing Sewage Sludge Digestion in Wastewater Treatment Plants: a Case Study from the Largest WWTP in Italy

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Marco Ravina

S. Borzooei, G. Campo, A. Cerutti, L. Meucci, D. Panepinto, V. Riggio, B. Ruffino, G. Scibilia, M.C. Zanetti

Politecnico di Torino - Department of Environment, Land and Infrastructure Engineering

Società Metropolitana Acque Torino - Research Center

e-EUBCE 2020

Castiglione Torinese WWTP

2,000,000 equivalent inhabitants

inflow rate 25,000 m^3/h

Castiglione Torinese WWTP

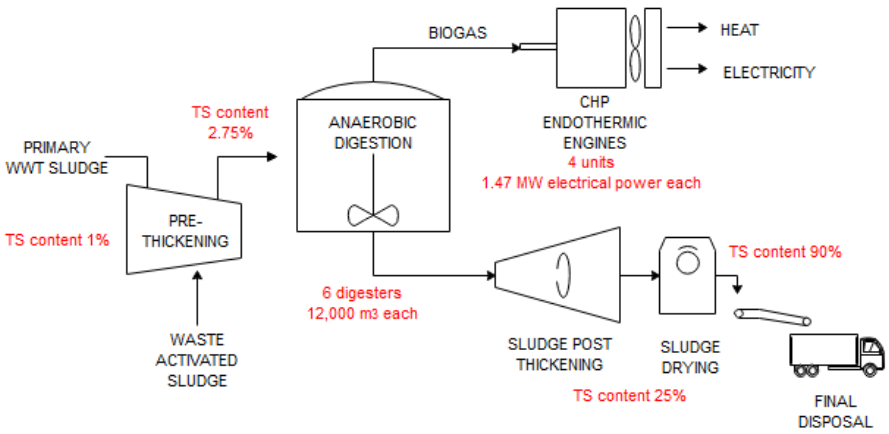
Objective: Sludge treatment and anaerobic digestion stage optimization

1. Evaluation of combined thermal and chemical pre-treatments (named hybrid pre-treatments) on waste activated sludge (WAS)

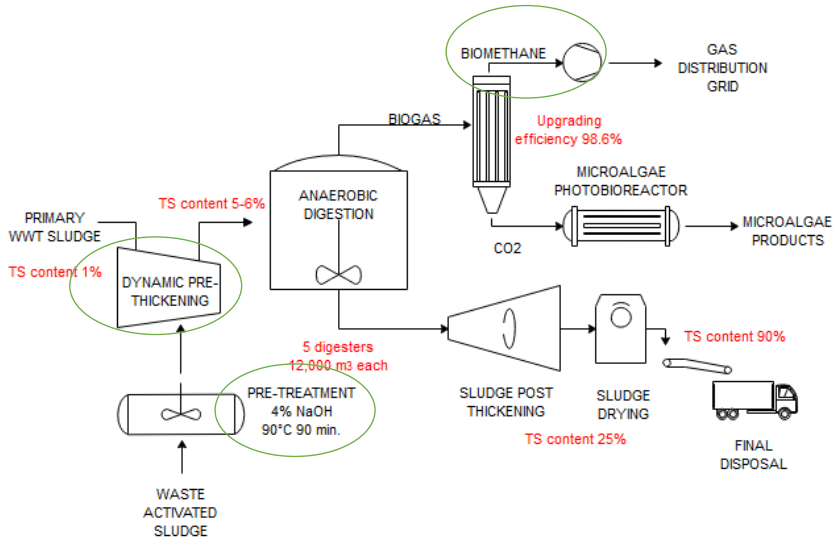
2. Evaluation of the introduction of a biogas upgrading process to biomethane

in terms of mass, energy and greenhouse gas emission balance.

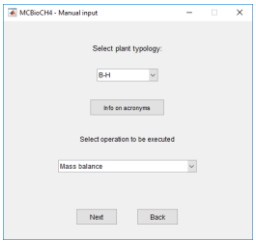
Present process



Optimized process simulation



Evaluation model



MCBioCH4 is a MATLAB® - based standalone application fully equipped with graphical user's interface

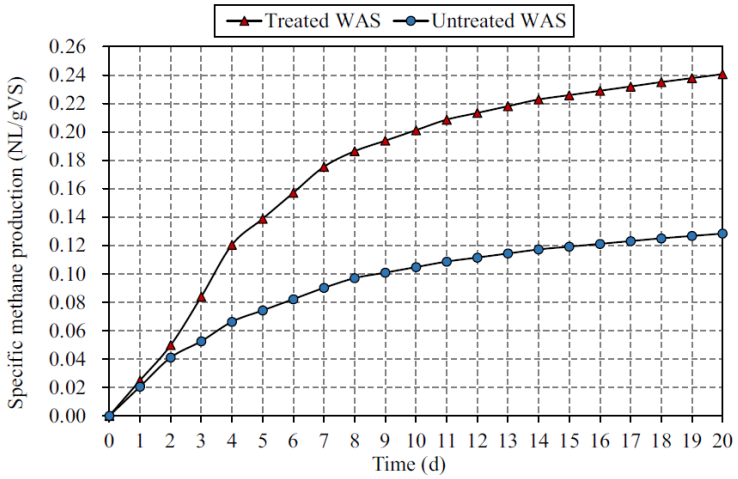
Mass balance
- → Biogas/biomethane production
- → GHG losses from AD process
- → GHG losses from upgrading process

Energy balance
- → Biomethane energy content & useful energy
- → Cradle-to-grave energy accounting
- → Plant energy auto-consumption

Emission balance
- → Cradle-to-grave emissions of the process
- → Emission avoidance due to fossil fuel replacement

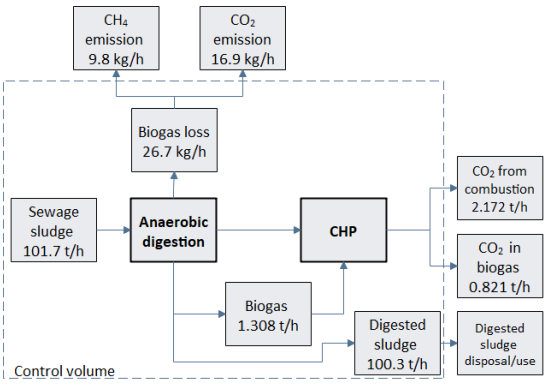
WAS pre-treatment tests and results

- Raw and treated WAS were digested in mesophilic conditions (38 °C) in 6 L batch reactors.
- The biogas produced was collected in 5 L Tedlar bags
- Test lasted 20 days
- Results showed that the thermo-alkali treatment determined an increase in SBP and SMP of 46.2% and 86.1%, respectively

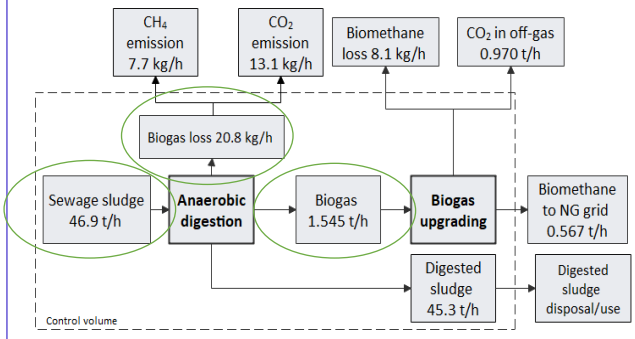


Full process simulation - Mass balance

Present situation

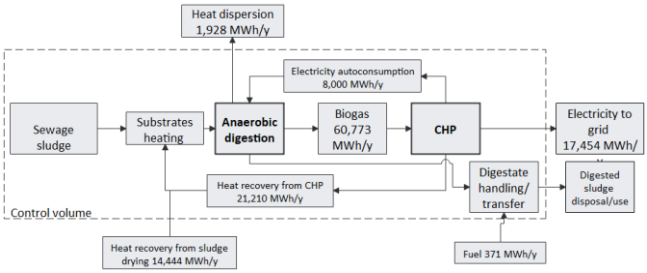


Optimized configuration

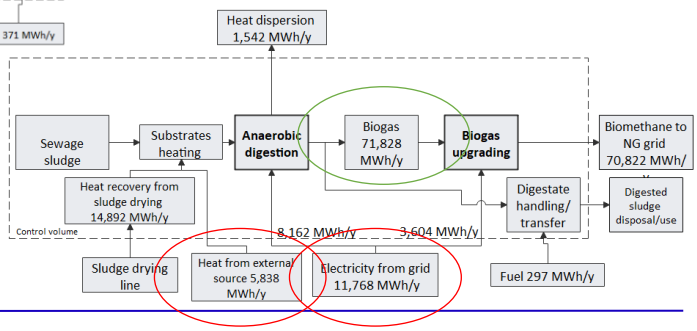


Full process simulation - Energy balance

Present situation



Optimized configuration



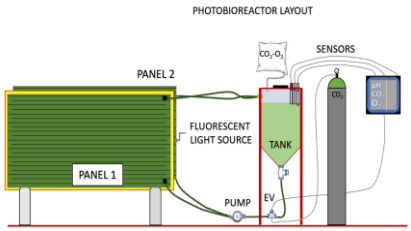
Full process simulation - Greenhouse gas balance

Input parameter/value	Present		Alternative		Difference
	t $CO2_{eq}$/y	t $CO2_{eq}$/m^3 biogas y	t $CO2_{eq}$/y	t $CO2_{eq}$/m^3 biogas y	
Total CH_4 loss from the process	2,437	0.213	3,883	0.287	+34%
Total CO_2 loss from the process	147	0.013	115	0.008	-39%
Net electricity production	-5,883	-0.514	-	-	-
Biomethane replacing natural gas	-	-	-14,594	-1.078	-
Thermal energy auto-consumption covered by external source	-	-	1,203	0.089	+100%
Electricity auto-consumption covered by external source	-	-	3,967	0.293	+100%
Energy consumption for digestate handling/transfer	117	0.010	93	0.007	-30%
Produced GHG emissions	**2,701**	**0.236**	**9,261**	**0.684**	**+180%**
Avoided GHG emissions	**-5,883**	**-0.514**	**-14,594**	**-1.078**	**-109%**
GHG emission balance	**-3,182**	**-0.278**	**-5,333**	**-0.394**	**-41%**

Conclusion

→ Optimization would provide important positive impacts on the overall energy and mass balance of the WWTP sludge line:

1. the installation of a dynamic thickener would allow a **reduction of the sludge volume** entering into the digestion process. Consequently, the thermal energy auto-consumed in the digestion stage would be lower than the present.
2. biogas **production would be around 20% higher** than the methane fraction contained in the biogas actually produced.
3. energy saving and the increased specific biomethane production would **improve the overall GHG balance** of the system



Next steps:

→ Further tests and implementation at the field scale

→ Integration of a microalgae photo-bioreactor for CO_2 capture

Thank you

marco.ravina@polito.it