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Original

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

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Castiglione Torinese WWTP





Castiglione Torinese WWTP



Post-thickening
/ dewatering

Anaerobic
digestion

Pre-thickening

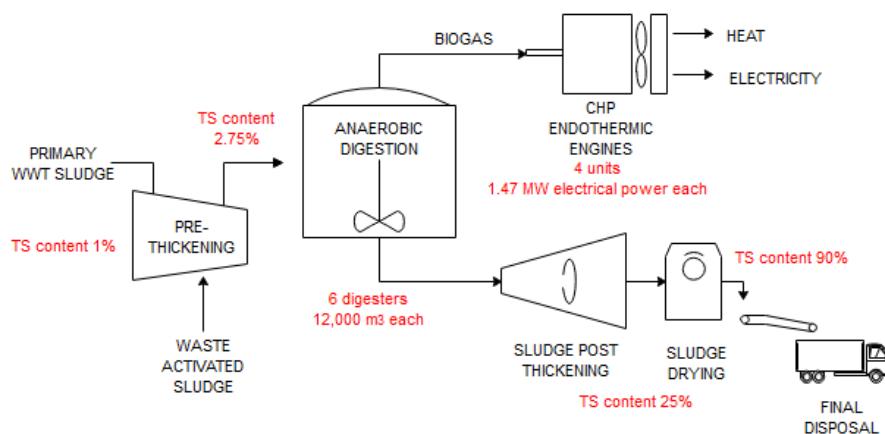
Objective: Sludge treatment and anaerobic digestion stage optimization

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.

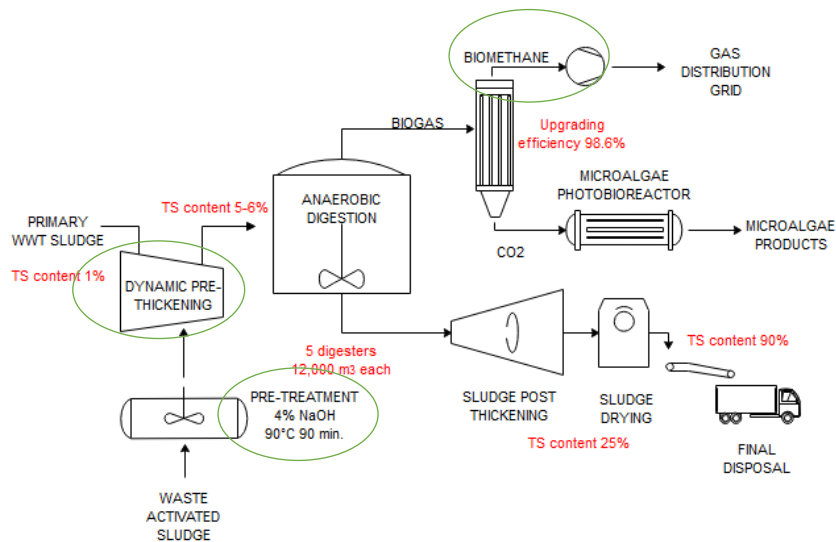


Present process





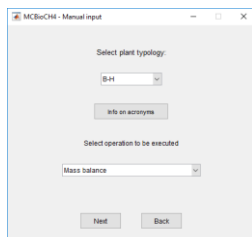
Optimized process simulation



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

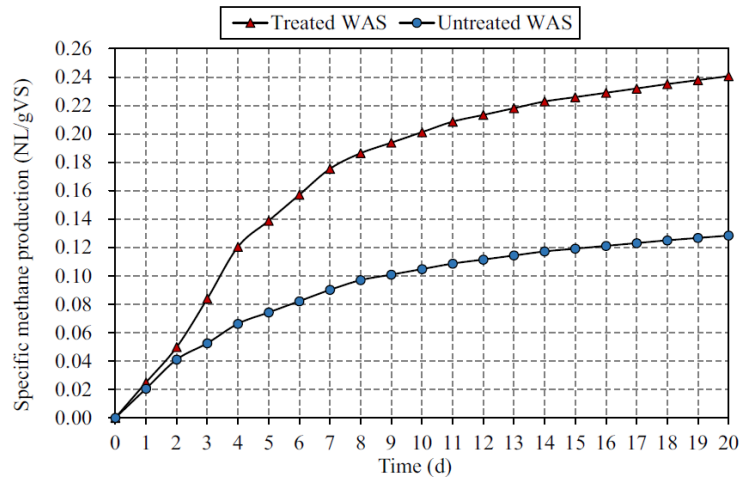
- Cradle-to-grave emissions of the process
- Emission avoidance due to fossil fuel replacement



WAS pre-treatment tests and results



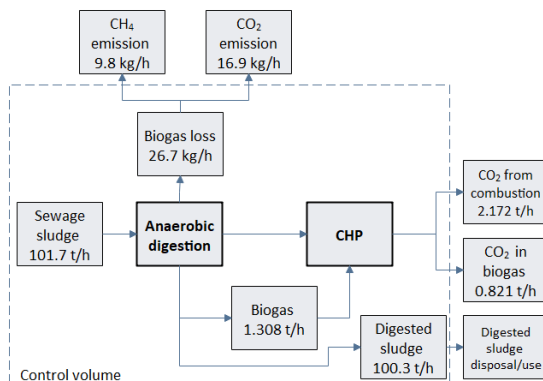
- Raw and treated WAS were digested in mesophilic conditions (38 °C) in 6 L batch reactors.
- The biogas produced was collected in 5 L Tedlar bags
- Test lasted 20 days
- Results showed that the thermo-alkali treatment determined an increase in SBP and SMP of 46.2% and 86.1%, respectively



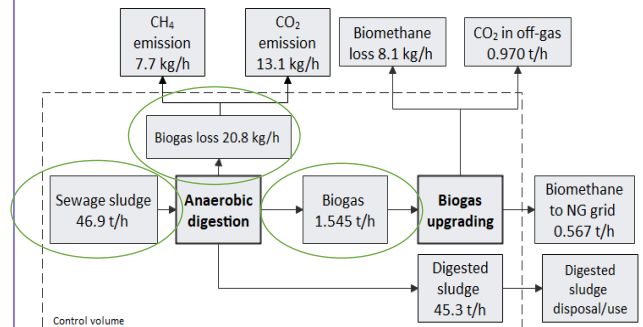
Full process simulation - Mass balance



Present situation



Optimized configuration

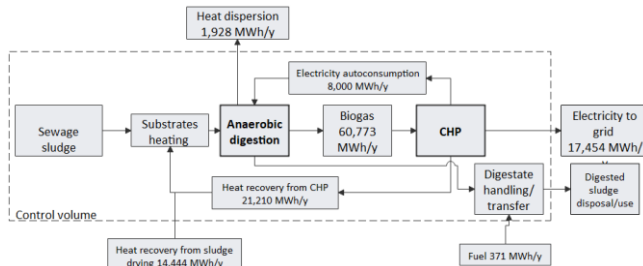




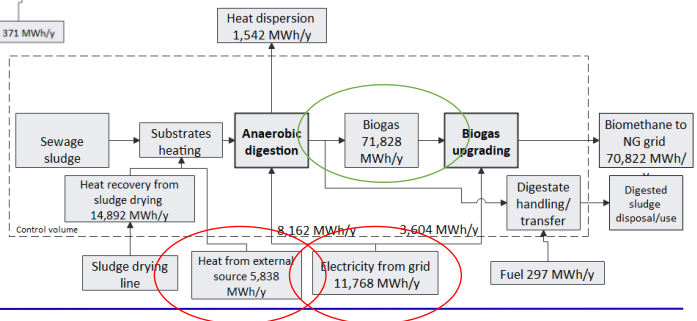
Full process simulation - Energy balance



Present situation



Optimized configuration



Full process simulation - Greenhouse gas balance



Input parameter/value	Present		Alternative		Difference
	t CO ₂ _{eq} /y	t CO ₂ _{eq} /m ³ biogas y	t CO ₂ _{eq} /y	t CO ₂ _{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



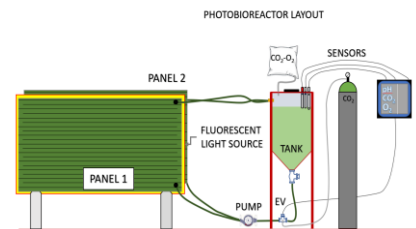
→ Optimization would provide important positive impacts on the overall energy and mass balance of the WWTP sludge line:

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 CO₂ capture



Thank you

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