TINOS 2015

3rd International Conference on Sustainable Solid Waste Management
2-4/07/2015 – Pyrgos Village, Tinos Island – Greece

Preliminary technical and economic analysis of alkali and thermo-alkali pretreatments for the anaerobic digestion of waste activated sludge

B. Ruffino[1], G. Campo[1], M.C. Zanetti[1], G. Genon[1],
D. Novarino[2], G. Scibilia[2], E. Lorenzi[2]

[1]DIATI, Politecnico di Torino, Italy
[2]SMAT S.p.A., Società Metropolitana Acque Torino, Italy

barbara.ruffino@polito.it; eugenio.lorenzi@smatorino.it

AIM OF THE WORK

Preliminary technical and economic assessment of alkali and hybrid thermo-alkali pretreatments at low temperature values (70°C-90°C) for the improvement of the anaerobic digestion of WAS from SMAT Plant

Municipal and industrial wastewater

Capacity: 2,000,000 E.I. (1.5M civil inhabitants, 800 industrial plants)

Average flow rate: 25,000 m^3/h

Average sludge production: 300 – 350 m^3/h (1% TS)

PRETREATMENTS: Operative Parameters

WAS
0.8% TS

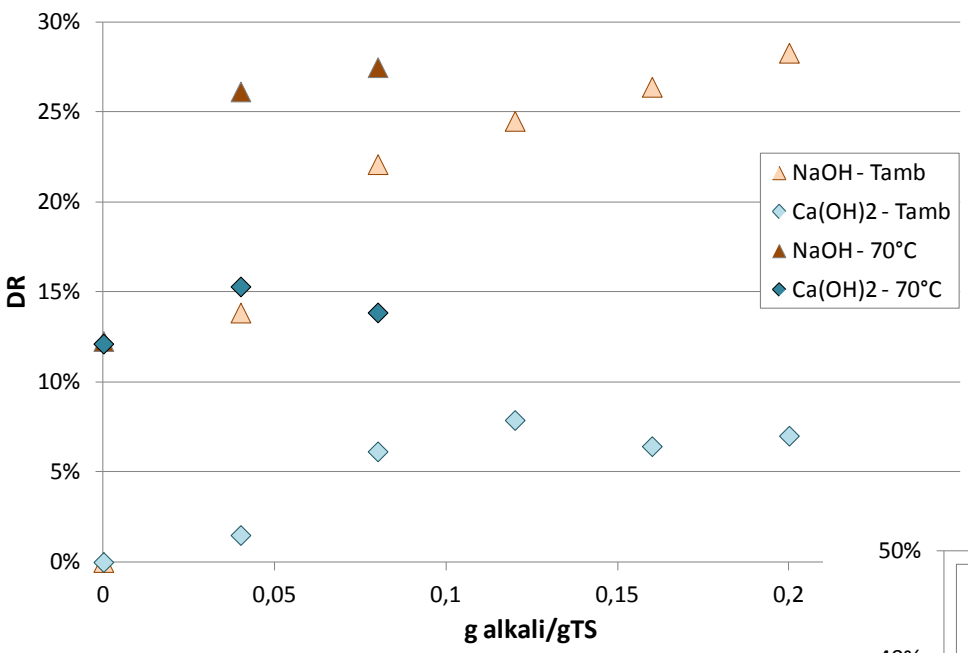
Thickening

WAS
5-6% TS

Alkali or hybrid
thermo-alkali
pretreatment

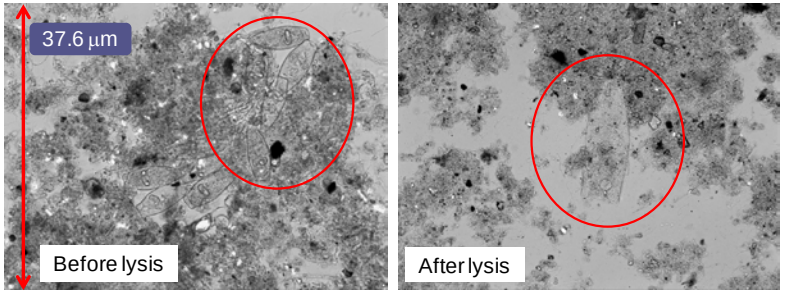
Series	Reagent	Dose g alkali/100 g TS	T (°C)	Contact time (min)
I	NaOH	4-20	Room	90
II	$Ca(OH)_2$	4-20	Room	90
III	NaOH	4-8	70	90
IV	$Ca(OH)_2$	4-8	70	90
V	NaOH	4	Room-70-90	180

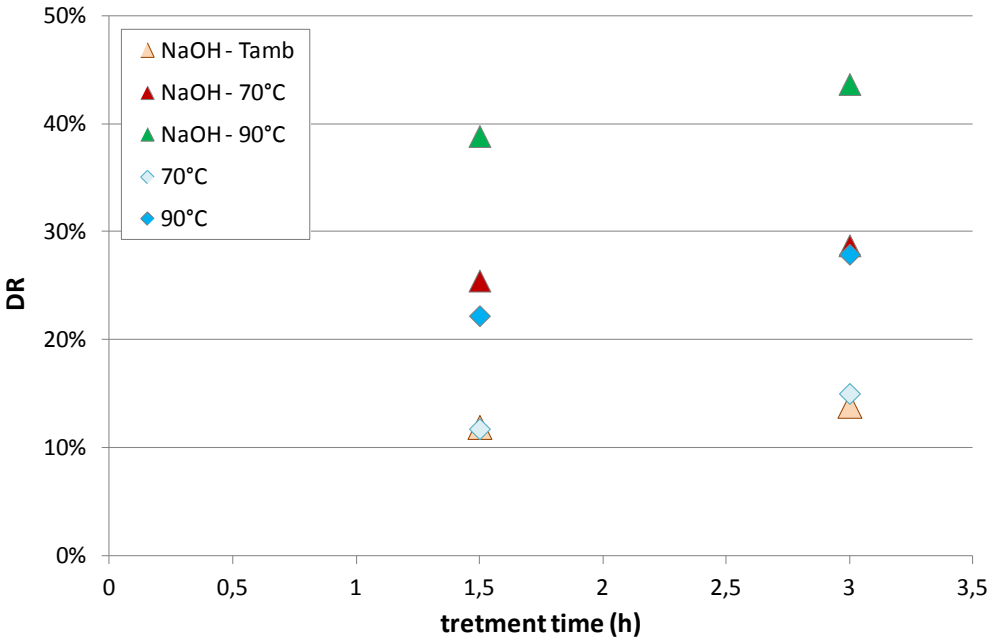
RESULTS – Pretreatments series I-V - DR



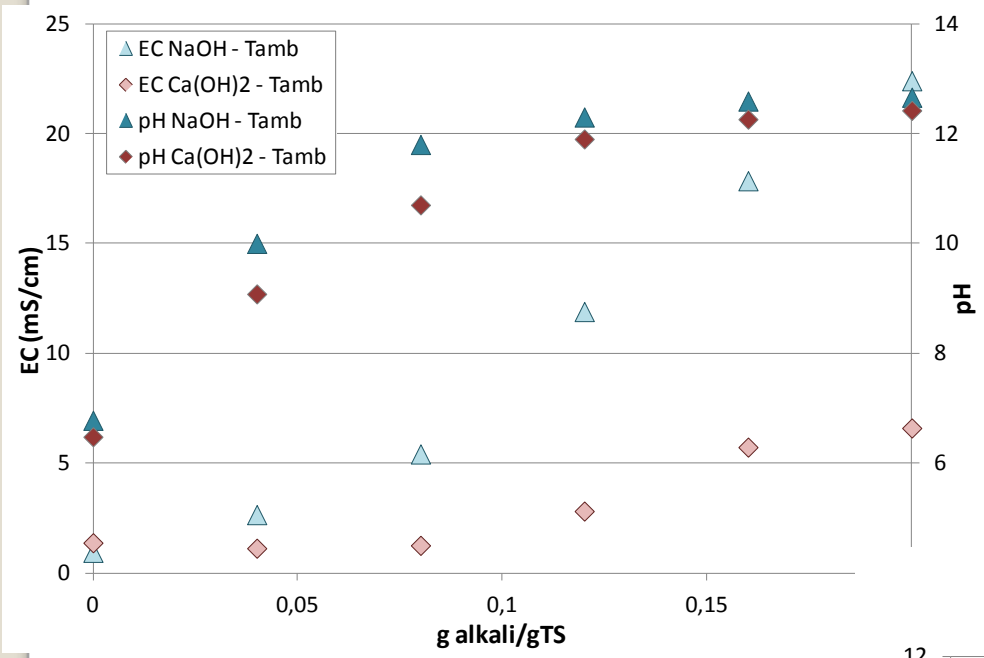
Disintegration Rate (DR)

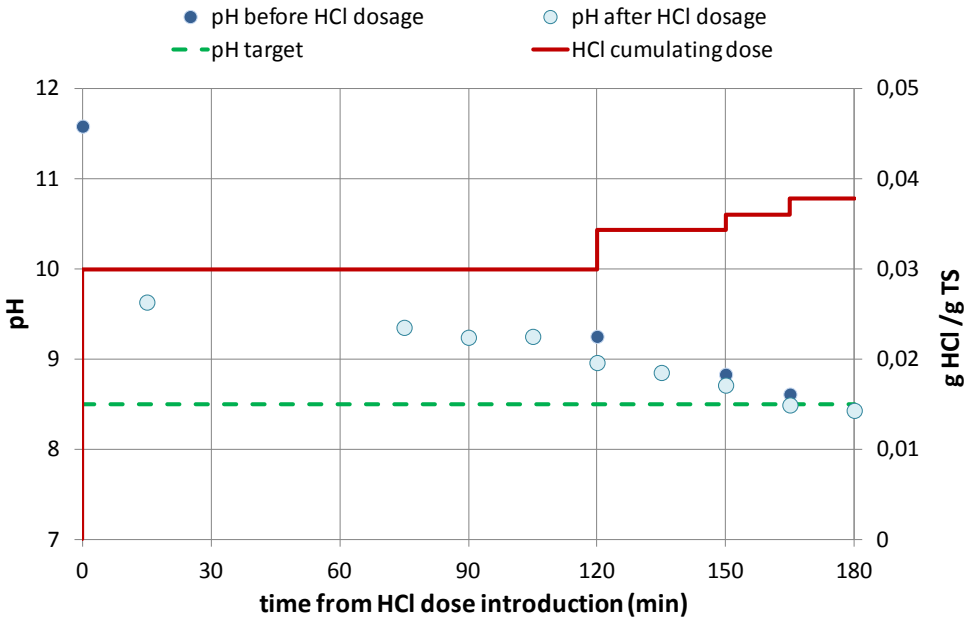
$$\frac{SCOD_{lys} - SCOD_0}{COD_{tot} - SCOD_0} \cdot 100\%$$





RESULTS – Pretreatments series I-II – EC, pH





Experimental Setup for Digestibility Tests

SERIES 1: NaOH, 0.08 g/gTS, t = 90 min, final pH 7.5 and 8.5

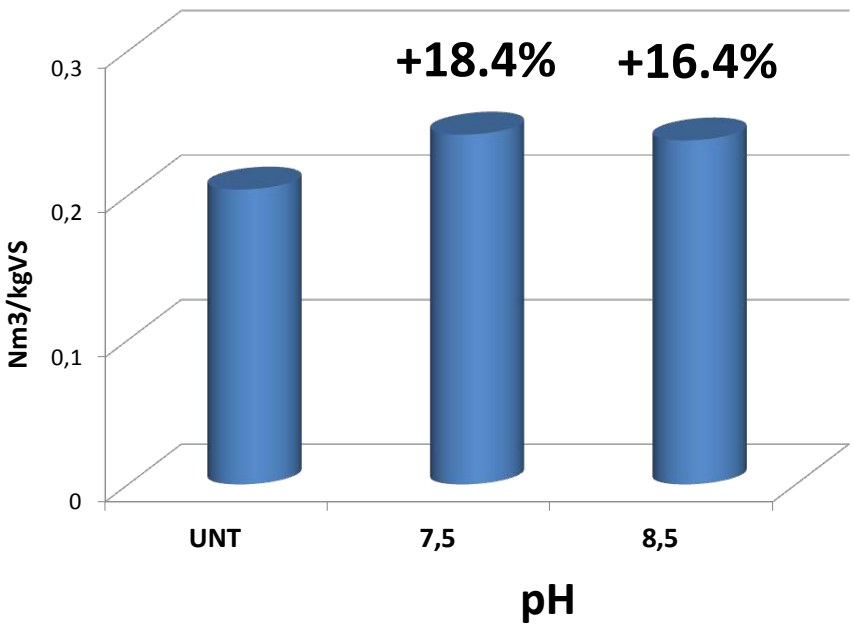
SERIES 2: NaOH, 0.04 g/gTS, t = 90 min, T = 20 and 70°C, final pH 8.5

Operative conditions:

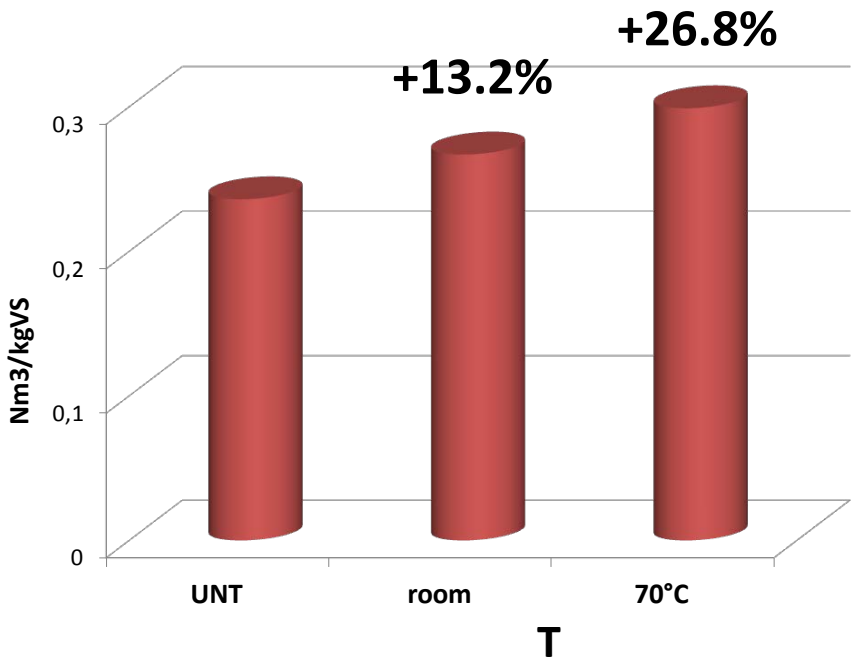
- 6-L poly methyl methacrylate (PMMA) digesters
- Batch mode
- Mesophilic conditions (35°C)

RESULTS – Digestibility tests

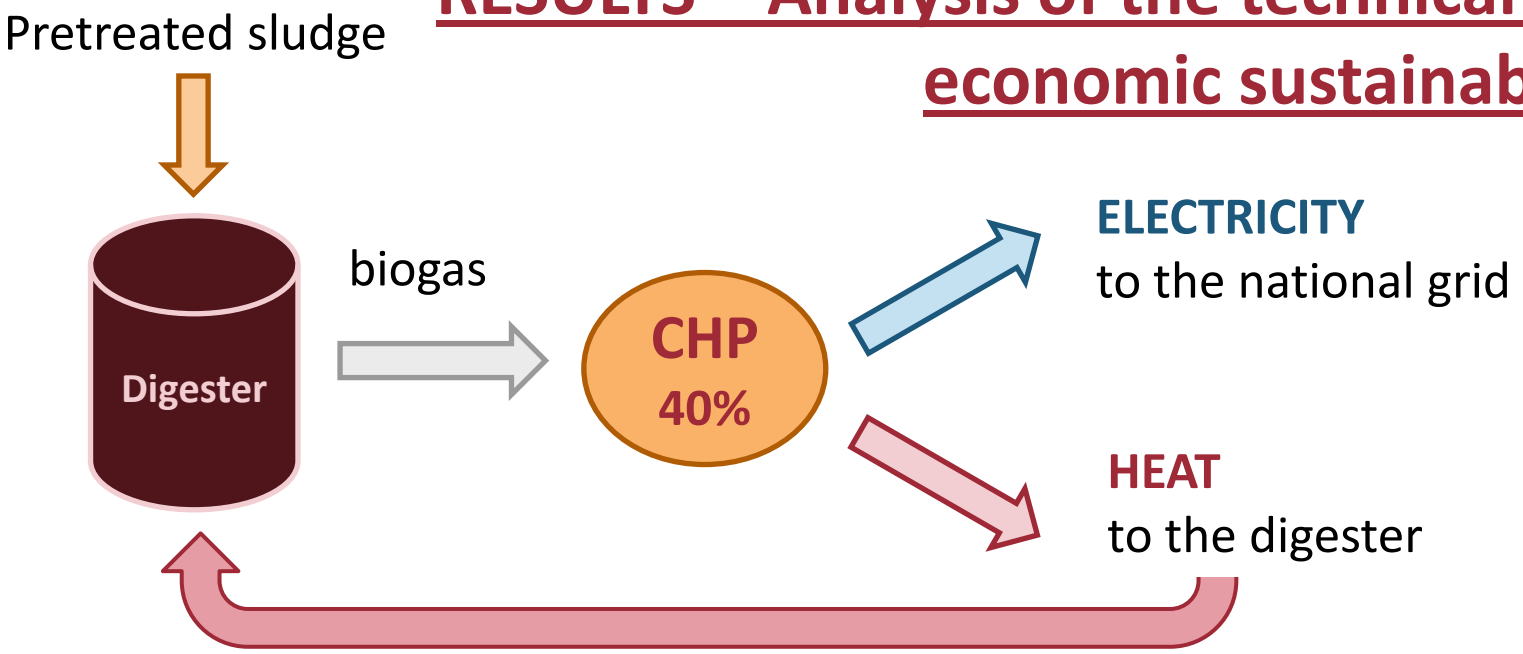
SERIES 1



SERIES 2



RESULTS – Analysis of the technical and economic sustainability



Methane LHV (kJ/Nm^3)	35,880	
Methane LHV (kWh/Nm^3)	9.97	
	Electrical energy	**Thermal energy**
CHP efficiency (kWh/kWhCH_4)	0.4	0.4
Energy from one Nm$^3CH_4$ (kWh/Nm$^3CH_4$)	3.99	3.99
Total electrical energy price (base + public subsidy, €/kWhe)	0.222	-
Economic value of energy from methane (€/Nm^3)	0.885	0.170

RESULTS – Analysis of the technical and economic sustainability

Scenario		1	2	3	4
Target pH before AD		7.5	8.5	8.5	8.5
Pretreatment temperature	°C	20	20	20	70
Alkaline pretreatment, NaOH dose	g/gTS	0.08	0.08	0.04	0.04
pH resulting from alkali pretreatment		11.6	11.6	10.1	9.17
Acid treatment, HCl dose (experimental)	g/gTS	0.0473	0.0378	0.0146	0.0067
Cost of the alkaline pretreatment	€/kg TS	0.024	0.024	0.012	0.012
Cost of the acid treatment	€/kg TS	0.028	0.023	0.009	0.004
Total cost of the pretreatment (TS basis)	€/kg TS	0.052	0.047	0.021	0.016
Total cost of the pretreatment (VS basis)	€/kg VS	0.074	0.066	0.029	0.022
Increase in CH_4 yield - experimental	**%**	**18.4**	**16.4**	**13.2**	**26.8**
Economic value of the electricity increment	€/kg VS	0.024	0.021	0.019	0.042
Economic value of the thermal energy increment	€/kg VS	0.005	0.004	0.004	0.008
Economic value of the total energy increment	€/kg VS	0.029	0.025	0.023	0.051
Increase in CH_4 yield – target – electricity only	**%**	**68.2**	**60.8**	**22.8**	**17.6**
Increase in CH_4 yield – target	**%**	**57.0**	**50.8**	**19.0**	**14.7**

CONCLUSIONS

This work investigated the technical and economic feasibility of alkali and hybrid thermo-alkali pretreatments for the improvement of WAS anaerobic digestion in the largest WWTP in Italy.

Here a list of the main outcomes that came from the experimentation:

- the comparison between NaOH and $Ca(OH)_2$ revealed that NaOH was a more performing chemical in sludge disintegration and COD liberation;
- NaOH showed good performances already at low doses (0.08 gNaOH/g TS) with DR values in the order of 20%;
- the thermal effect improved the alkali performance. DR values (for an alkali dose of 0.04 g NaOH/g TS) doubled if the temperature value raised from 20 to 70°C, and increased of approximately four times if temperature raised to 90°C;
- biogas yield increased of 13.2% and 26.8% when WAS samples were treated respectively at room temperature and 70°C with 0.04 gNaOH/g TS for 90 minutes.

CONCLUSIONS

However, until nowadays several economic issues (mainly related to **alkali and acid costs**) have limited the real-world applications of alkali and hybrid WAS pretreatments.

The preliminary economic analysis performed in this work demonstrated that **only an increase in the methane yield in the order of 60% could offset the cost of reagents for alkali pretreatments and pH conditioning**.

On the other hand, if the alkali effect is **coupled to heat** (and lower alkali and acid doses are required to obtain the same final effect), **increases in the methane yields in the order of 15-20% were sufficient (*)**.

Consequently, the system described in the scenario 4 was economically sustainable.

(*) Ruffino B., Campo G., Genon G., Lorenzi E., Novarino D., Scibilia G., Zanetti M.C. (2015), **Bioresource Technology**, 175, 298-308, ISSN: 0960-8524, Elsevier. DOI: 10.1016/j.biortech.2014.10.071.

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Thank you for your attention!

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