Two-phase anaerobic co-digestion of organic waste and activated sludge:

bench study & implementation potential in energy and material (VFA) recovery

F. Micolucci*, C. Da Ros, A. Mattioli*, C. Cavinato** and P. Pavan****

* Department of Biotechnology, University of Verona, Strada Le Grazie 15, I-37134 Verona, Italy (E-mail: *federico.micolucci@univr.it*)
** Department of Environmental Sciences, Informatic and Statistics, University Ca' Foscari of Venice, Via Cesare Pavese 18, 31100 Treviso, Italy

BACKGROUND

➤The *two-phase anaerobic digestion approach* physically divides into 2 steps the biogas producing process:

1. **dark fermentation** → **Bio-hydrogen (H_2)**
2. **methanogenesis** → **Bio-methane (CH_4)**

Bio-hydrogen + Bio-methane → ***BioHythane***

50-55% CH_4, 5-10% H_2 & 35-40% CO_2

BioHythane allows a better combustion with reduced greenhouse gasses emissions compared with fossil fuels.

➤ Process stability = pH 5.5 → Controlled by **co-digestion** of biowaste & waste activated sludge (WAS)

➤ Dark fermentation produces a **low chain carbon** rich stream to enhance denitrification kinetics in WWTP

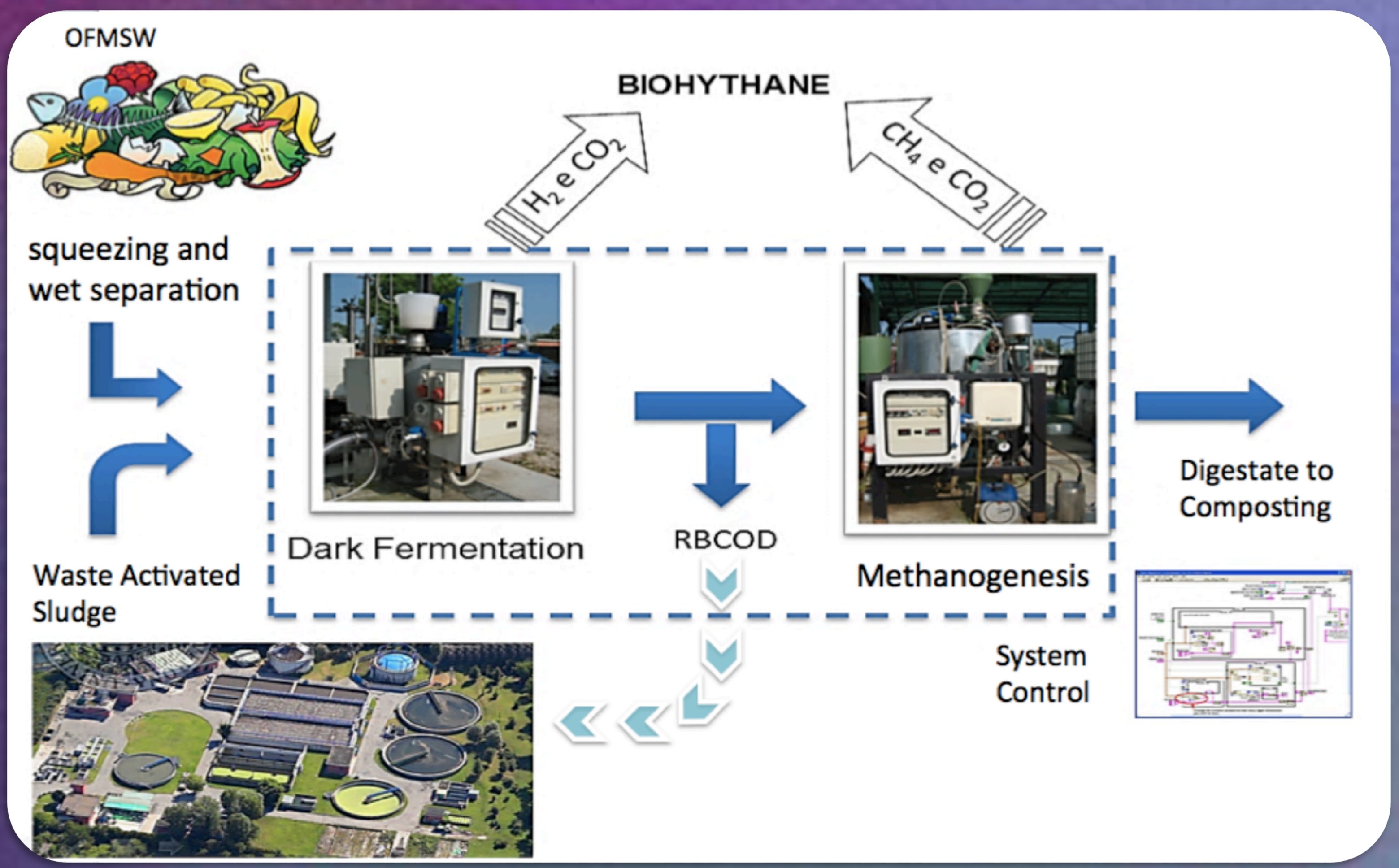

Figure 1. Scheme of process

THE GOAL

Integrate waste and wastewater cycles:
Experimental results are used to evaluate the benefits coming from the implementation of this technology in a full scale WWTP, using as model a real plant located in north Italy (70.000 PE basin).

MATERIAL AND METHODS

Two laboratory-scale CSTR. Experiment length 70 d.
The substrate employed in this study was a mix of BIOWASTE & WAS. The volume ratio BIOWASTE:WAS was 1:5 v/v. Reactor effluents were monitored daily & analyses performed according to APHA (1995).

Table 1. Operational conditions

		Dark fermentation	Methanogenesis
HRT	d	3	16
OLR	kgTVS/m^{3}d	16	3
Temperature	°C	55	55
Reactor volume	L	3.5	18.5

RESULTS AND DISCUSSION

➤ **Process performances and yields are summarized in Table 2.**
➤ **rbCOD RECOVERY FOR BIOLOGICAL NUTRIENT REMOVAL**

Application scenario in Treviso WWTP by **Upscaling** of the studied process → the RBCOD needed to the N removal is given by the cycle integration

the complete mass balance of the whole approach in Figure 2.

Table 2. Effluents characteristics and specific yields

Parameters	Units	Dark fermentation	Methanogenesis
TS	g/kg	48±5	25±4
TVS	g/kg	37±4	16±2
COD	g/kg TS	40±3	19±2
TKN	g/kg TS	34±1	35±1
Ptot	g/kg TS	11±0	19±1
pH		5.09±0.08	7.97±0.26
Partial Alkalinity (pH = 5.7)	mgCaCO$_3$/l	NP	3328±165
Total Alkalinity (pH = 4.3)	mgCaCO$_3$/l	1210±180	4409±16
NH_4^+ – N	mgN–NH_4^+/l	268±48	949±48
Tot VFA	gCOD/l	15.8±1.4	0.5±0.5
Yields			
SHP	l H_2/kg TVS	29±5	np
SMP	l CH_4/kg TVS	np	287±36

The hydrogen production is **156.2 m^{3}H$_2$/d**
→ treating whole available sludge and 13.1 t/d of biowaste

First phase effluent with VFA 15.8 gCOD/l:

➤ **62 m^3/d** to BNR → COD required to denitrify the water entering in the plant is 1038 kg/d

➤ **864 m^3/d**, is channeled to the methanogenic reactor → Methane production of 1032.6 m^3/d

The system is able to support a complete denitrification in WWTP using less than the 15.2 % of the total carbon which is produced by the first phase reactor. Total production of 1921 m^3/d of Biohythane with an average % composition of 54/8/38 as CH_4/H_2/CO_2 respectively.

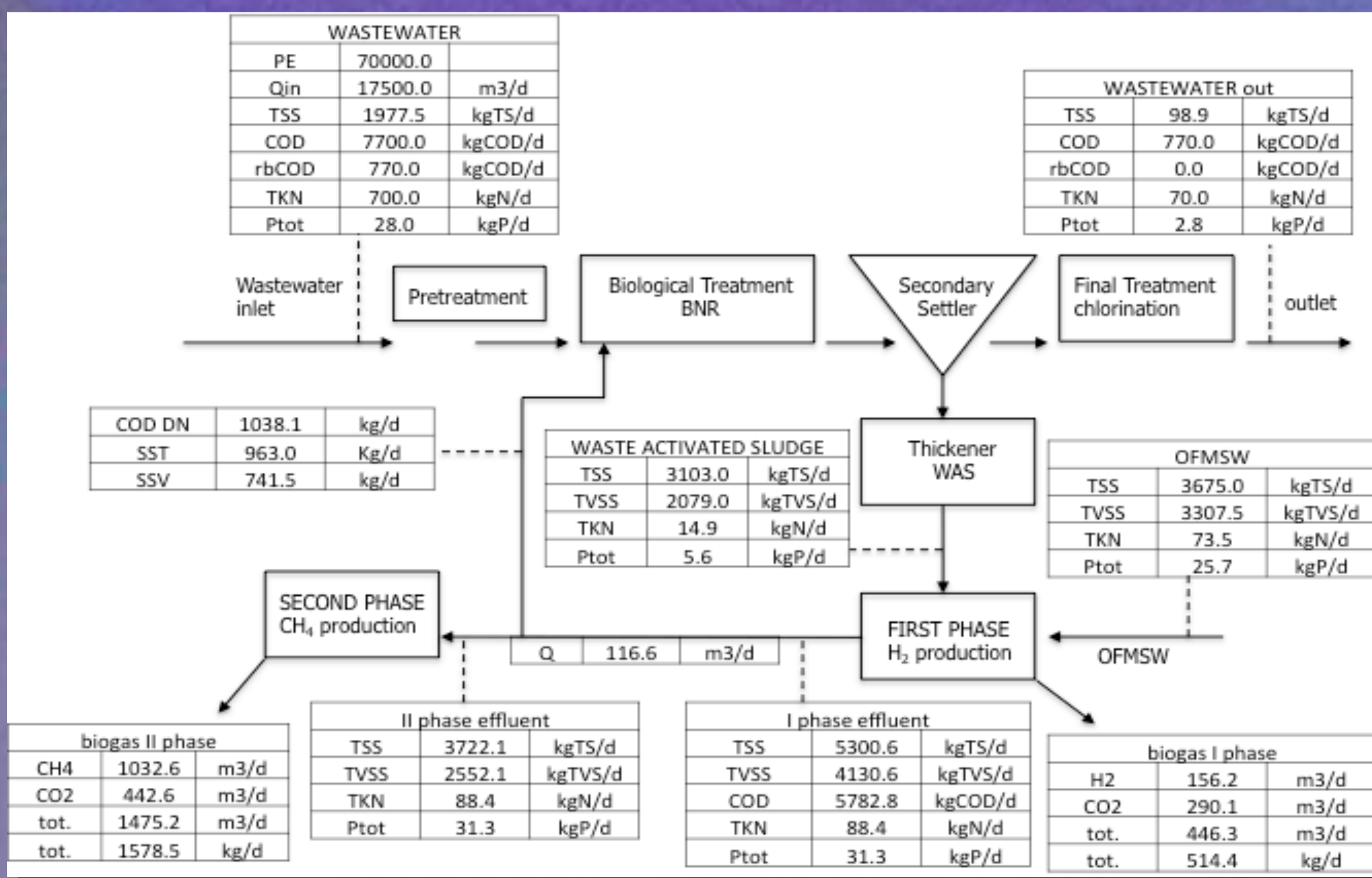

Figure 2. Complete mass balance of upscaling

CONCLUSIONS

The integrated approach has considerable advantages in the field of the 'smart' opportunities for the urban services management.
On a 70.000 PE basis

➤ **H_2 production of 156.2 m^3/d** & **CH_4 of 1032.6 m^3/d** ;
➤ Reduction of CO_2 emissions
➤ Total wastewater denitrification is reached through yield of 426 gVFA/kgTVS$_{fed}$(first-phase), which leads to a specific denitrification rate of 5.5 kgN/kgMLVSS h.
➤ External chemicals for denitrification are not utilized

The hospitality of Treviso City Council & ATS, alto trevigiano servizi srl, are gratefully acknowledged

REFERENCES

Bolzonella, D., Battistoni, P., Susini, C., Cecchi, F., (2006). Anaerobic codigestion of waste activated sludge and OFMSW: the experiences of Viareggio and Treviso plants (Italy). Wat. Sci. Technol., 53(8), 203–211.
De la Rubia, M.A., Raposo, F., Rincón, B., Borja, R., (2009). Evaluation of the hydrolytic–acidogenic step of a two-stage mesophilic anaerobic digestion process of sunflower oil cake. Bioresour. Technol. 100, 4133–4138.