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Co-digestion of *Condensate* Produced from drying of Household Food Waste and *Landfill Leachate* for methane production through Anaerobic Digestion

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Municipal Solid Waste Management Scheme in Greece

Innovative Approach for FMSW valorization Waste4Think (Horizon2020)

30L bins

120L bins

Separate Collection

Drying/Shredding

Food Residue Biomass (FORBI)

WASTE 4think

Advantages of FORBI

- Has 1/4 to 1/5 the weight of biowaste, implying reduced transportation costs
- Has low-moisture and may be stored for prolonged periods of time without deterioration
- Is homogeneous
- Does not emit odors
- May be used for producing fuels, energy and other products

FORBI Valorization

1. Gaseous Biofuels (Methane, Hydrogen, Hythane)
2. Liquid Biofuels (Bioethanol)
3. Compost
4. Solid biofuels (pellets)
5. AF for the cement industry
6. Direct production of Electricity (microbial fuel cell technology)
7. Adsorbent
8. Animal Feed

HIGH TRL

Biogas

Alternative Fuel for Cement Industry

Compost enhancer

Dryer (92-98^{0}C)/shredder

Solid Fraction of FMSW, ***FORBI***

Resource and Energy Recovery

Liquid Fraction of FMSW, ***Condensate***

Liquid Fraction of FMSW (Condensate)

Table 1 Typical Characteristics of Condensate

Parameter	
pH	3.5-4.5
COD (mg O_2/L)	13200 ± 2577
TOC (mg /L)	4344 ± 679
Acetic Acid (mg/L)	1340 ± 643
Lactic Acid (mg/L)	41.9 ± 39.3
Ethanol (mg/L)	3328 ± 1629
Total Nitrogen (mg/L)	12.8 ± 6.9

- ✓ **Depending on the drying conditions, the storage time before drying and the feedstock, the exact characteristics may vary, but in general the condensate will have:**
  - ✓ **High Organic Load**
  - ✓ **Low Concentration of Nitrogen**

Alternative Management Possibilities of Condensate

- It may be dumped to the sewer without a sensible impact on the wastewater treatment
- It could be digested anaerobically, but it would require nitrogen addition
- It could be co-digested effectively along with another stream, which contains high nitrogen but low COD content.

Table 2 Characteristics of Landfill Leachate depending on the age of the landfill

Parameter (mg/L)	Landfill Leachate (<2 y)		Landfill Leachate (>2y)
	Range	Typical	
BOD_5	2000-30000	10000	100-200
TOC	1500-20000	6000	80-160
COD	3000-60000	18000	100-500
TSS	200-2000	500	100-400
Organic Nitrogen	10-800	200	80-120
NH_4^+-N	10-800	200	20-40
NO_3^-	5-40	25	5-10
Total P	5-100	30	5-10
Alkalinity	1000-10000	3000	200-1000
pH	4.5-7.5	6	>7.5
Hardness	300-10000	3500	200-500
Ca	200-3000	1000	100-400
Mg	50-1500	250	50-200
K	200-1000	300	50-400
Na	200-2500	500	100-200
Cl^-	200-3000	500	100-400
SO_4^{2-}	50-1000	300	20-150

Landfill Leachate

Landfill Leachate → a liquid that is produced from the degradation of the organic fraction of the wastes in the landfill, in combination with the percolating rain water.

- Causes significant threat to surface water and groundwater.
- Low Concentration of Carbon, when the landfill is older than 2y

The aim of the study:

To evaluate the possibility of co-digesting condensate and landfill leachate.

Condensate (C source) + Landfill leachate (N source)

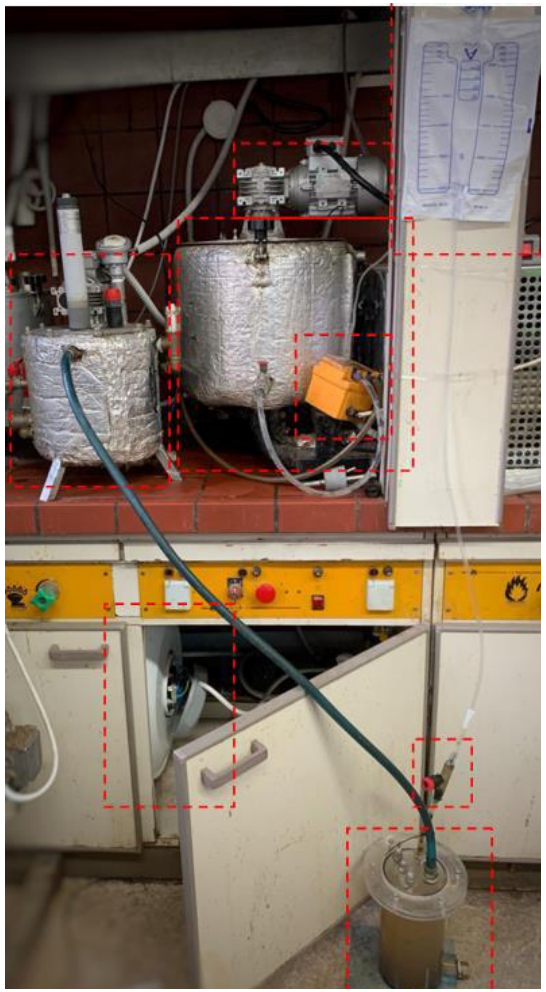
A 4L digester of the CSTR type was used.

Start Up :

3L of anaerobic sludge obtained from the mesophilic anaerobic digester of the Wastewater Treatment Plant of Metamorphosi, Attica, Greece and 1L of glucose solution, 1 g/L.

→ Hydraulic retention time (HRT): 20 days
→ Mesophilic Conditions: 35 ^{0}C
→ 3 Experimental Phases:

- 1st Experimental Phase: Glucose based solution
- 2nd Experimental Phase : Synthetic Condensate and synthetic landfill leachate
- 3rd Experimental Phase : Real Condensate and synthetic landfill leachate



Characteristics of individual waste streams

Synthetic Condensate

Parameter	
pH	3.92
Soluble COD (g O_2/L)	5
Acetic Acid (g/L)	1.26
Propionic Acid (g /L)	0.2
Butyric Acid (g /L)	0.74
Lactic Acid (mL/L)	0.19
Ethanol (mL/L)	0.61
Glucose (g /L)	0.70

Synthetic Landfill Leachate

Parameter	
pH	8.1
Soluble COD (g O_2/L)	7
Alcalinity (mg $CaCO_3$/L)	3000
Total P (mg/L)	20
Total Nitrogen (mg/L)	200

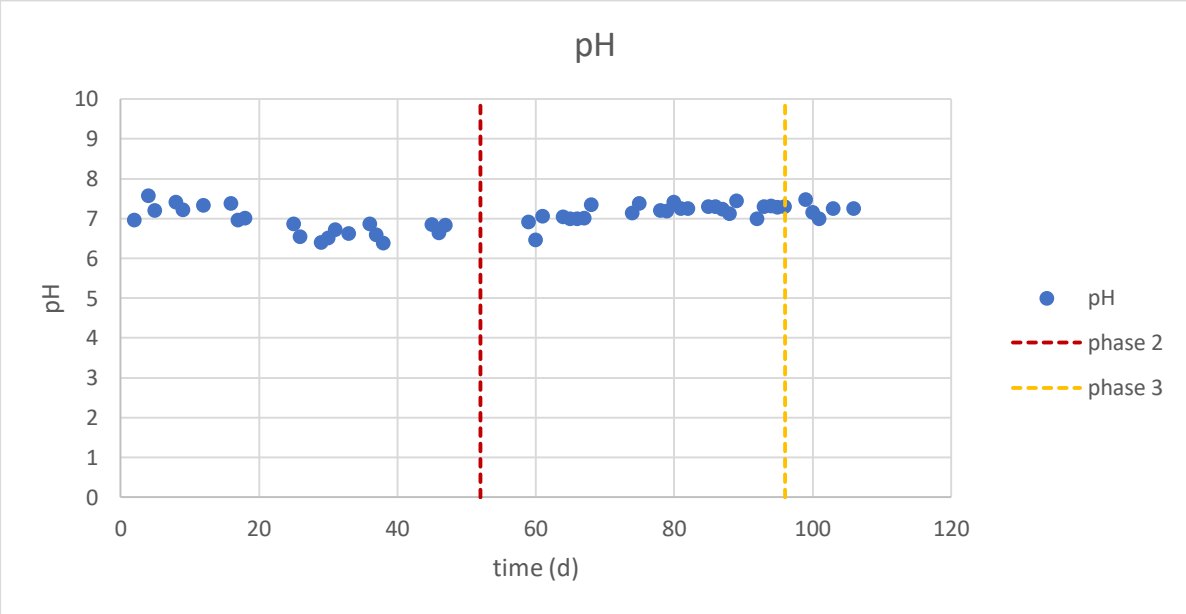
Real Condensate

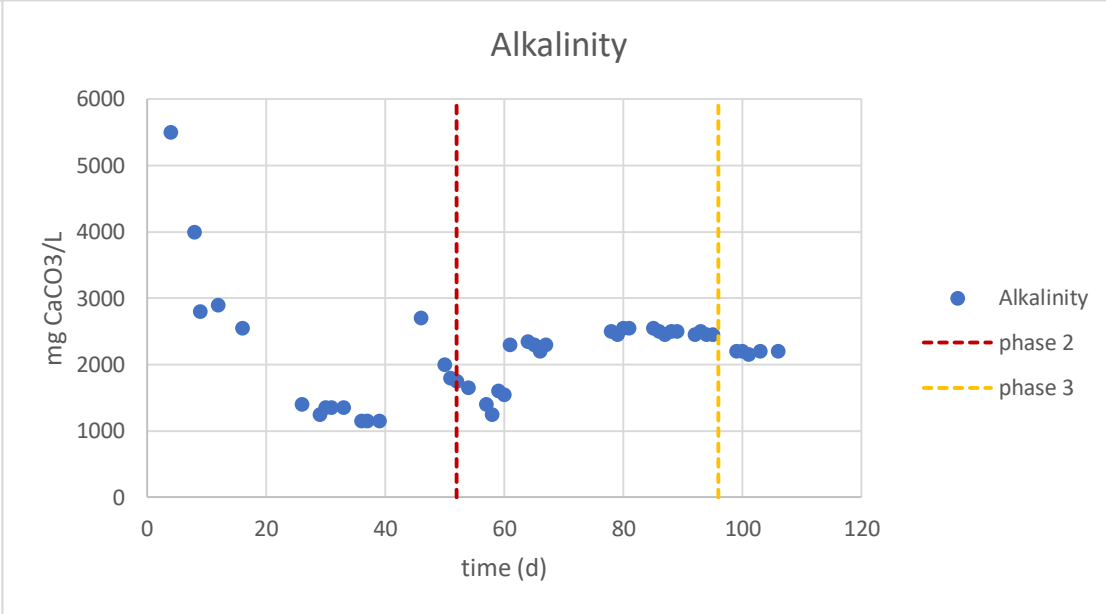
Parameter	
pH	3.68
Soluble COD (g O_2/L)	4.9
Acetic Acid (mg /L)	842
Propionic Acid (mg /L)	438
Butyric Acid (mg /L)	1546
Total Nitrogen (mg/L)	94

Feed Characteristics

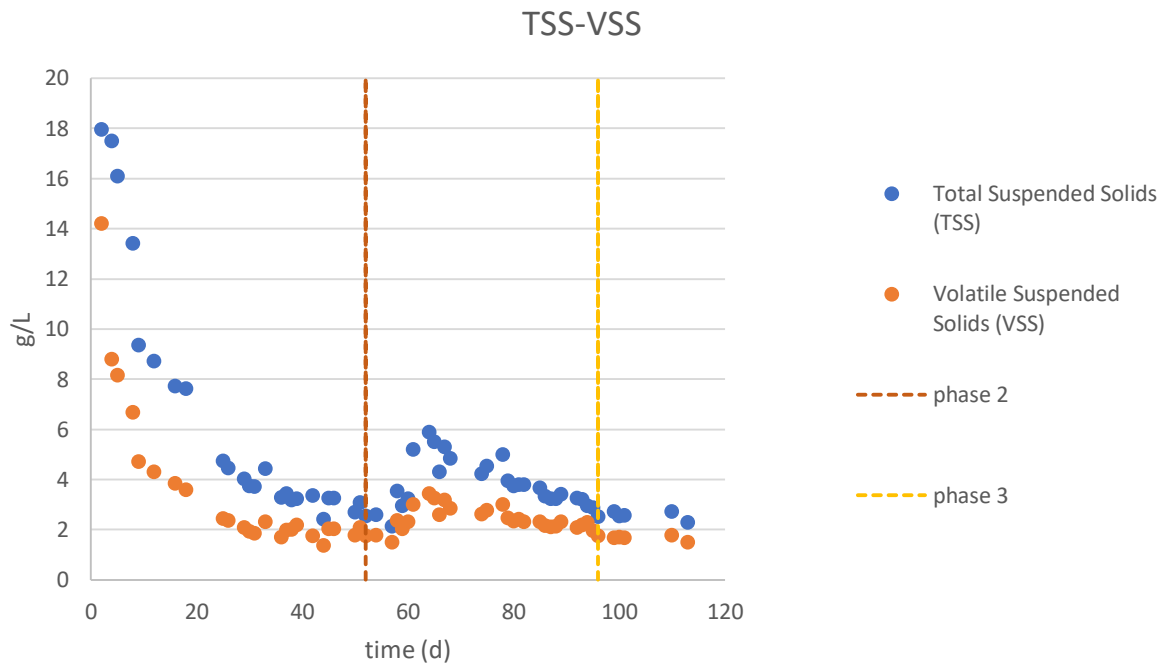
Parameter	1st Experimental Phase Glucose based Solution	2nd Experimental Phase Synthetic Condensate and Synthetic Landfill Leachate (25/75)	3rd Experimental Phase Condensate and Synthetic Landfill Leachate (25/75)
pH	7.2	5.0	4.8
Alkalinity (mg $CaCO_3$/L)	1250	2250	2400
sCOD (mg/L)	6500	6300	6200
OLR (g COD/L/d)	0.33	0.32	0.31
Total Nitrogen (g/L)	0.13	0.13	0.13

Results of the co-digestion

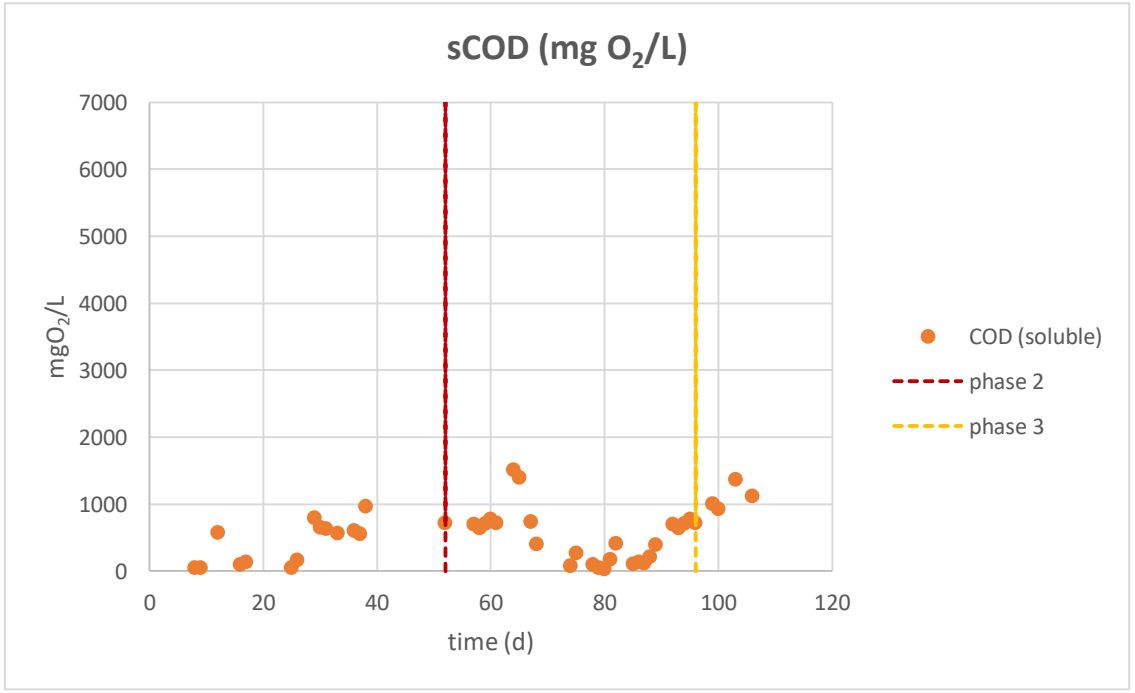


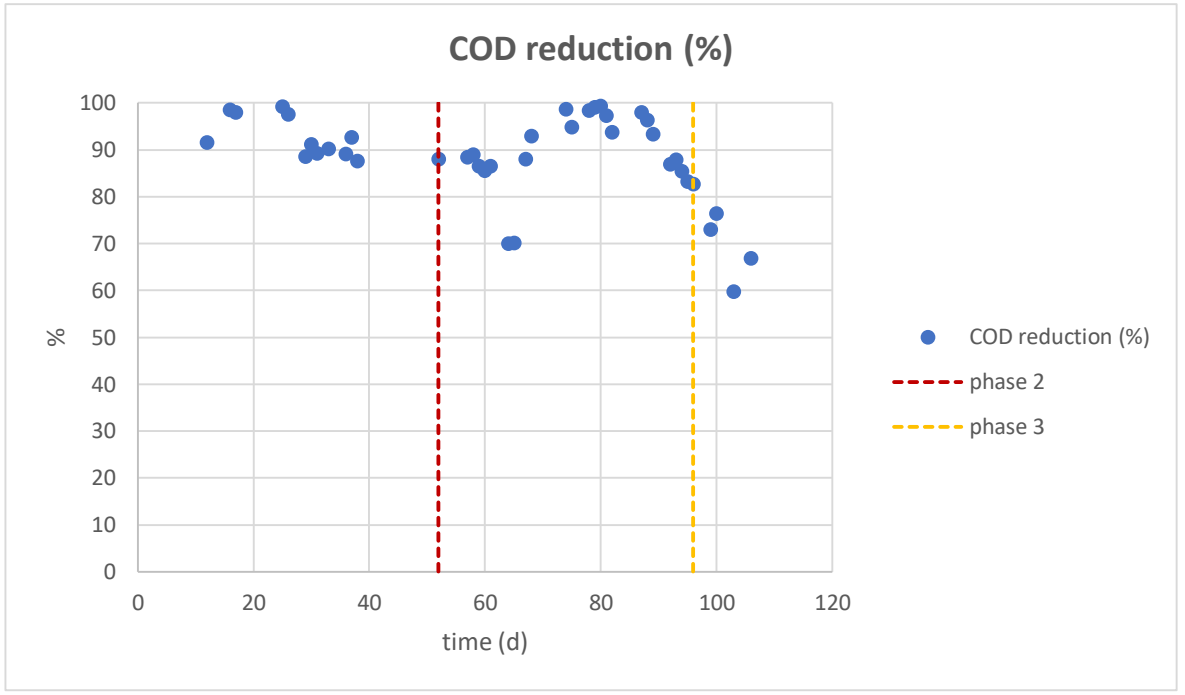


- ✓ The pH of the reactor remained steady during the operation, and around 7 which is within the optimum for anaerobic digestion
- ✓ The alkalinity was high during start up.

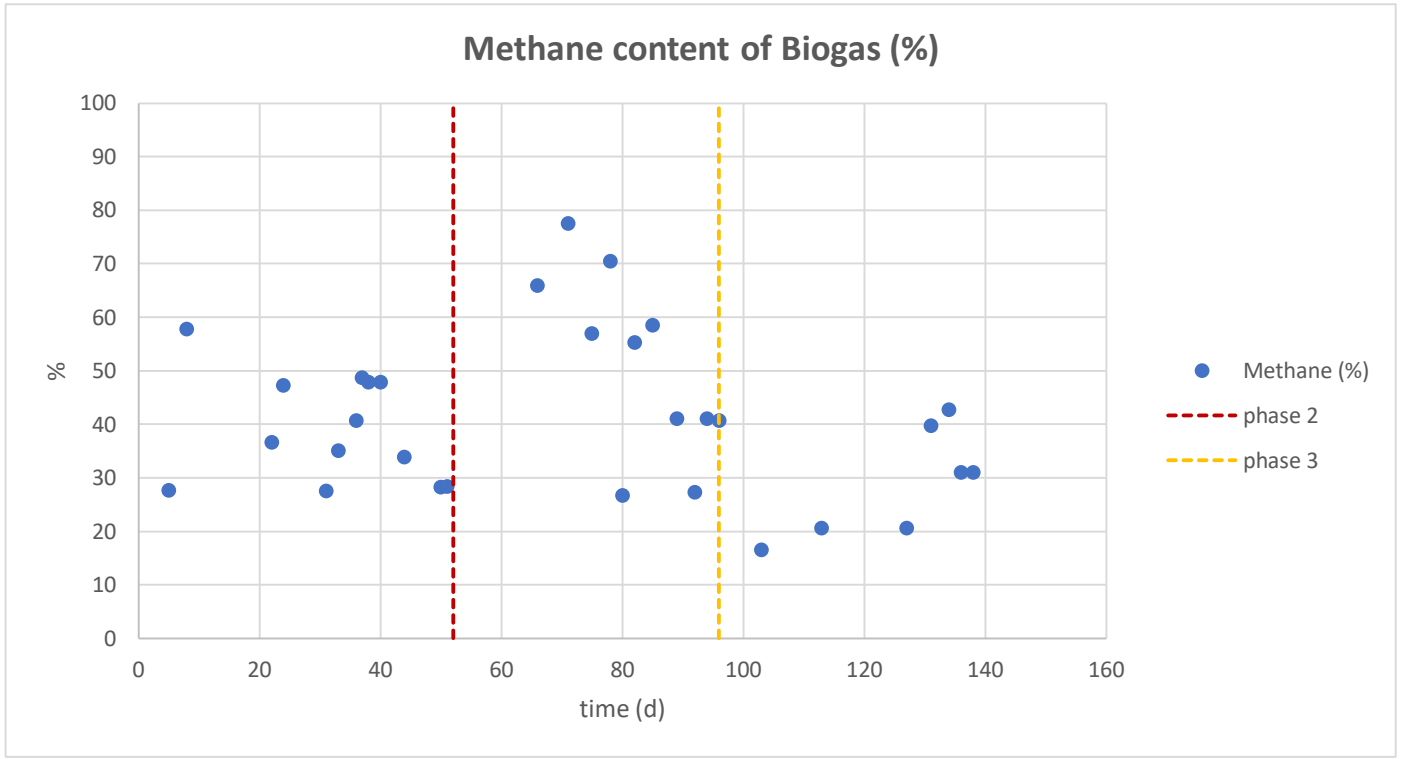


- High concentrations of Total Suspended Solids (TSS) and Volatile Suspended Solids (VSS) were observed during start up, and then decreased.
- VSS/TSS ~ 0.70





- The concentration of COD inside the bioreactor was low during the whole operation
- The COD reduction was above 90% for the first two phases, and decreased to approximately 70% during the 3rd phase



- Using synthetic condensate the methane content varied between 50-60%.
- When using real condensate the methane content dropped to 40%.

Conclusions

- Condensate, the liquid fraction from the drying and shredding of FHW, contains easily degradable carbon that can easily be consumed by microorganisms, and Landfill Leachate is rich in sufficient amounts of nitrogen, phosphorus and minerals.

- The condensate may be used to provide the necessary carbon for an effective anaerobic treatment of wastewaters with low carbon but high nitrogen content, such as landfill leachate.

- Co-digestion of synthetic condensate with landfill leachate led to an effective treatment and valorization of both streams

- The use of real condensate led to a lower performance, the elucidation of which requires further research

Thank you for your attention

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