1st International biogas and compost workshop

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ANAEROBIC DIGESTION OF NITROGEN-RICH CHICKEN MANURE

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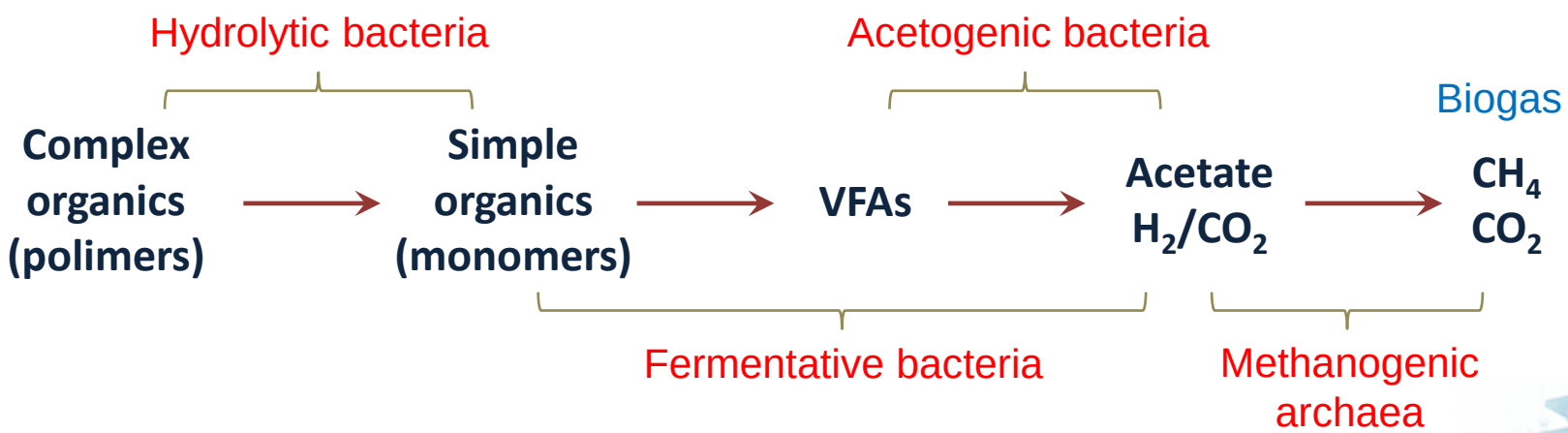
Anaerobic Digestion (AD)

- A process in which complex organic materials are converted to biogas in the absence of O_2 via activity of several groups of anaerobic microorganisms linked trophically to each other.



Composition of Biogas

Component	Percentage (%)
Methane (CH_4)	50-70
Carbondioxide (CO_2)	30-40
Nitrogen (N_2)	0-5
Hydrogen (H_2)	<1
Oxygen (O_2)	<0.4
Hydrogen sulfide (H_2S)	0-0.4

Energy Content of Biogas

	Energy Content (kWh)
1 Nm^3 biogas (60%CH_4)	6.0
1 Nm^3 upgraded biogas (97% CH_4)	9.7
1 Nm^3 natural gas	11.0
1 L gasoline	9.2
1 L diesel	9.8
1 kg coal	7.8

Wastes suitable for biogas production

- Sewage sludges (primary and secondary sludge)
- Animal manures (chicken, cow etc.)
- Agricultural residues, Energy crops
- Yard (green) wastes
- Organic fraction of municipal waste
- Fruit and vegetable processing wastes
- Slaughterhouse wastes
- (Micro)algae biomass
- Waste paper
- Industrial wastewater (Potato, sugar, dairy, brewery, etc.)

Turkish Regulation for Renewable Energy Generation

- Turkey aspires to have an installed capacity of 30% of renewable energy by 2023.
- REL (No. 5346): Law on Utilization of Renewable Energy Sources for the Purpose of Generating Electrical Energy
- Installed capacity < 1 MW → no need to obtain a license
- Feed-in tariff[1] applied to biogas (incl. LFG) investments: 13.3 USD cent/kWh
- Local equipment bonus: 5.6 USD cent/kWh

[1] Feed-in tariff (FIT) is a pricing mechanism designed to promote investment in renewable energy technologies

Biogas Potential in Turkey

Source	**Biogas Potential** (TWh/year)
Animal Manure	21,78
Industrial Waste	4,11
Municipal Waste	3,06
Agricultural Residue	2,33
Total	**31.28**

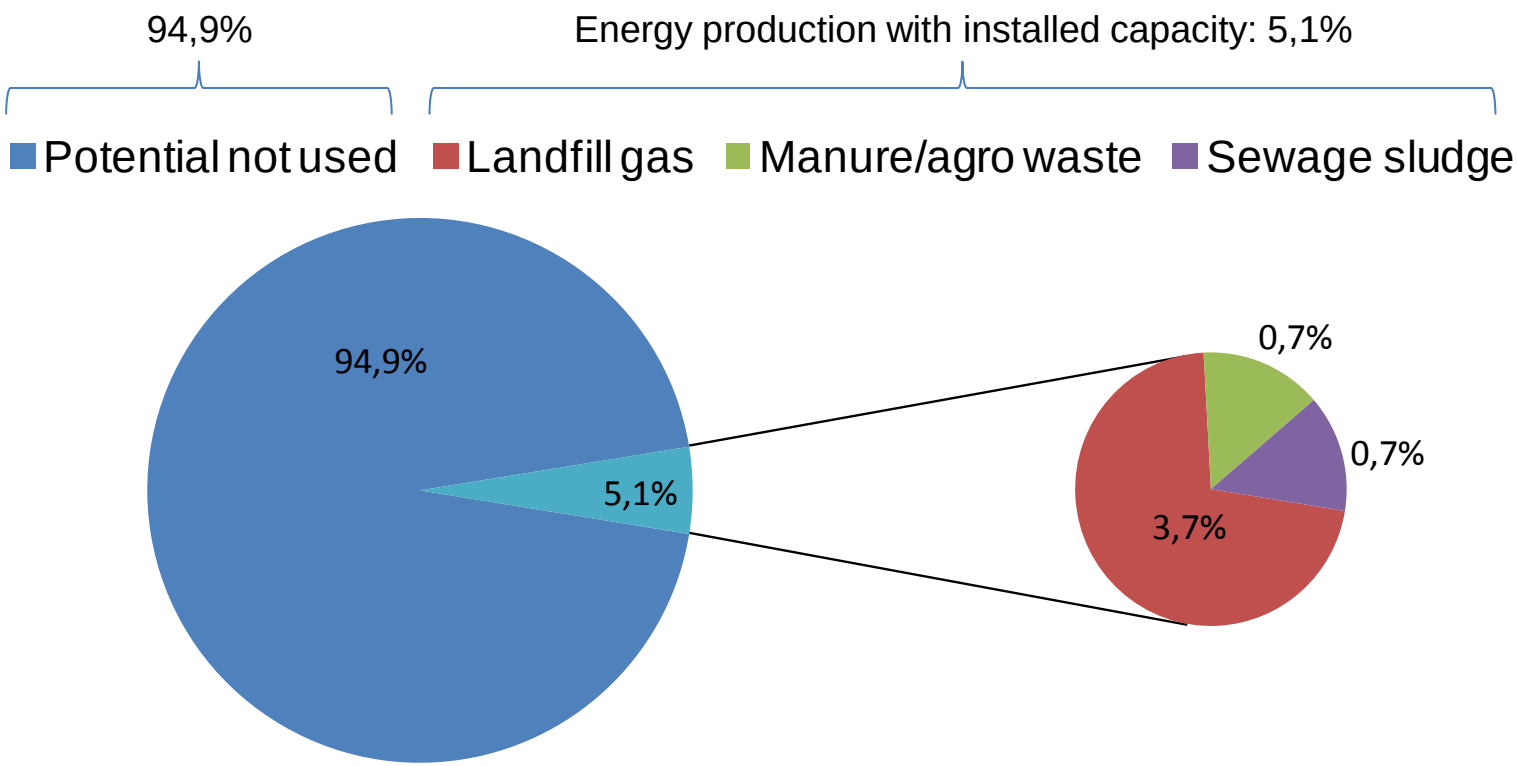
Turkish-German Biogas Project, 2011

Biogas Plants in Turkey

Landfill gas (131 MW) Manure/agricultural waste (26.5 MW) Sewage sludge (25.5 MW)

Total installed capacity: 183 MW

Use of Biogas Potential



Number of Livestock in Turkey

Bovine (cattle etc.)	11.518.827
Ruminants (sheep, goat, etc.)	29.382.924
Poultry (broiler and laying hen)	234.918.385
Total Number	**275.820.136**

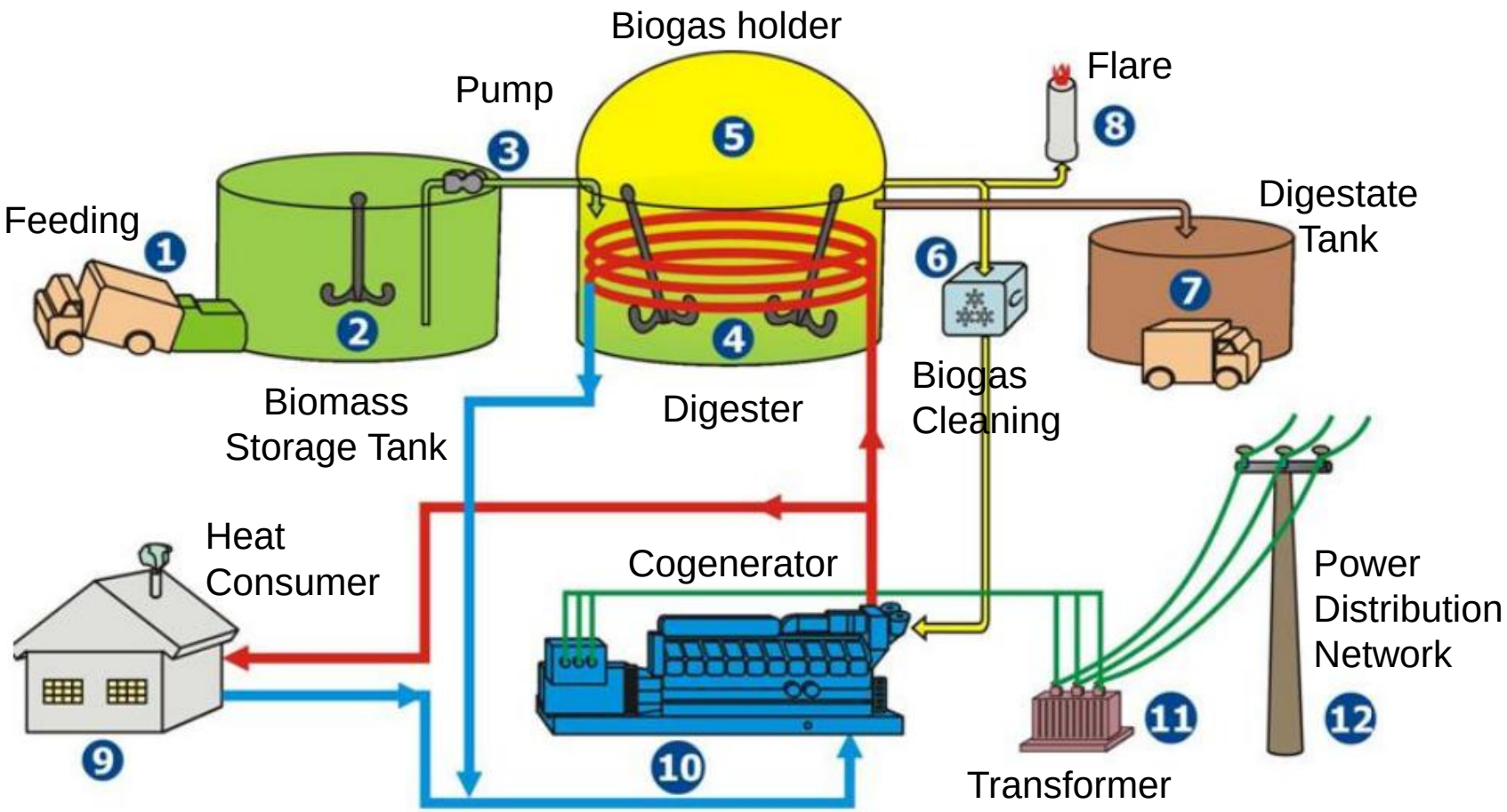
TUIK (Turkish Statistical Institute), 2010

Biogas Yield & Energy Value of Manure

Animals	# of animals for 1 ton/d of manure	Dry matter, %	Biogas yield, m3/ton	Energy value, kWh/ton
Cattle	20-40	8-12%	25	150
Laying hen	8000-9000	25-30%	90-150	540-900
Broiler	10000-15000	50-60%	50-100	300-600
Pig	250-300	9-10%	26	156

http://www.anaerobic-digestion.com

A Typical Manure Type Biogas Plant



Chicken Manure Digestion

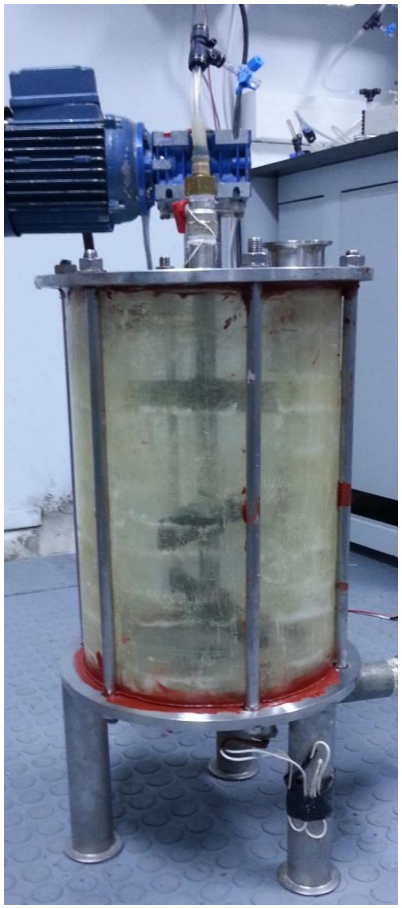
- Chicken manure is rich in organic nitrogen
- Cause decline in biogas production if digested with being diluted with water or other organic waste listed in slide 5
- To achieve biogas production w/o dilution, ammonia has to be removed
  - From raw chicken manure before digestion or
  - Directly from the digester

Model Manure Type Biogas Plant

- Chicken manure : 250-300 ton/d
- Agricultural/food waste : 50-100 ton/d (co-substrate)
- Water/wastewater : 500 m^3/d (for dilution)
- Biogas generation : ~40.000 m^3/d (60% CH4)
- Electricity production : ~70.000 kWh/d
- Fertilizer Production : ~200 ton/d (%50 Dry)

  : ~600 m^3/d (Liquid)
- Investment cost : 10-12 million Euro
- Payback period : ~3 years

Laboratory Experiments



Lab-scale Anaerobic Digester

- Total volume 16 L (14.5 L wet)
- Continuously stirred (45 rpm)
- Fed once a day
- Kept at 36-42 ^{o}C using heating coils
- Biogas is stored in aluminium foil gas bags

Analyses

Parameter	Method	Frequency
Biogas volume	Milligascounter	Daily
Methane %	GC-TCD	2/week
VFAs	GC-FID	3/week
Total alkalinity	Titrimetric	3/week
pH	pH meter	3/week
TS and VS	Gravimetric	3/week
TKN	Digestion & distillation	2/week
NH_4-N	Nesslerization	2/week

Operation Conditions

Period Days	**I** 0-49	**II** 49-70	**III** 70-128	**IV** 128-157	**V** 157-177	**VI** 177-277	**VII** 277-322
OLR, kgVS/m^3.d	2.78	3.51-3.61				1.72	2.53
TKN_{inf}, mg/l	3960	5020	5950	6560	5610	2160	3200
HRT, d	23				28	23	
TS_{inf}, %	9.8	12.4	13.5		14.9	5.7	8.6
Temp., ^oC	36+/-1^oC					After Day 236 42+/-1^oC	

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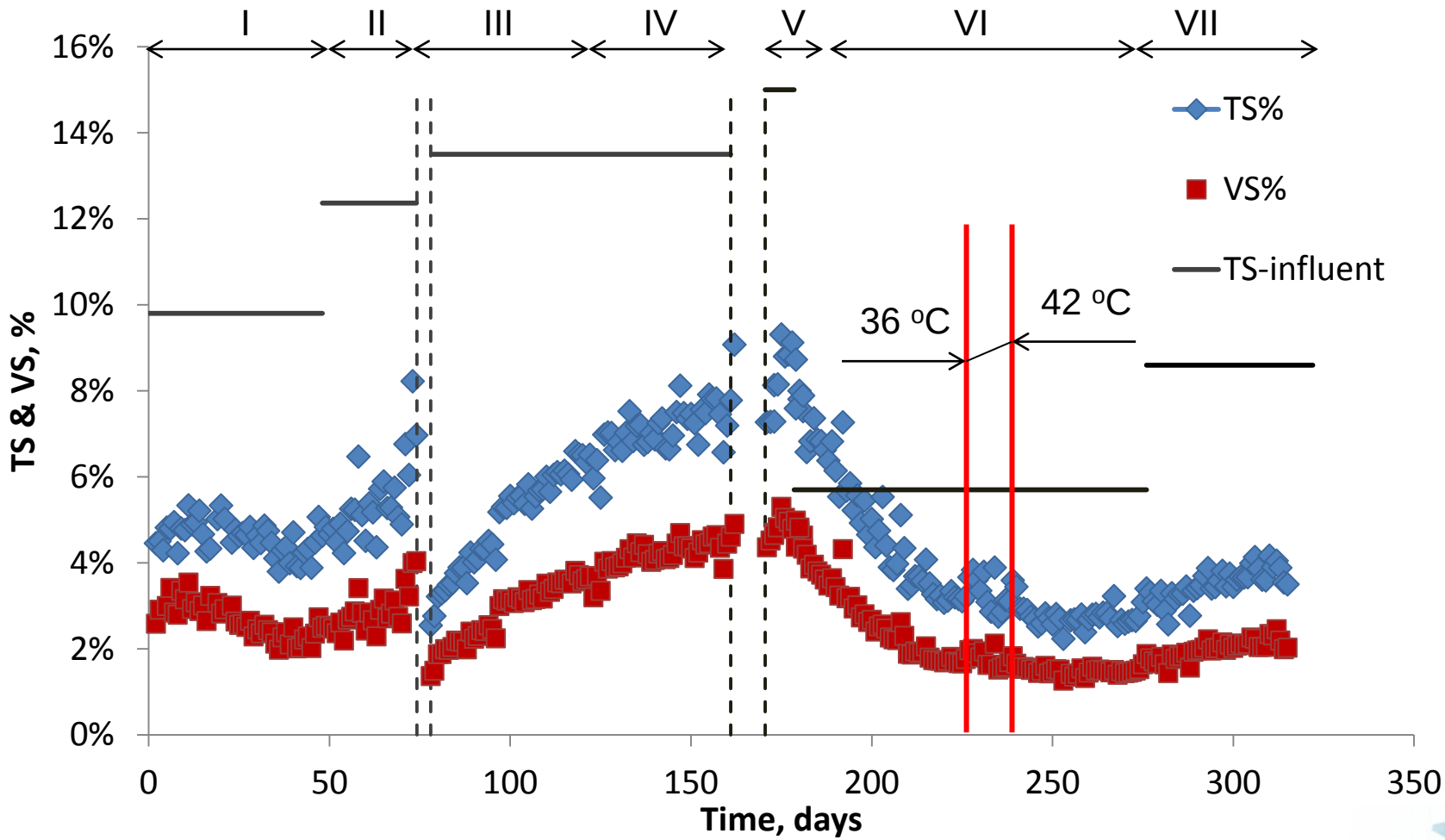
Results - TS & VS



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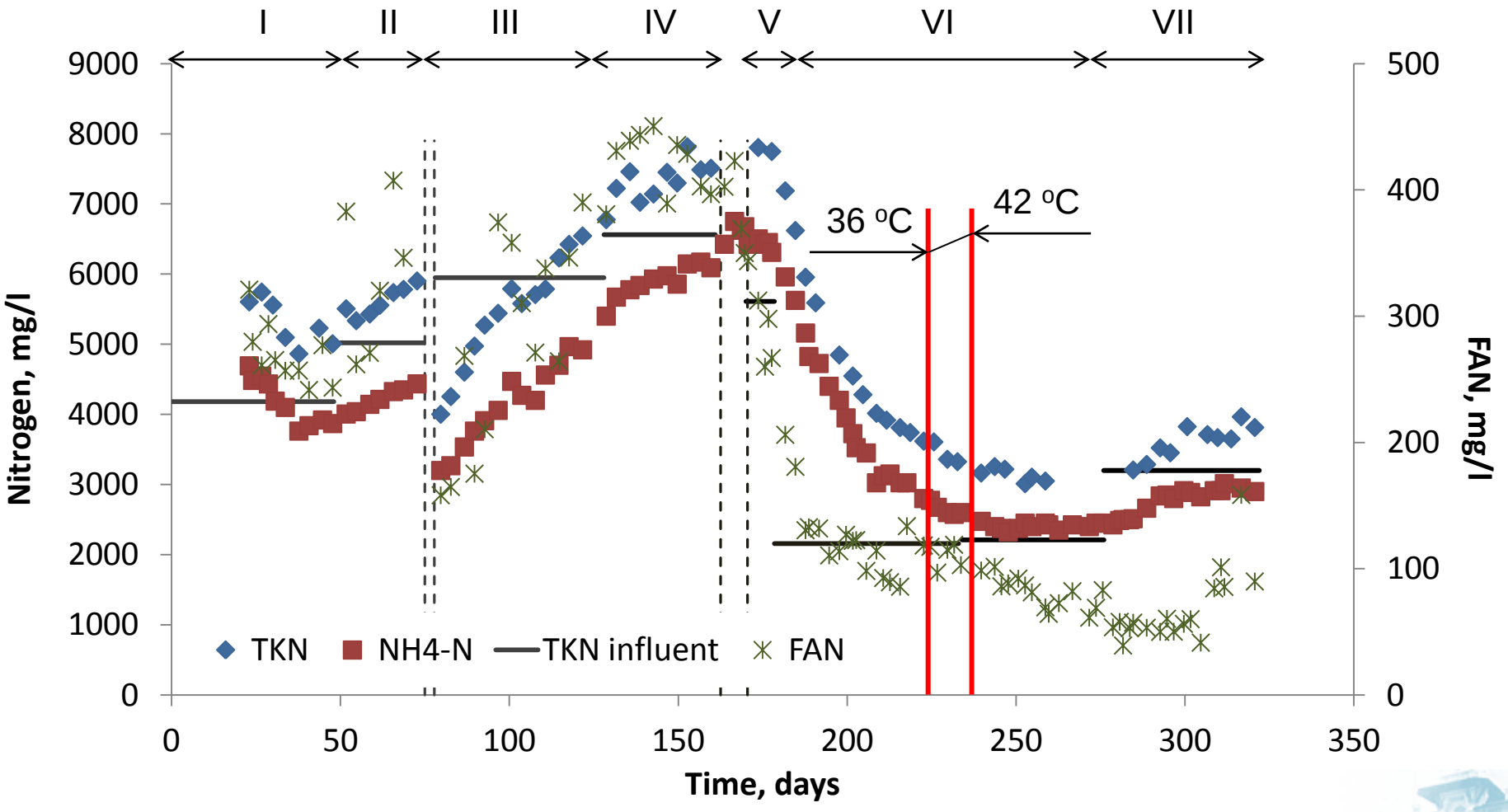
Results - TKN & NH_4^+-N



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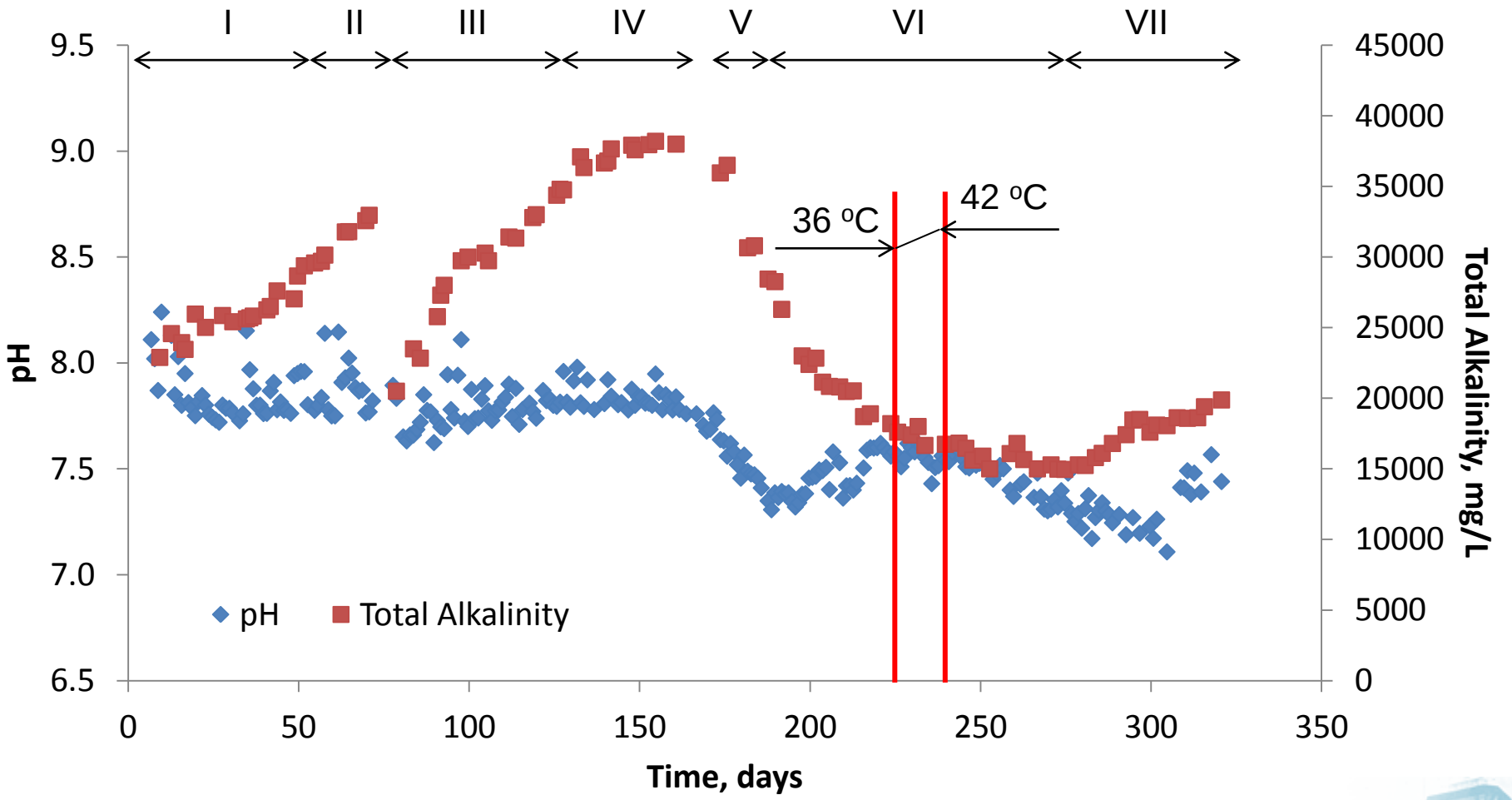
Results - pH & Alkalinity



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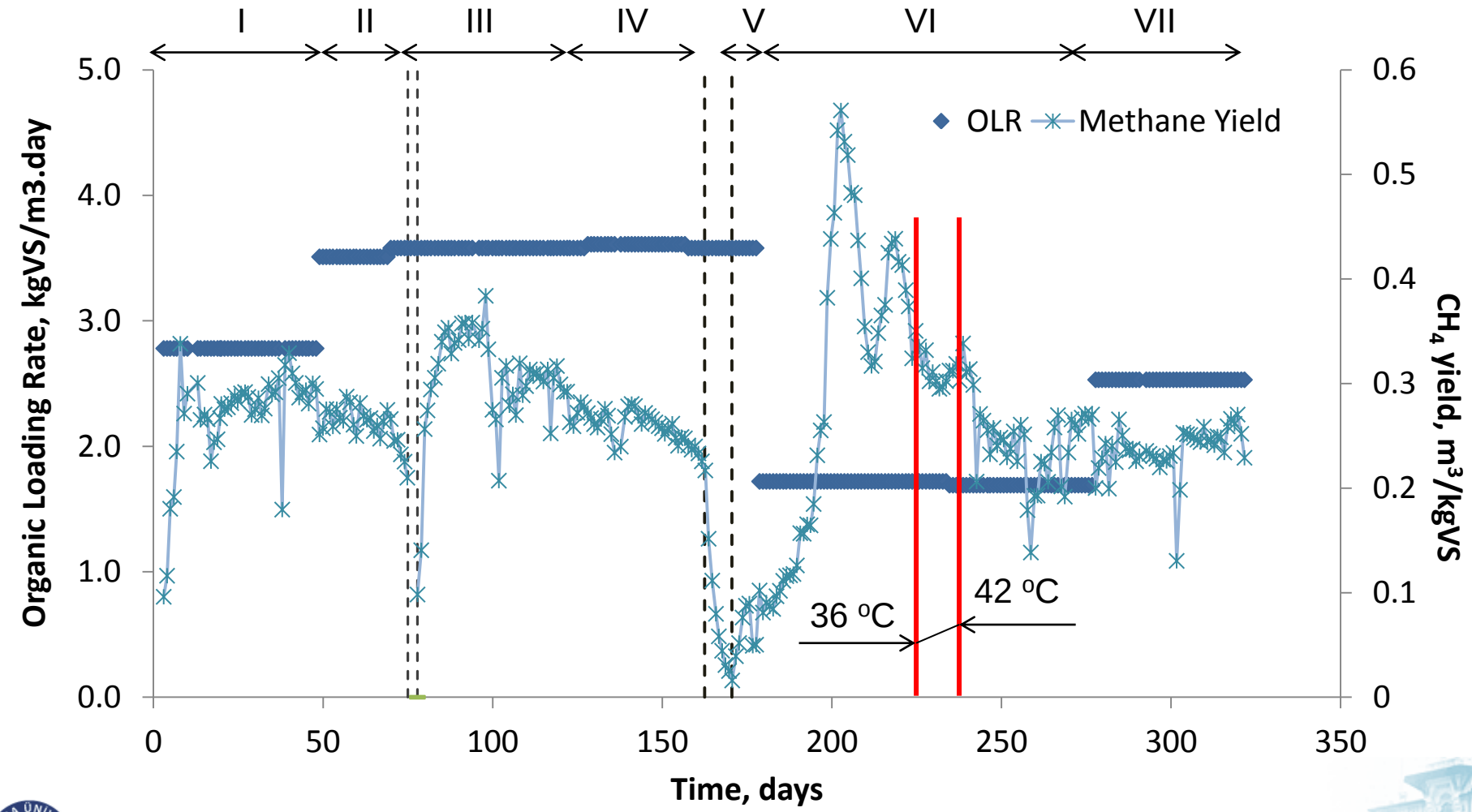
Results - OLR & CH_4 Yield



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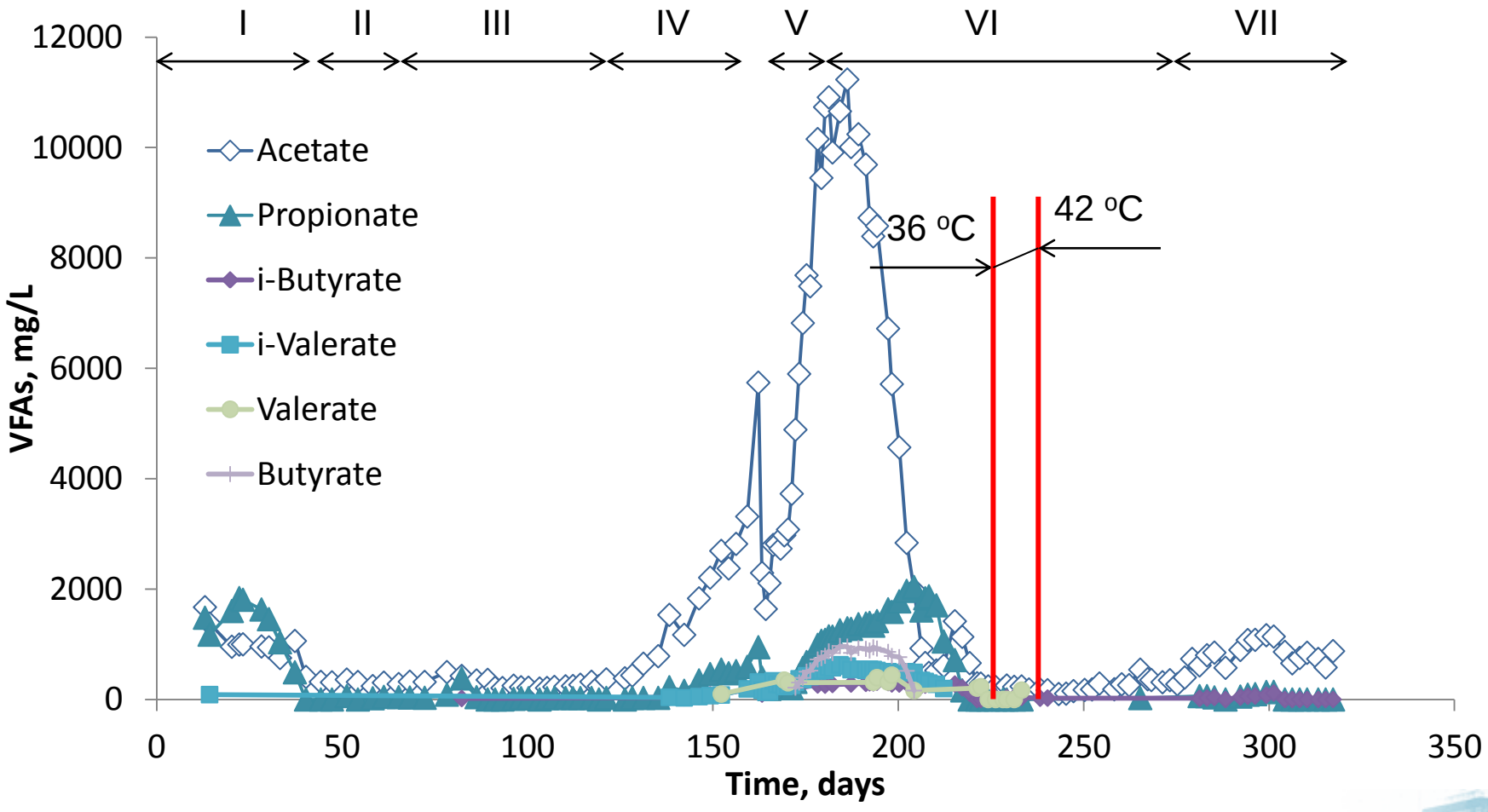
Results - VFAs



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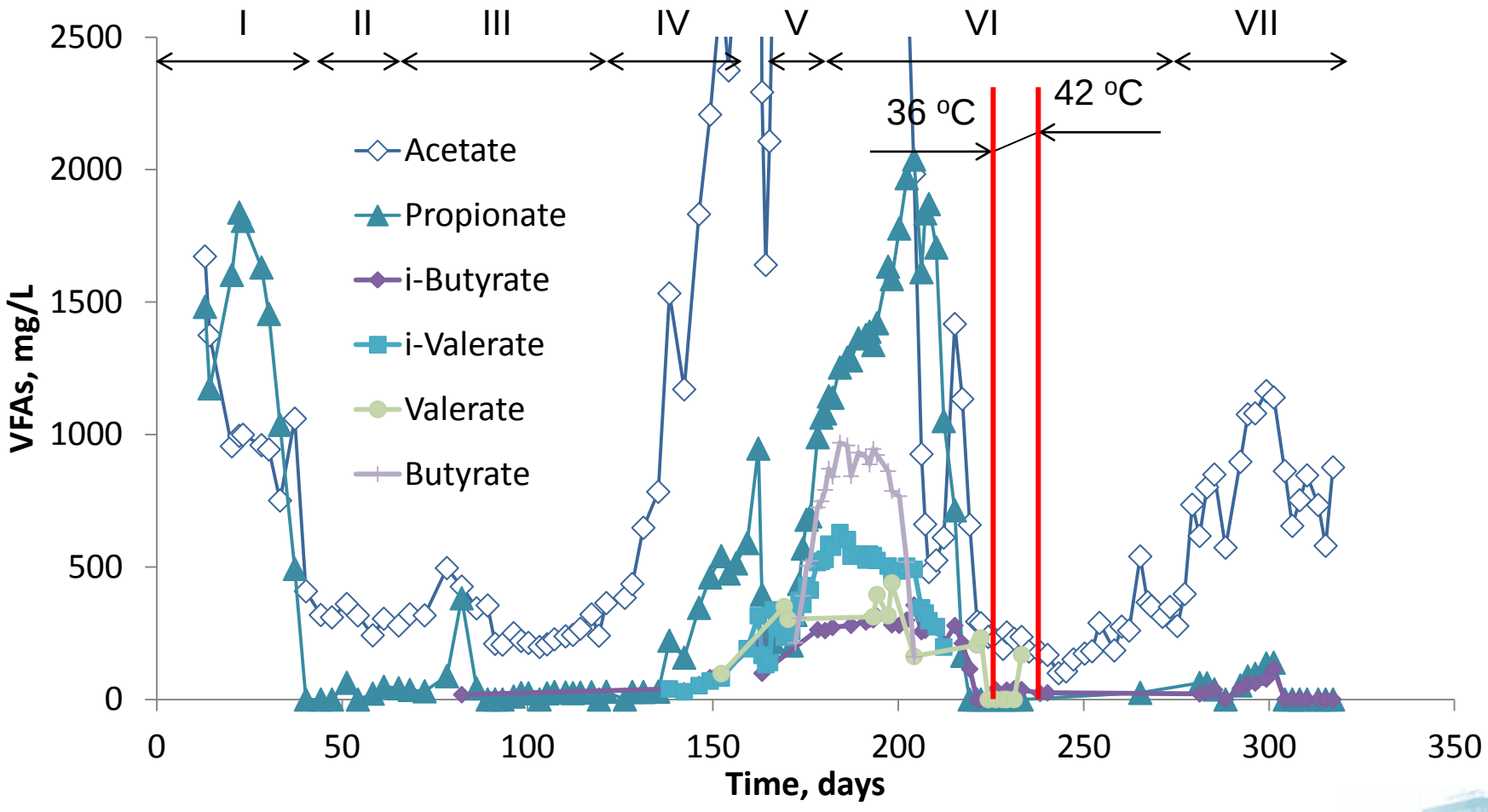

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Conclusions

- Biogas production target = 40.000 m^3/d
- CH_4 production target = 24.000 m^3/d
- Achieved in laboratory study
  - CH_4 yield > 0.25 $m^3/kgVS$ (if NH_4^+-N <5000 mg/l)
  - CH_4 production = 20.000-25.000 m^3/d
  - CH_4 yield < 0.25 $m^3/kgVS$ (if NH_4^+-N >5000 mg/l)
  - CH_4 production = 15.000-20.000 m^3/d
- Therefore NH_4 has to be kept below 5000 mg/l with dilution or by being removed from digester

Future Study Plan

- **TUBITAK** Project No. 113Y333 **“**The effects of trace element supplementation and ammonia removal on biogas production from nitrogen rich organic wastes” 2014-2017.
  - Effects of TM supplementation will be investigated
  - Stripping and membrane separation will be tested to continuously remove ammonia from the digester
- Partner of **COST-ES1302** action ‘European Network on Ecological Functions of Trace Metals in Anaerobic Biotechnologies’

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