’Pomeranian Biogas Model’ [POM-BIOGAS] Project

Grant Agreement no. Pol.-Nor/202919/57/2013

WP2

WP2

Task 2.1 Design & construction of the pilot installation

Task 2.2 Testing hydrolysis of the substrates

Task 2.3 Testing biogas production from mixture no. 1

Task 2.4 Testing biogas production from mixture no. 2

Task 2.5 Testing biogas production from mixture no. 3

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norway grants

A. **Collecting organic waste fraction**

organic waste fractions are collected at waste utilization plant in Gdańsk Szadółki;

B. **Homogenisation and composition**

preparation of the substrate: fragmentation. homogenisation. sieving. dilution to 8% d.m. analysis;

C. **Pre-treatment**

thermal hydrolysis of the substrate before methane fermentation is carried out in R3;

D. **Methane fermentation**

controlling parameters of the process to produce biogas;

WP2

E. **Biogas Upgrading** (WP3)

F. **Use of digestate** (WP4)

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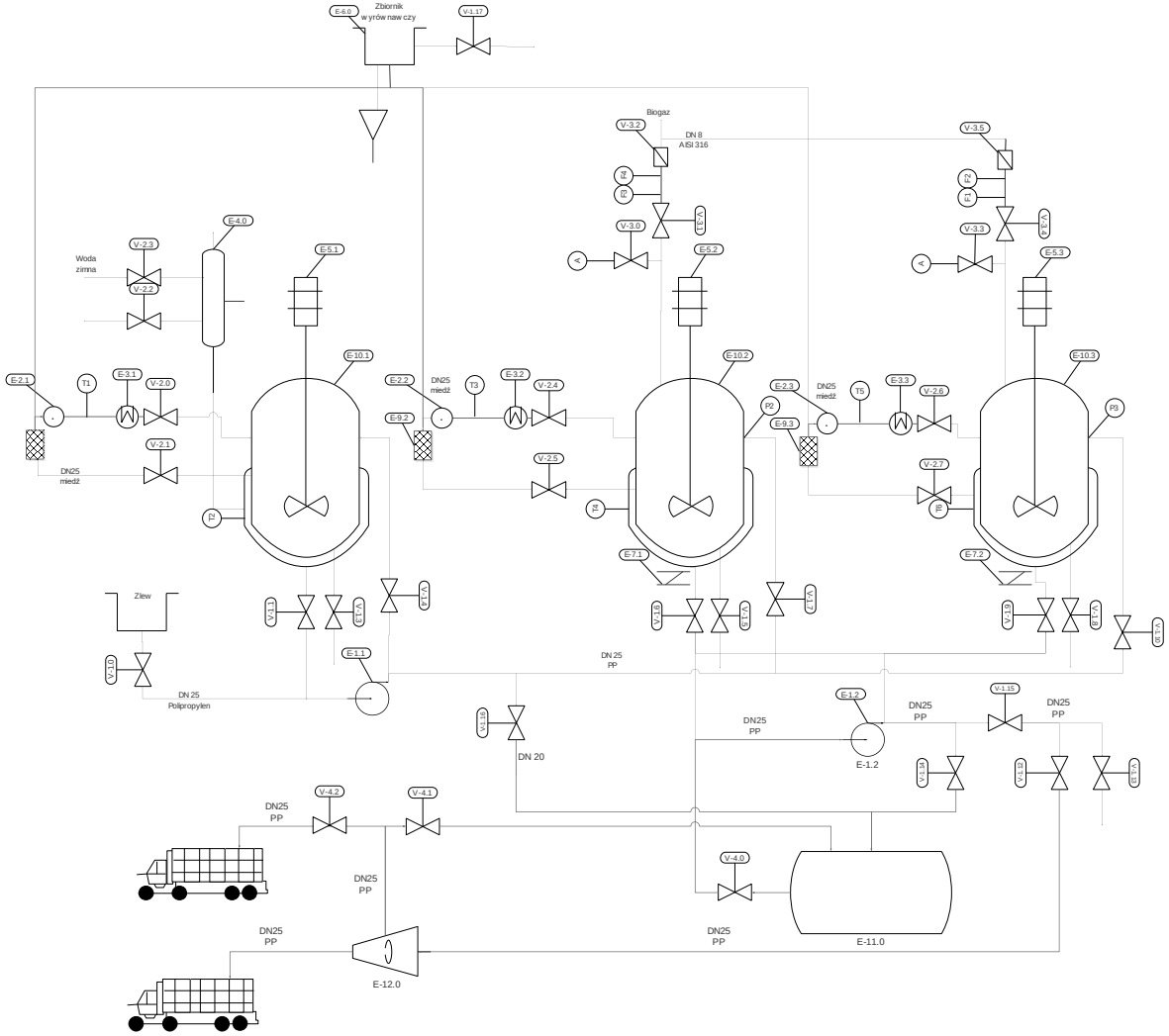
Pilot installation

The installation was designed for digestion of organic fraction of municipal wastes in thermophilic process in semi-commercial scale. The size of plant was selected to avoid the sampling errors resulted from inhomogeneity of raw material input (organic fraction of municipal wastes). The system consists mainly of three modules: bio-thermal treatment system of feed, twin digesters, dewatering and digeste treatment system.



Goal

The goal was to test biogas production from the mixture of organic fraction of municipal and industrial waste. Bbiogas yields (l/ kg VS), biogas composition (content of CH4, CO2, NH3 and H2S) were measured over fermentation time.

The overall biogas production process included several steps:

A. Collection of substrate - bio-fraction from municipal waste

B. Unpacking – preparation of the organic waste fractions to get a substrate free from packaging;

C. Homogenisation and screening – disintegration of collected biomass and screening to ensure appropriate solid particle size

D. Pre-treatment – thermal hydrolysis of the substrate mixture

E. Methane fermentation – creating appropriate conditions for fermentation and methane production, collecting the digestate and feeding with substrate

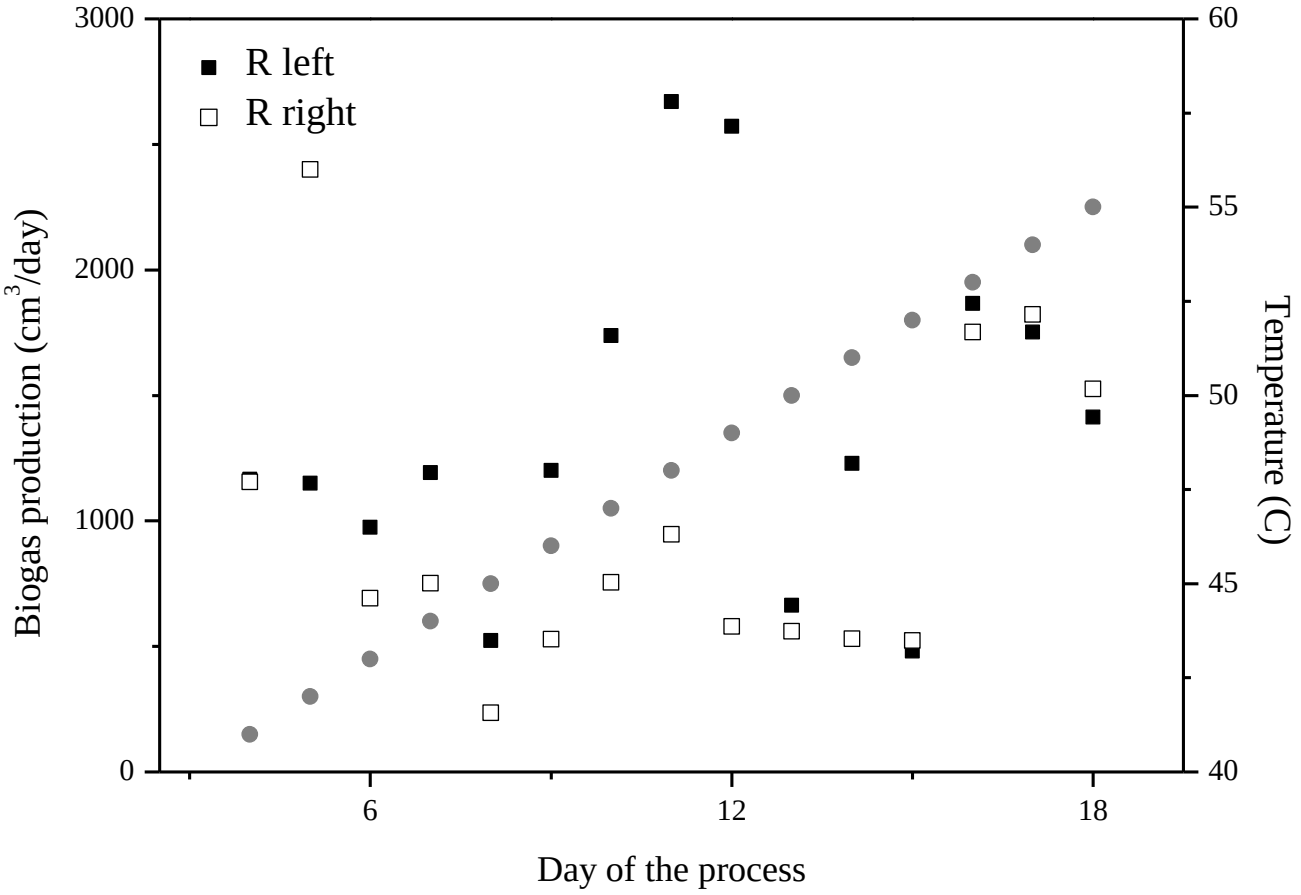
Experiment no. 1

Fermentation was conducted in laboratory installation based on two reactors with capacity of 10 litres and working volume of 7 litres. Mixing of the reactors content was set up at 17 rpm.

Initial temperature of the process was set at 41ºC raised daily for 1ºC until temperature of 55ºC was reached.

The inoculum was based on the content of cattle stomachs that was collected from slaughterhouse in Stężyca.

Hydraulic retention time [days]	14
Daily loading [kg d.m./day]	$4*10^{-5}$
Daily loading per cubic meter [kg d.m./day m^3]	$5.7*10^{-3}$



pH level was maintained approx. constant at 5.4 and it was too low to achieve satisfying biogas yield.

Such low pH is a result of volatile acids accumulation and limits proper growth of methanogenic microorganisms.

Unfavourable conditions for bacteria life activity resulted in low average fermentation efficiency of 30 m^3/kg s.m.

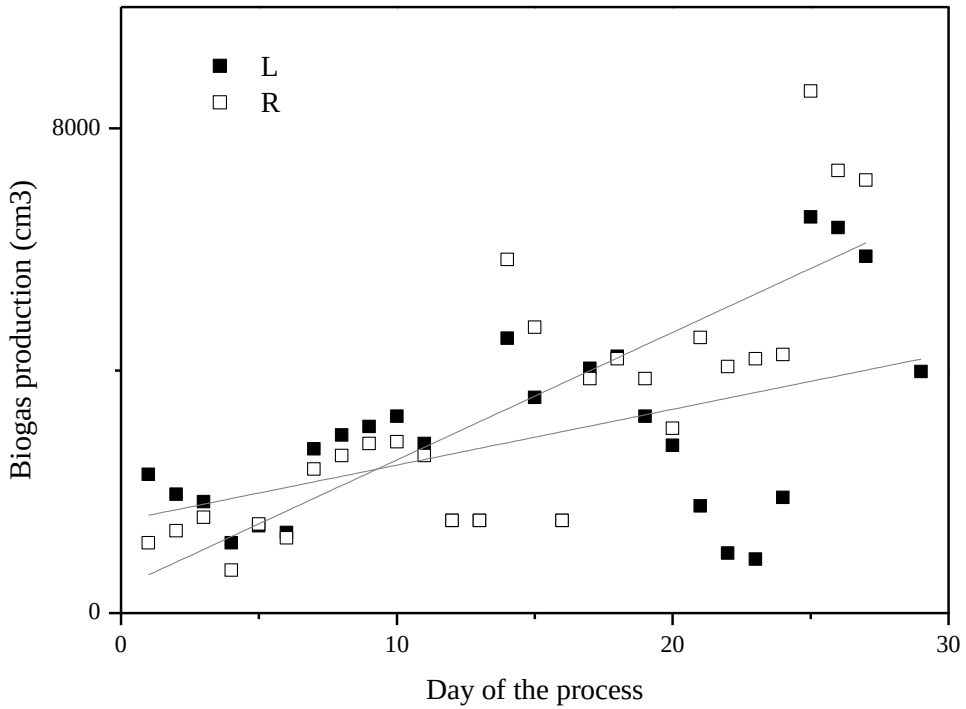
Rate of biomass decomposition was 50%.

Experiment no. 2

Fermentation was conducted in laboratory installation based on two reactors with capacity of 10 litres and working volume of 7 litres. Mixing of the reactors content was set up at 17 rpm. Biogas production process was conducted in thermophilic conditions at a temperature of 55ºC and is classified as wet fermentation as the dry solids did not exceed 8%.

Inoculum was sampled from thermophilic fermentation process in POLDANOR.

Hydraulic retention time [days]	140 in the 1st week 56 in the 2nd week 28 in the 3rd week 19 in the 4th week
Daily loading [kg d.m./day]	$9.2*10^{-3}$ in the 1st week $2*10^{-2}$ in the 2nd week $2.4*10^{-2}$ in the 3rd week $3.6*10^{-2}$ in the 4th week



Overall trend of increasing biogas production is visible according to increase of daily biomass loading.

Average biogas yield obtained in the experiment was 181 m^3/kg d.m. in reactor left and 162 m^3/kg d.m. in reactor right.

As a result of variability of substrate dry mass content decreased during the process from 10% to 4% and from 9% to 3% in left and right reactor, respectively.

Moreover, significant changes in methane content were visible, it decreased from 70% to 42% in left reactor and from 70% to 53% in right reactor.

Experiment no. 3

Start: 19/03/2016

Type of fermentation: thermophilic, wet fermentation at temperature of 55°C;

Type of substrate: organic fraction from municipal solid wastes (Szadółki, Gdańsk);

Inoculum: digestate from thermophilic process conducted within task 2.4.;

Installation: two reactors with a capacity of 1000 liters, working volume of 600 liters;

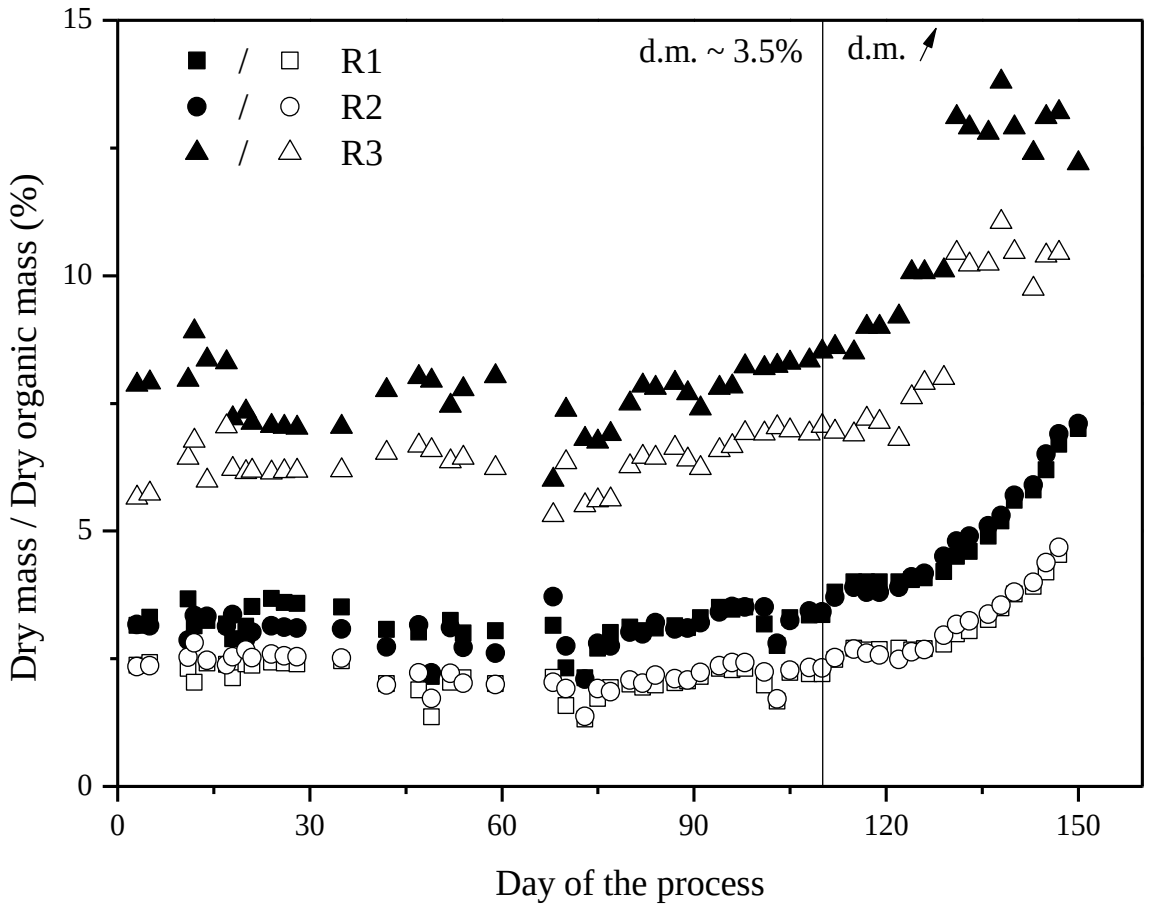
Rate of mixing the content of reactors: 70 rpm.

Substrates

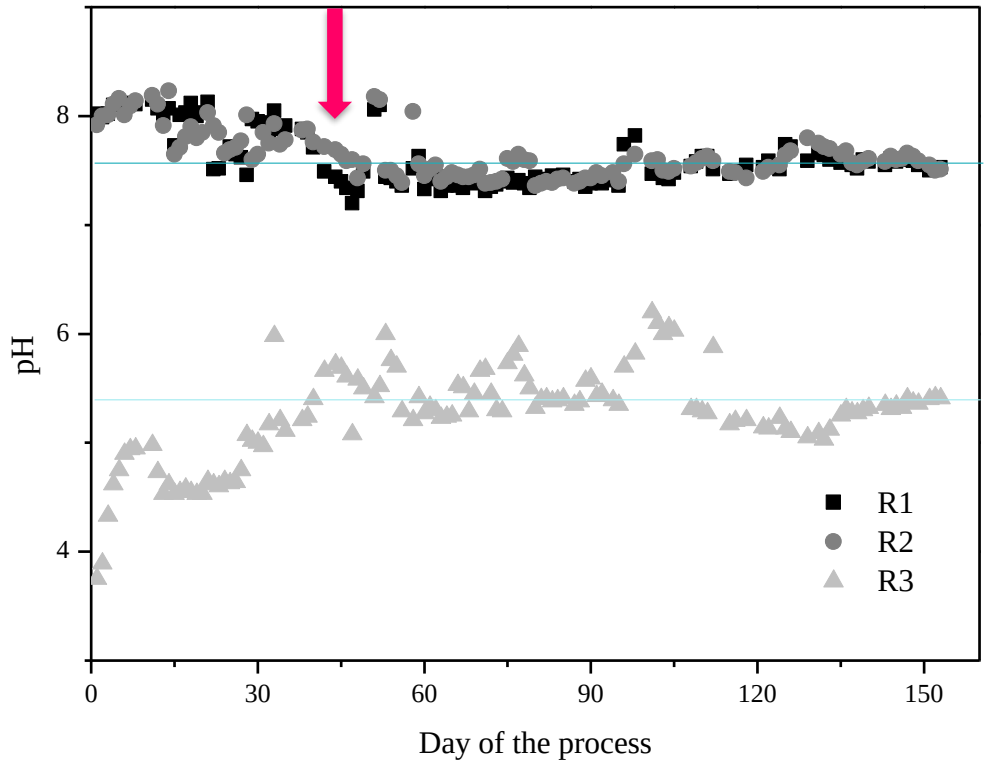
Intial parameters

Time period	Time [days]	Hydraulic retention time [days]	Daily loading [kg d.o.m./d]	Daily loading per cubic meter [kg d.o.m./m^3d]
1st	6	30	1.14	1.90
2nd	96	20	1.89	3.15
3rd	23	15	2.82	4.70
4th	20	12	4.88	8.13
5th	19	11	6.27	10.45

Dry mass was kept approximately constant for 110 days to avoid overloading biogas reactors with proteins and inhibitors. Afterwards, level of dry mass was regularly increased as presented



pH



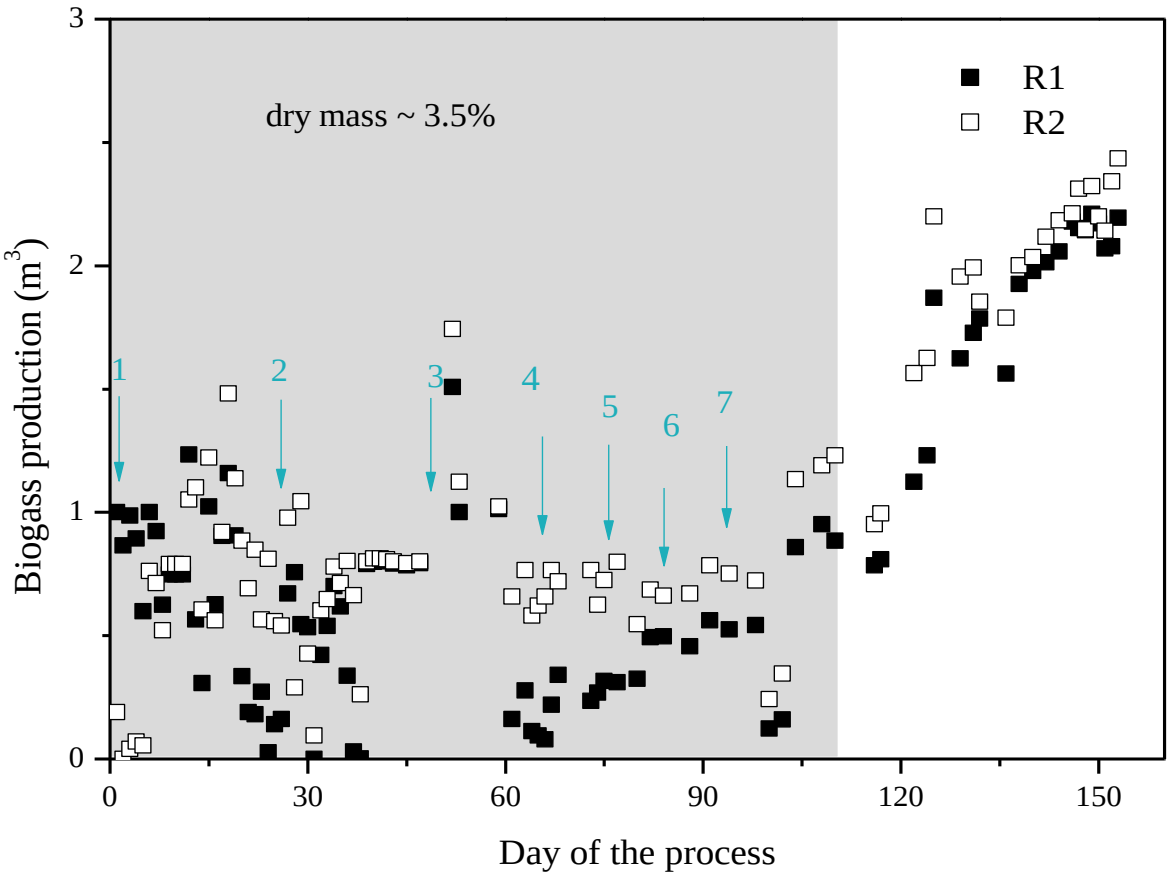
After about 45 days of process stabilization, pH became stable till the end of experiment. There were three sudden pH increments, that in general are not favorable for methanogenic microorganisms, however the process kept its balance and remained stable. The average value was about 7.56 in both fermentation reactors. In thermolysis reactor R3, pH fluctuations were visible in regards to variability of substrates, however the average pH was 5.37.

Biogas production

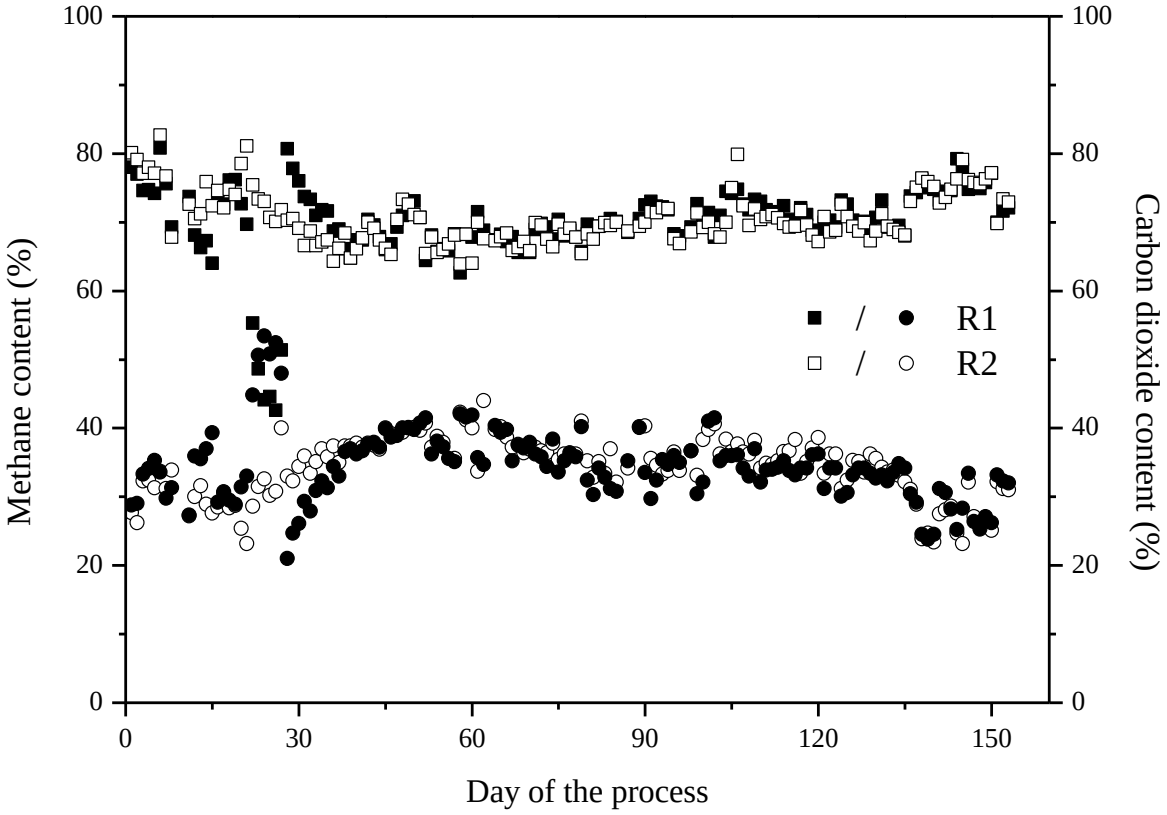
For the 2nd time period with dry mass of about 3.5% the average volume of produced biogas was:

- 0.542 m^3 in R1
- 0.766 m^3 in R2.

Increasing content of dry mass resulted in the increase of biogas production up to 2.5 m^3.



Biogas composition



The main product of the process had a very good quality due to relatively high methane content, the average of 70% was obtained.

Parameter (average)	R1	R2
Decomposition rate	66%	64%
Carbon/nitrogen ratio	18.05	17.66
Biogas yield	0.35 m3/kg d.o.m.	0.42 m3/kg d.o.m.
VFA	7078 mg/dm3	6792 mg/dm3
N-NH4+	733 mg/dm3	690 mg/dm3
VFA/Alkalinity	0.55	0.52

Conclusions

- the process remained stable for 164 days;
- amount of solid waste was reduced;
- thermophilic conditions of the process enable short hydraulic retention time, high loading and provide high hygienisation of digestate;
- product is almost odourless and can be further used without any nuisance;
- taking into account the biogas yields and its quality, obtained results are very promising and can be a basis for extended research on industrial scale.