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Digestate and its utilisation methods

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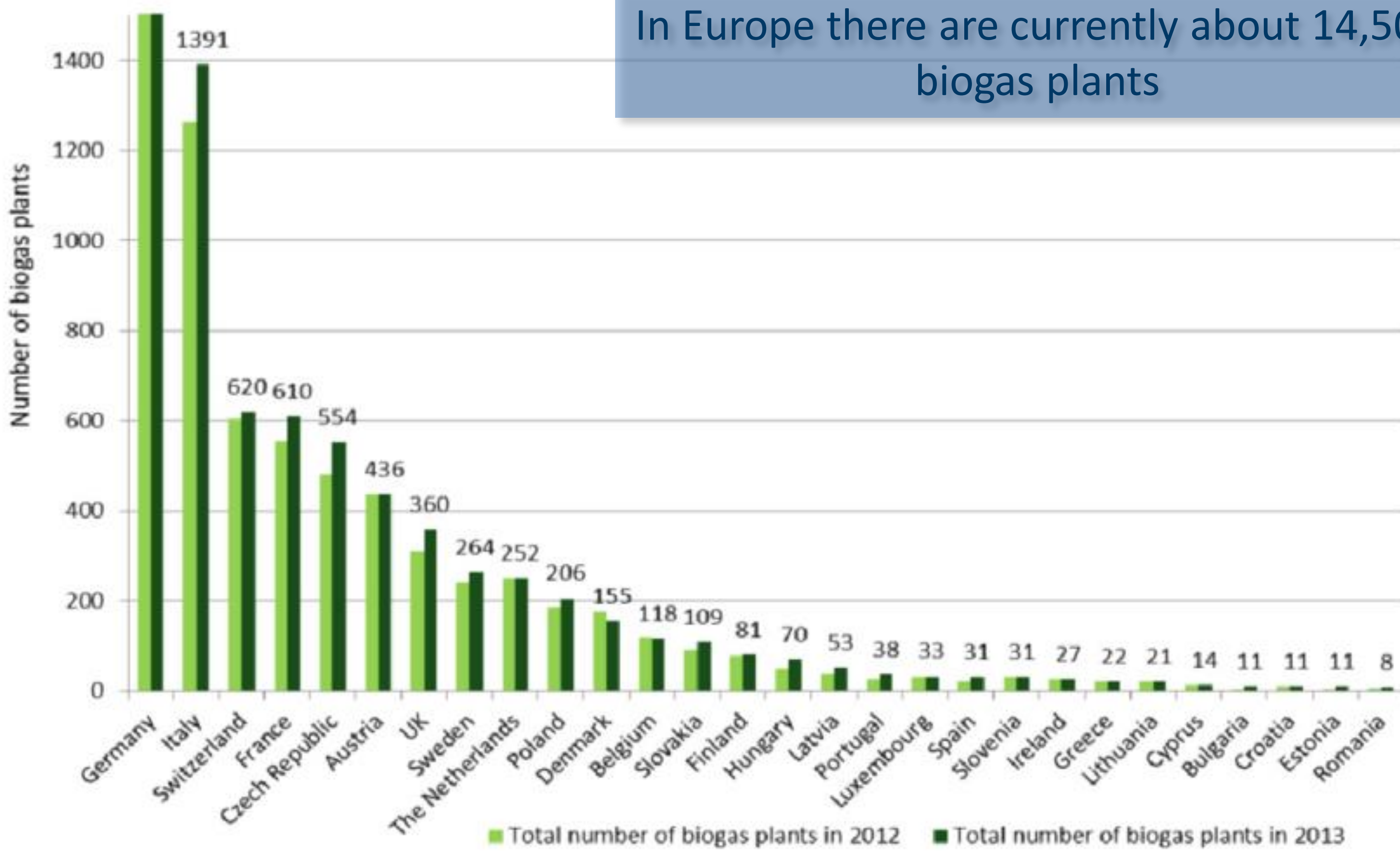
Pre-BASIC Biogas Seminar, Malmö 8 November 2016

Biogas plants in Europe in 2012 and 2013

In Europe there are currently about 14,500 biogas plants



https://www.researchgate.net/figure/305892932_fig1_Fig-2-Biogas-plants-in-Europe-in-2012-and-2013-Biogas-Report-2014-EBA-2014 [accessed Nov 5, 2016]

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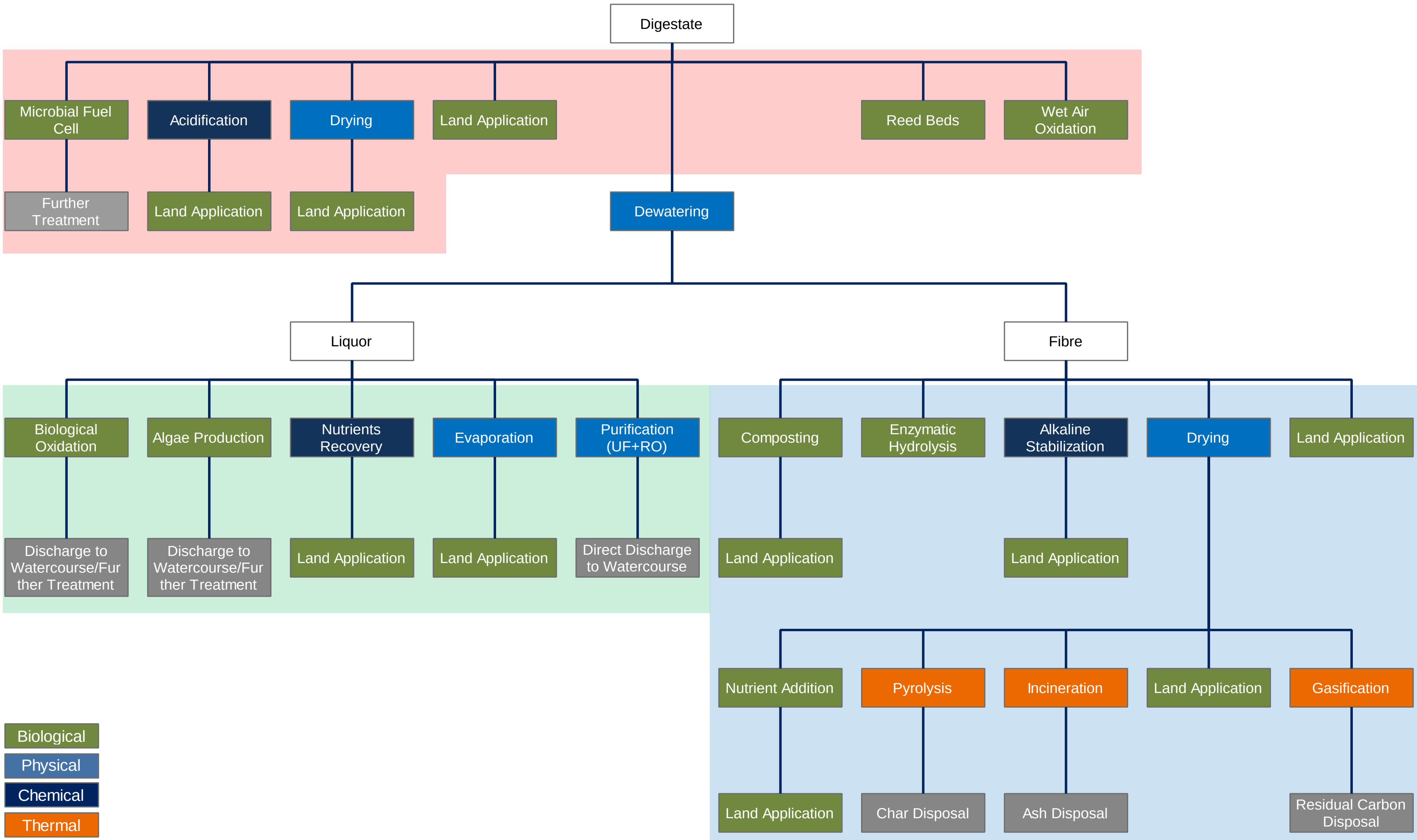
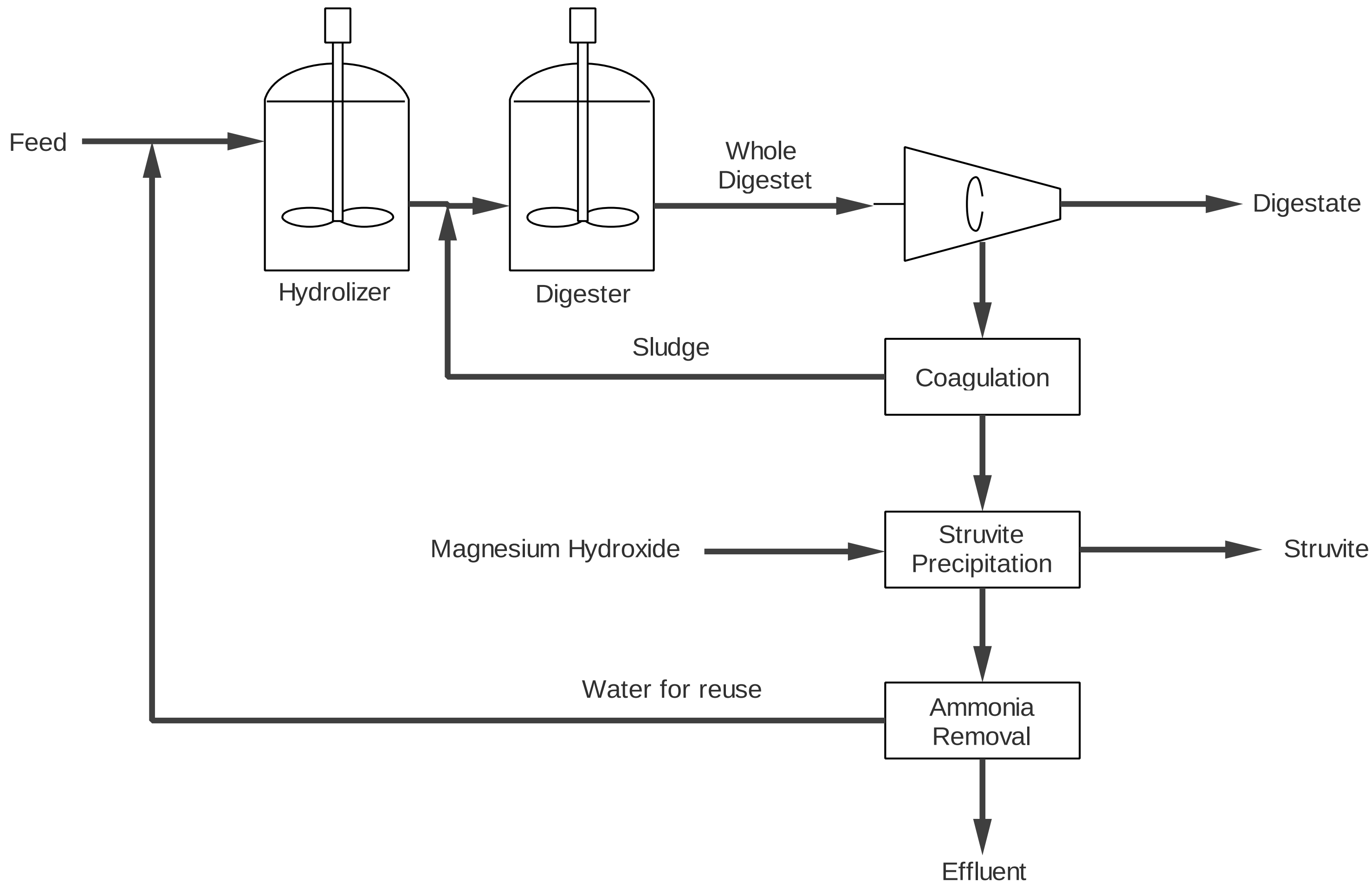
Methods of digestate utilization



Methods of digestate utilization

- Methods of digestate utilization
  - Agricultural usage 36%
  - Non agricultural usage 64%
    - Thermal utilization 7.4%
    - Landfill disposal 18.5%
    - Others 38.1%

Flow Diagram of Potential Digestate Enhancement System



Steps of biogas production process

Collecting of substrate

- bio-fraction from municipal waste

Homogenization and screening

•disintegration of collected biomass and screening to ensure appropriate solid particle size (10 mm)

Pre-treatment

•thermal hydrolysis of the substrate mixture, pH=5.5, 8hr, T=90°C, TOC=51.7%, COD=28560 mgO_2/dm^3

Methane fermentation

•thermophilic fermentation T=55°C

Dewatering of digestate

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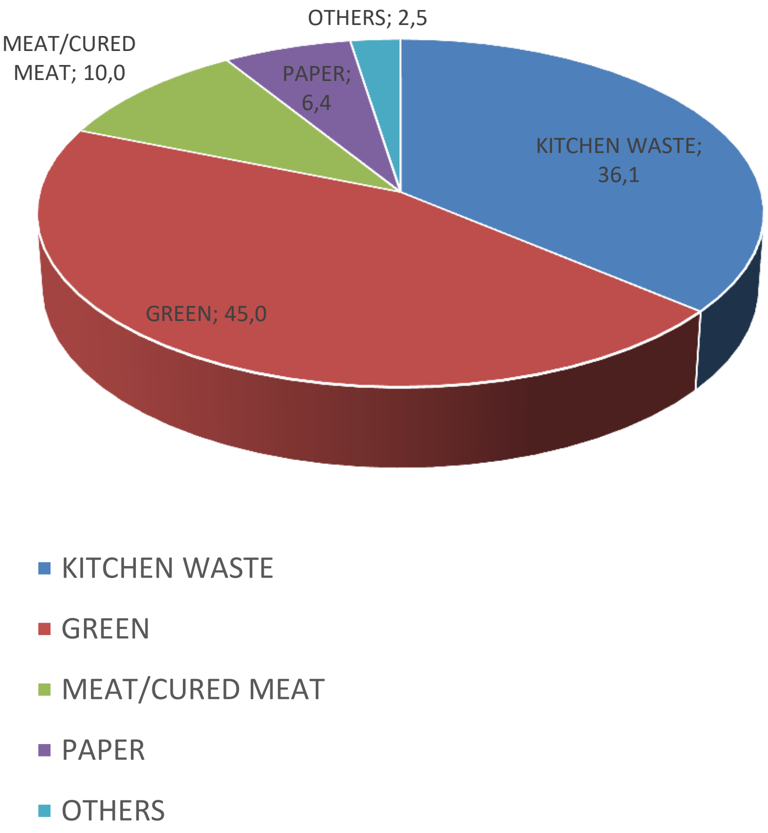
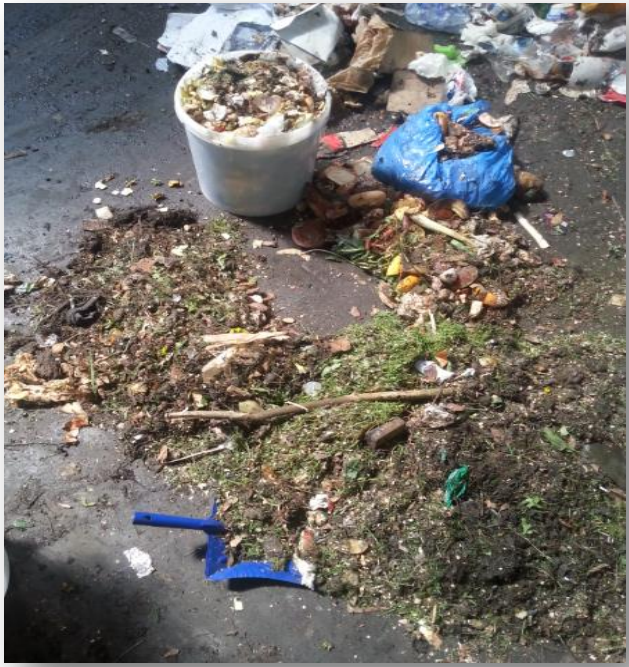
Composition of collected municipal wastes fraction





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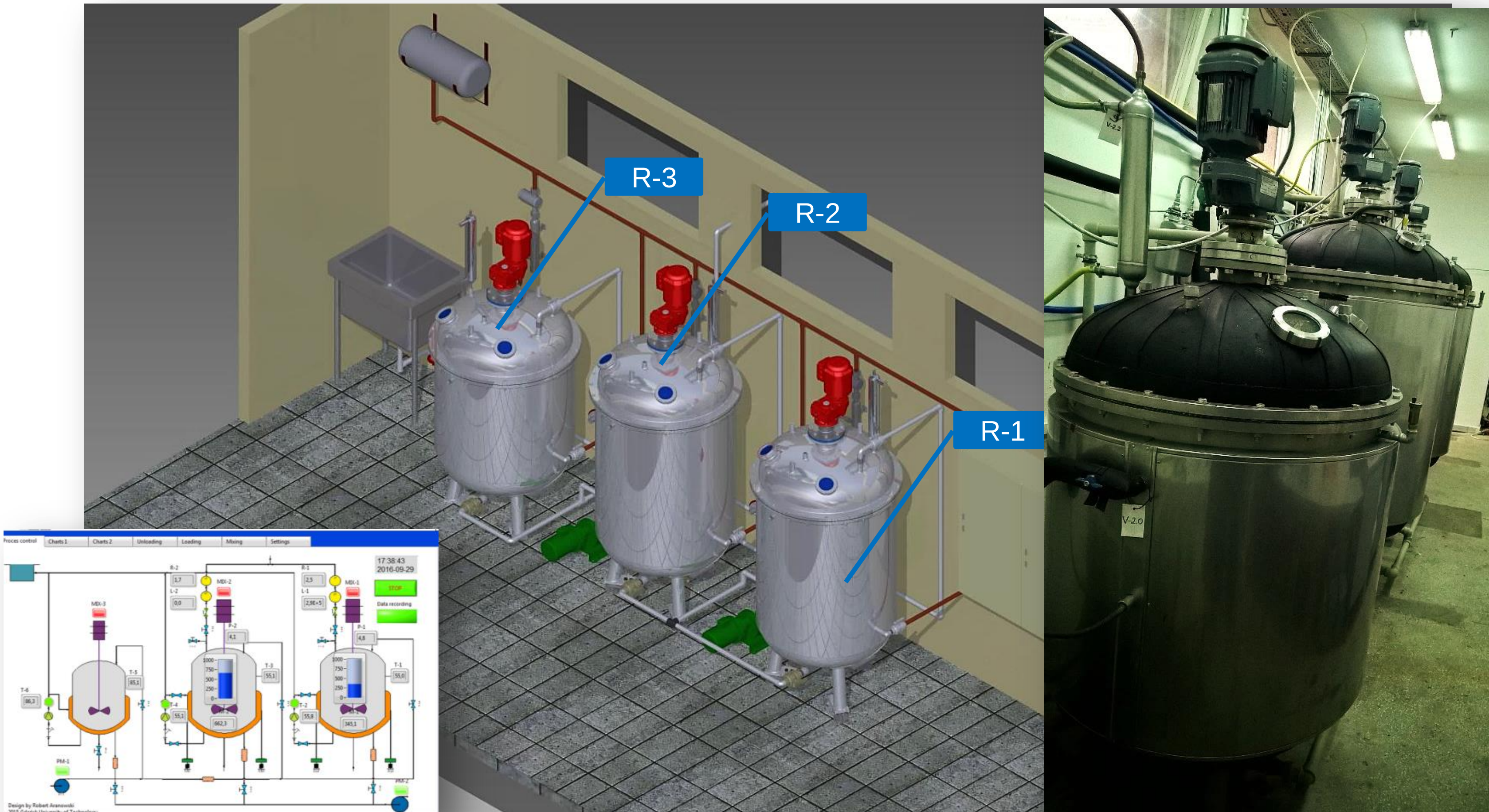
Visualization of pilot installation



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Parameters of digestion process

Parameter (average)	Bioreactor 1	Bioreactor 2
Hydraulic retention time	11 days	
Organic loading rate	10.45 kg d.o.m./m^3 d	
Decomposition rate	66%	64%
Carbon/nitrogen ratio	18.05	17.66
Biogas yield	0.35 m^3/kg d.o.m.	0.42 m^3/kg d.o.m.
VFA	7078 mg/dm^3	6792 mg/dm^3
N-NH_4^+	733 mg/dm^3	690 mg/dm^3
VFA/Alkalinity	0.23	0.21

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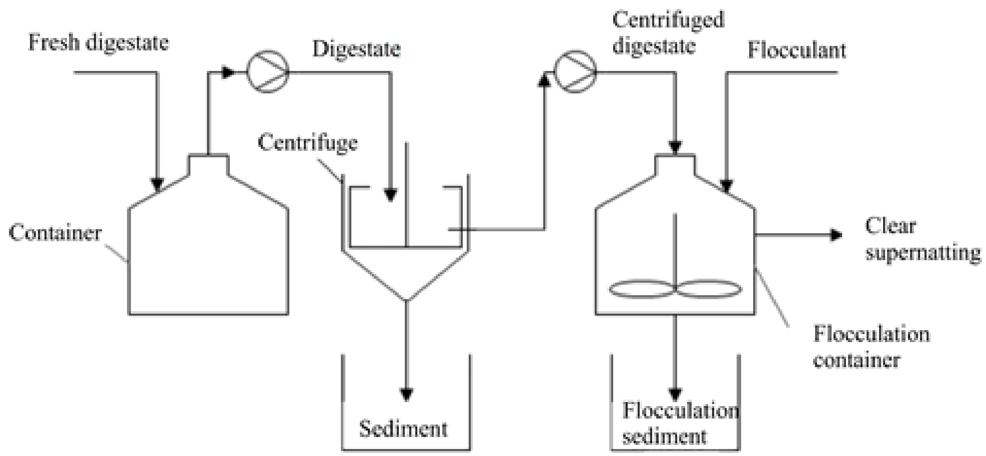
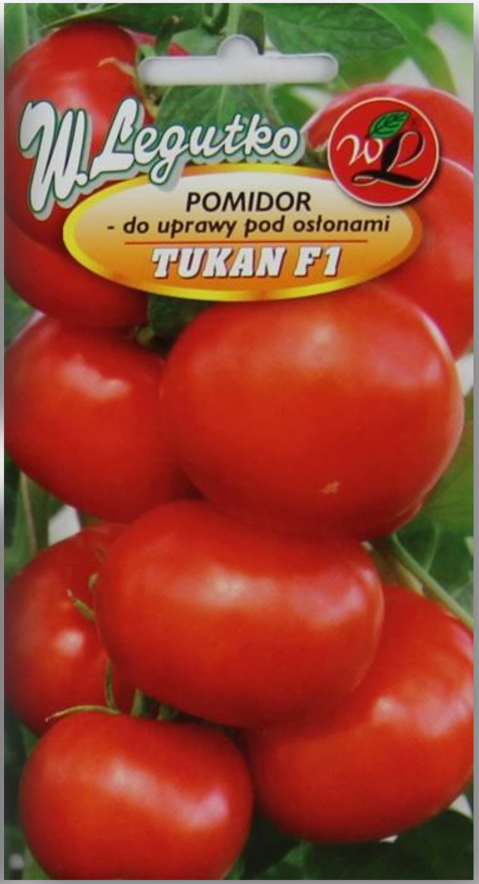
Dewatering of digestate

- Centrifuging (0.5 m^3/h)
- Flocculation by using the cationic polyelectrolyte – polyacrylamide



Assessment of the agricultural potential of digestate



Test 1
Lolium multiflorum *GAZA*
www.pl.wikipedia.org/wiki/Życica_wielokwiatowa

Test 2
Tukan F1 Tomato
http://www.tvr24.pl/

Test 2 - *Tukan F1* Tomato

The experiment was conducted on tomato seedlings in the 15 pots, containing 9 dm^3 of soil in each pots

- Period of experiment - nine weeks (56 days), June-July

Series of experiment

- Series 1 (control group) – was watered with tap water
- Series 2 – 25% content of optimal nutrients dose
- Series 3 – 50% content of optimal nutrients dose
- Series 4 – 100% content of optimal nutrients dose
- Series 5 – watered with digestate,

Every seven days content of nutrients in the soil, yield of green biomass, were measured

Grape of tomato fruits

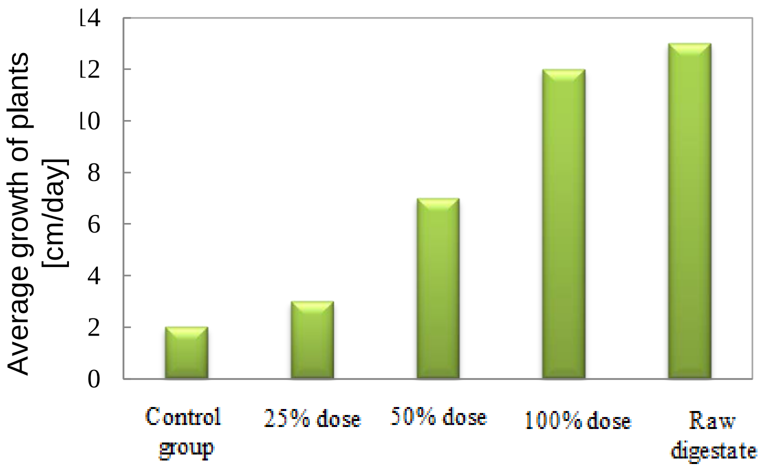
100% dose | 50% dose | 25% dose | Control group

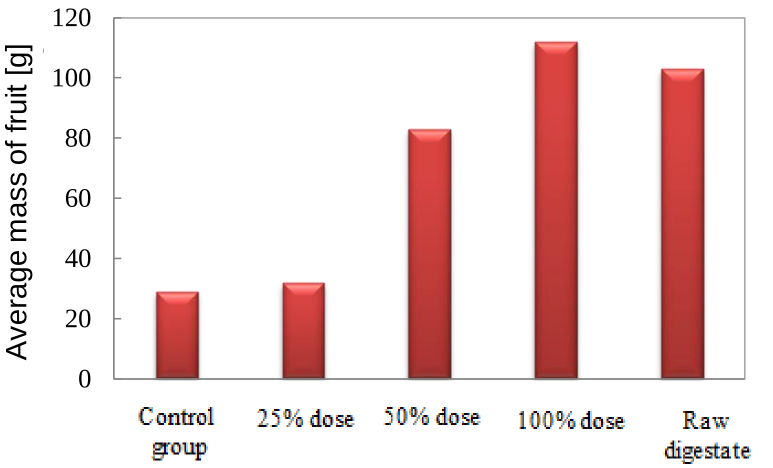
Fruit of tomatoes

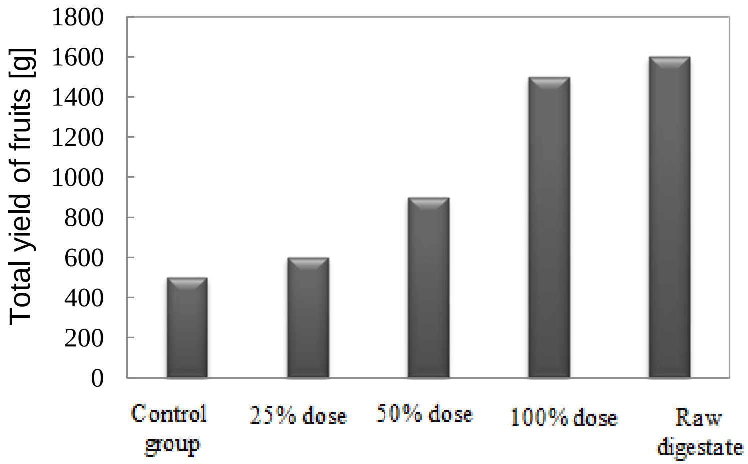
100% dose | 50% dose | 25% dose | Control group

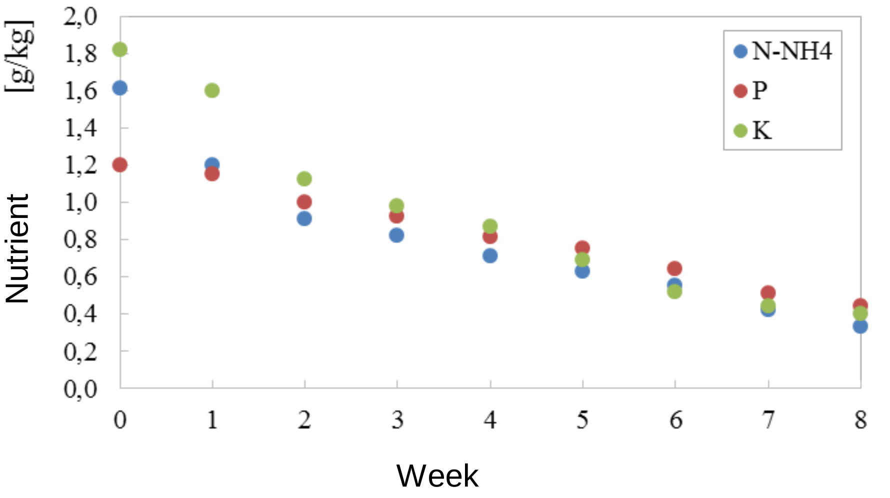
Leaves of seedlings watered with water (on the left) and watered with digestate covered 100% of the nutrients demand (on the right)

Results of experiment 2
Tukan F1 Tomato









Methodology of struvite precipitation

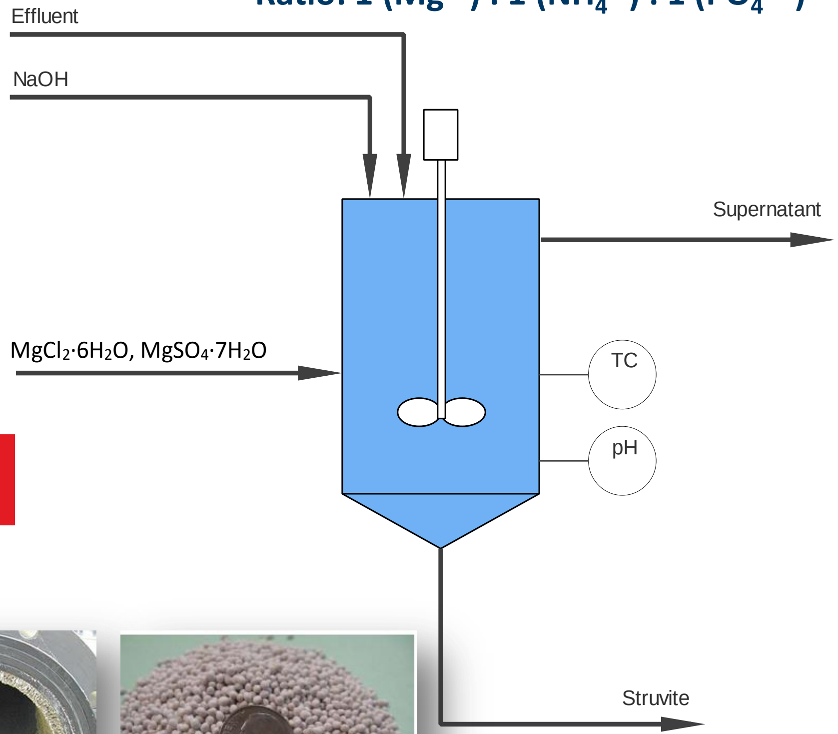
$$Mg^{2+} + NH_4^{+} + PO_4^{3-} + 6H_2O \leftrightarrow MgNH_4PO_4 \cdot 6H_2O$$

(struvite)

Feedstock

- Effluent from anaerobic digestion of organic municipal wastes (70 g PO_4-P/m^3 i 650 gNH_4-N/m^3)
- alkalizing solution: 1 M NaOH
- The source of magnesium cations: $MgCl_2 \cdot 6H_2O$, $MgSO_4 \cdot 7H_2O$

Ratio: 1 (Mg^{2+}) : 1 (NH_4^{+}) : 1 (PO_4^{3-})



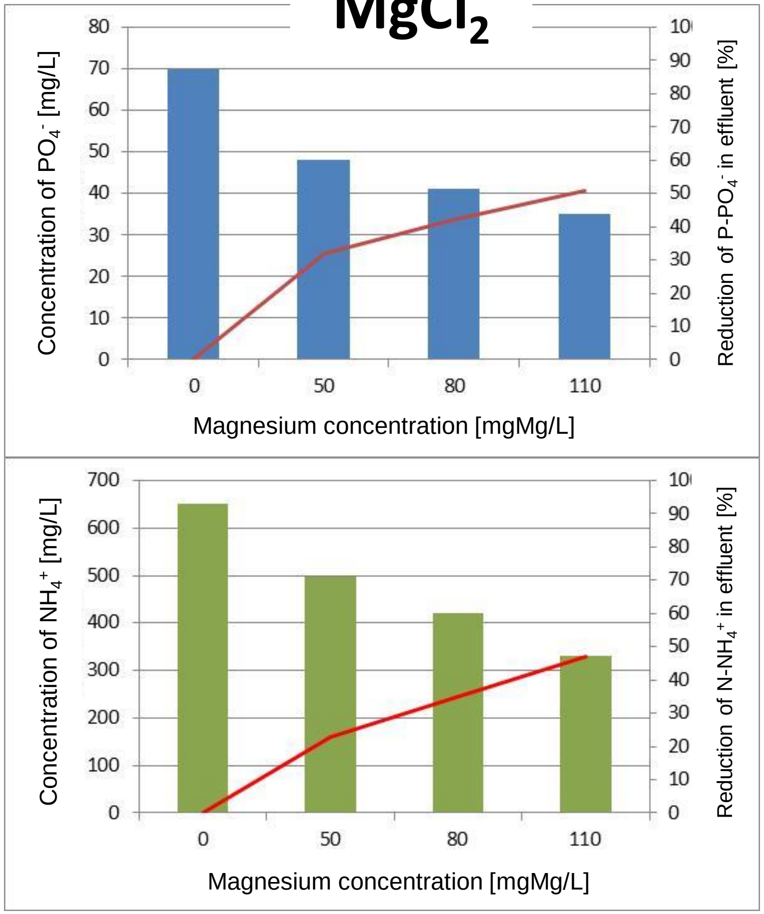
Operating parameters of the system

- Temperature 25°C
- pH=9
- Reaction time t=1 h
- Stirring speed 240 rpm

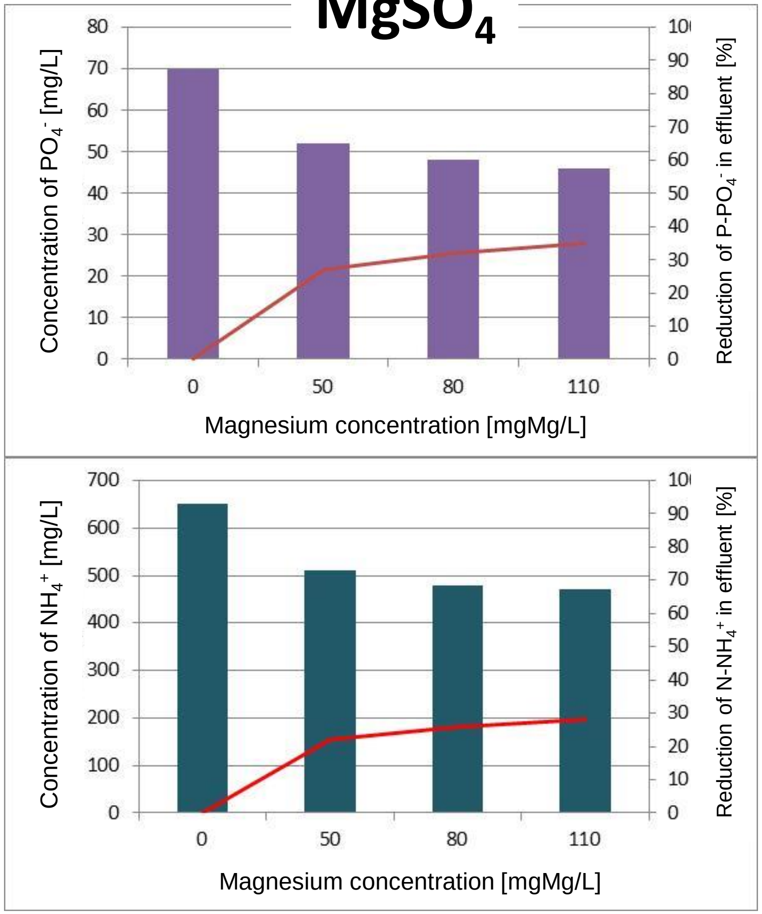

www.kemipol.com.pl

The efficiency of PO_4-P and NH_4-N removal in laboratory test

$MgCl_2$



$MgSO_4$



Removing nitrogen from effluents – test system

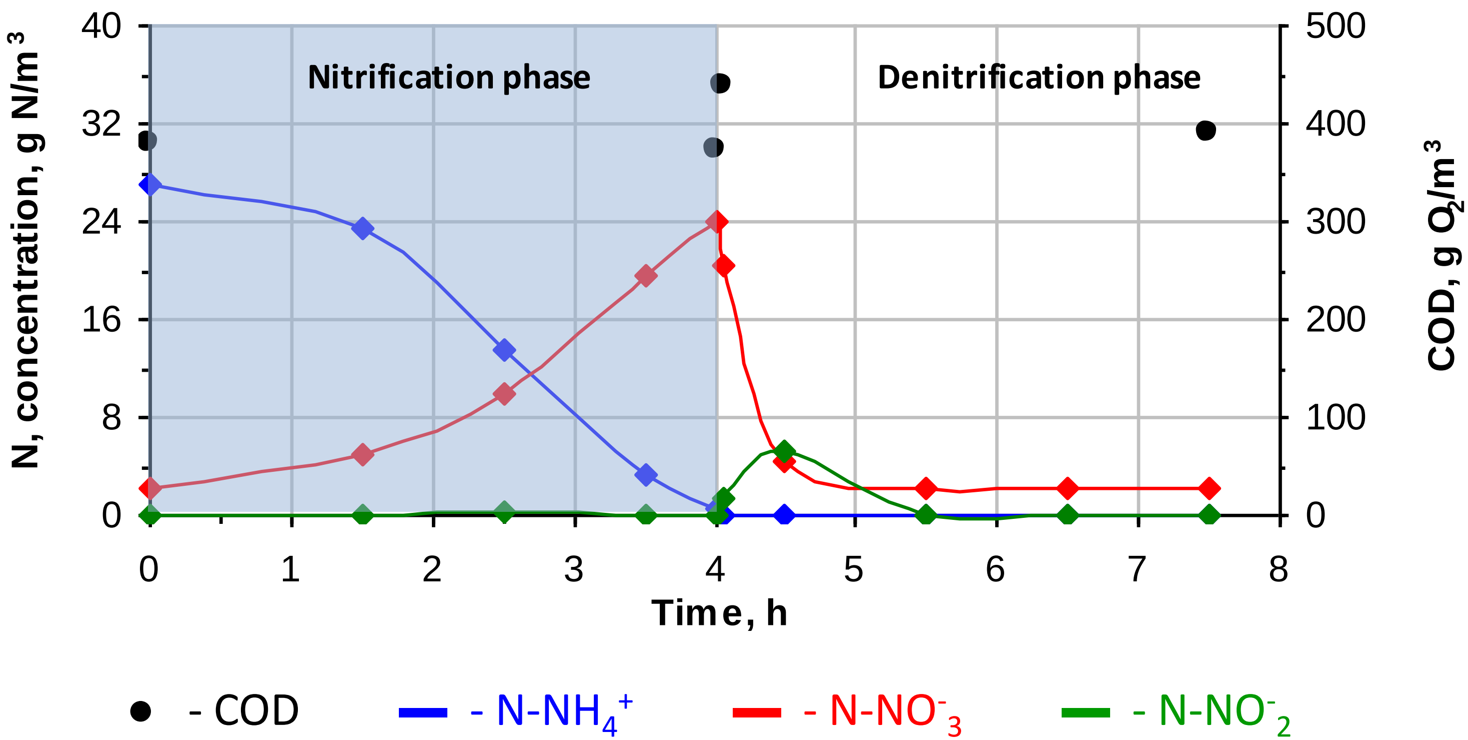
Laboratory scale of SBR

- Volume of bioreactors 2 x 10 dm^3
- Fully controlled (inflow and outflow of effluent, temperature, oxygen concentration and pH)

Pilot scale of SBR

- Volume of bioreactors 300 dm^3
- Fully controlled (inflow and outflow of effluent, temperature, oxygen concentration and pH)

Examples of test results in laboratory scale (20th day)



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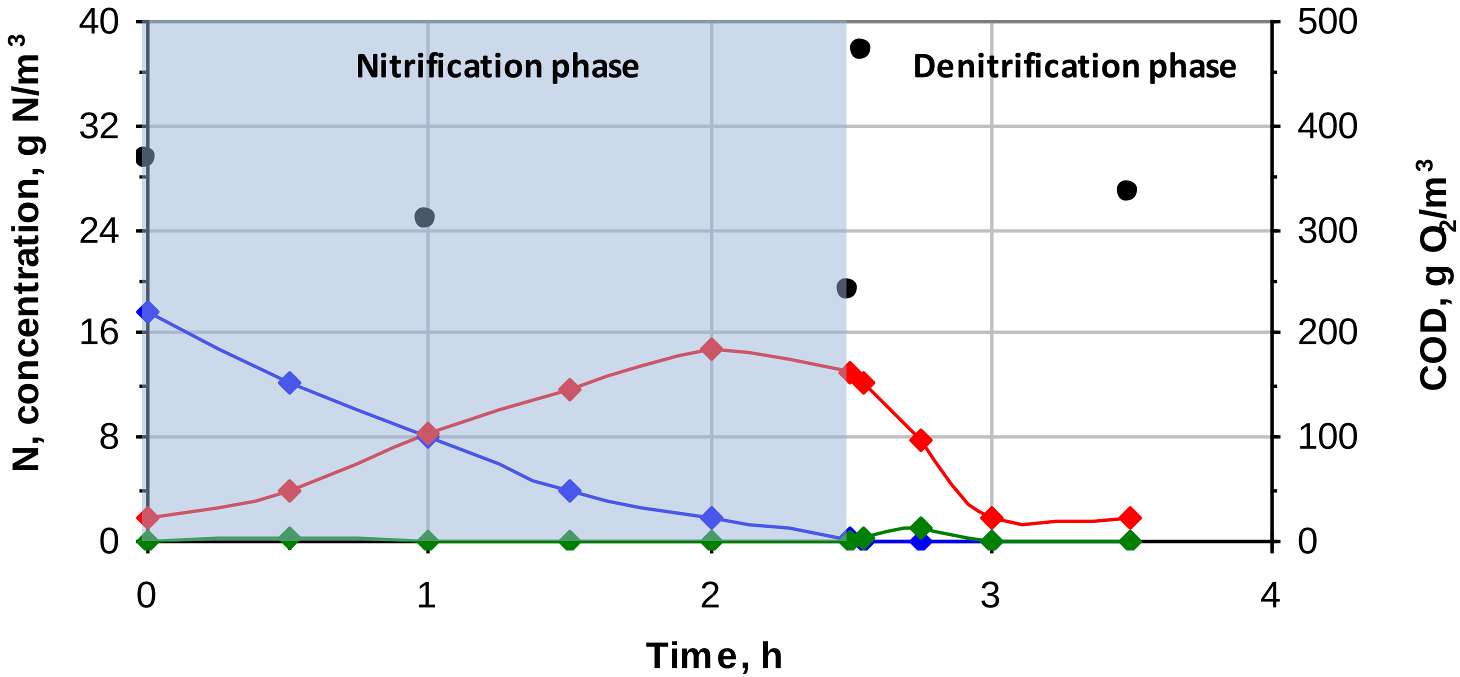
Examples of test results in pilot scale (20th day)



● - COD   - N-NH_4^+ - N-NO^-_3 - N-NO^-_2

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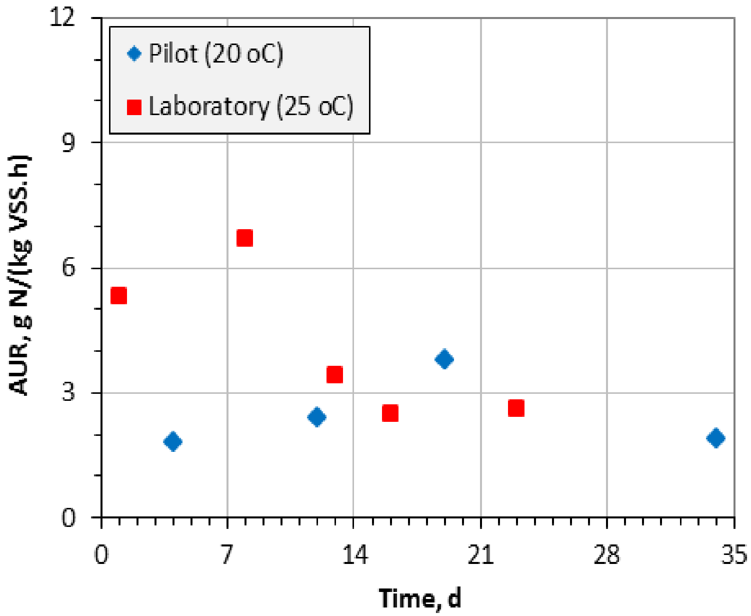
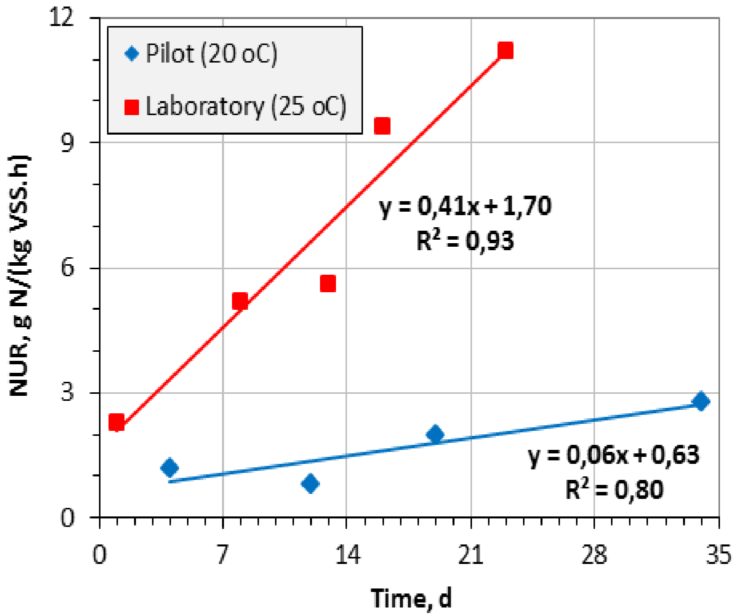
Summary of nitrification and denitrification results

Rate of nitrification



Rate of denitrification



Summary

The efficiency of nitrogen removal from LF digestate >90%

The rate of denitrification process >10 gN/(gVSS h)

The efficiency of recovery of phosphorus in the form of struvite > 50%, depending on many factors

The results show ability to integrate removal nitrogen and phosphorus recovery processes from digestate

The proposed solution allows recycling of water to the fermentawatetion of the organic fraction of municipal waste

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