# Grassification

## D 1.4.1.
## Co-digestion of roadside grass with VeDoWS manure and pig slurry

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## The GRASSIFICATION project

Roadside grass clippings are a problem fraction throughout the 2 Seas Programme area due to their high volume, subject to high processing costs. The industrial sector, however, is interested in the possibility of using roadside grass clippings as an alternative resource (as opposed to fossil sources or dedicated agricultural produce, e.g. isolation material). The common challenges for applying roadside grass clippings as a renewable feedstock in industrial processes are currently threefold:

- the supply chains are not yet optimal, resulting in higher costs;
- a highly variable and heterogeneous quantity;
- an unsupportive institutional framework leading to legal and political challenges.

The overall objective of the Grassification project is to apply a multi-dimensional approach to roadside grass clippings refining in order to optimize it into a viable value chain for the biobased and circular economy. The project commits itself to optimize logistics and technical aspects of the grass clippings supply chain and processing, demonstrate its market potential as well as formulate policy and legal recommendations to create a more supportive framework for the recycling of this renewable resource. These actions will increase the volume of usable material, lower costs, and generate a higher added-value for this so-called ‘waste’ streams. In this way, the use of roadside grass clippings as a renewable resource for the production of biobased products and hence the circular economy will become more attractive.

## Context of the document

With this activity, an exploratory digestion test on pilot-scale was conducted in the installation of Inagro to determine whether verge grass can be digested (20 v/v %) in co-digestion with VeDoWS manure and pig slurry and whether this can lead to a stable digestion process. Roadside grass is highly available approximately twice a year: in June and September, when mowing works are allowed and verges are mown. Despite mowing being mandatory in Belgium, according to the verge decree (Bermbesluit), processing is not yet optimal. Given the peak of available grass for further processing, preservation steps are required, such as ensiling and digestion.

Co-digestion of grass has already been studied in previous projects (GR3, Graskracht, Bermg(r)as), but not in co-digestion with manure. Based on results in these projects, this research focused on co-digestion with manure and with higher volume of grass fed to the digester.

## Methods

The approach can be structured as follows:

1) Grass delivery and ensilage,
2) Manure and manure delivery,
3) Pilot plant,
4) Sampling and analyses.

**Grass delivery and ensilage**

The supplied roadside grass was ensiled at Inagro in a trench silo at the end of October 2019. This grass had been mown in Harelbeke with a flail mower with adapted head (Vandaele) developed in Grassification. This adapted head was shown to decrease litter and sand fractions in the grass clippings (see D1.1.2 of Grassification).

*Figure 1: (left) Flail mower mowing of roadside in the commune of Harelbeke with (right) an adapted mowing head (Vandaele).*

No further pretreatment was done before ensilage. Ensilage was done in a trench silo, see Figure 2. No additives were used. The grass was compacted and covered to create an anaerobic environment. The grass had an initial DM content of <30%.

*Figure 2: (a) Delivery of the grass end of October 2019 ; (b+c) spreading the grass in the trench silo + compacting it; (d) cover placed on the grass in the trench silo.*

Because the clippings could not be delivered in 1 day, the clippings were ensiled in 2 times. This is not ideal, but it does reflect the possible reality and challenges. In total, 20 tons of roadside grass was delivered.

**Manure and manure delivery**

Inagro is dependent on external parties for the supply of fresh pig slurry, as there is no own pig farm on the site. The faecal fraction from pigs (collected fresh by an adapted stable construction VeDoWS) was used in this trial, since the biogas potential of this fresh, faecal fraction is two times higher than pig slurry. Because the dry matter-content of this faecal fraction is often too high to be pumped, conventional pig slurry (although not fresh) was added in order to adjust the viscosity to prevent possible operational difficulties with the installation.

Contact was laid with the deliverer of VeDoWS manure to assure the manure has approximately the same quality throughout the testing period. Pig slurry was delivered twice a week.

**Anaerobic digestion**

The test was carried out in the Inagro pilot plant, operational since 2007 (Figure 3). The installation is a classic CSTR reactor (200 $m^3$ with a filled volume of approximately 150 $m^3$), with an electrical power of 31 kW, which is controlled by Inagro in the mesophilic temperature range (± 38 ° C). Biomass is mixed using a Peters Fermento Mixer (11 kW), adjustable in width and height. Before the biogas is burned in a combined heat and power unit (CHP), water vapor and sulfur are removed via a condensation step and biological desulphurization.

*Figure 3: Overview of the biogas pilot plant at Inagro: (1) Silage tanks to store and feed liquid fraction of pig slurry; (2) Screw press to feed the VeDoWS manure and the roadside grass; (3) Mixer; (4) Reactor; (5) Air injection for desulfurization; (6) CHP; (7) trench silo for VeDoWS.*

In general, the following amounts were fed daily to the digester:

- 1000 kg of VeDoWS manure
- 1400 kg of pig slurry
- 600 kg silage verge grass (representing 20 w/w% of the total mixture)

Figure 4 shows the daily relative percentage of grass fed to the digester, in relation to the total amount of VeDoWs, roadside grass and pig slurry. However, this is an approximation as Inagro fills in the screw press every two to three days with VeDoWS and roadside grass, as such that the digester is fed for two to three days. Only the amount of VeDoWS and grass added to the screw press, as well as the amount of feed from screw press, is noted in the digital logbook. Figure 4 shows variation in the percentage of grass fed to the digester. Some causes for this variation are: (1) small variation of the % of grass in the screw press (37%±1.6%); (2) due to the viscosity of the pig slurry, a full screw press consumes differently compared to a nearly empty screw press and this is manually adapted ; (3) variation in pig slurry supply and thus pig slurry feeding.

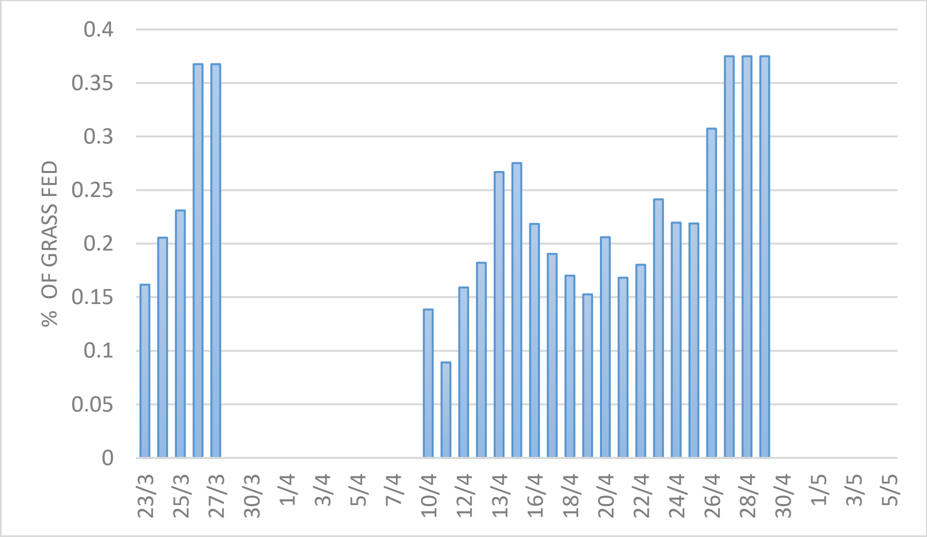

*Figure 4: **Daily % of grass fed to the digester***

The following parameters were monitored regularly:

- Feed of the digester
- Energy production and consumption
- Temperature
- Gas production and composition (% $CH_4$ continuously, $H_2S$ manually)
- Observations on foam forming
- Mixing settings
- Disposal volume of digestate
- Special observations

The experiment started on 23/03/2020 and ended on 05/05/2020. Unfortunately, the motor was defective from 25/3/2020 to 09/04/2020, and the digester was minimally fed. This causes difficulties in interpreting the results. Given the limited amount of grass available in the silage and the willingness of feeding with 20% w/w in roadside grass, a retention time of only 35 days was possible. Due to the encountered motor problems, the digester was fed as planned from 23 to 25 of March and from 10th of April to 5th of May. From the 30th of April, no additional grass was fed to the screw press as all the grass had been consumed. The problems encountered underline the importance of setting-up bigger experiments to account for possible obstacles.

**Sampling and analyses**

Sampling of VeDoWS, pig slurry and roadside grass was based on the sampling protocol of VITO, available on: https://emis.vito.be/nl/referentielabo-vlm. Table 1 shows the sampling dates:

*Table 1: Sampling moments of VeDoWS, pig slurry, roadside grass and digestate*

| | 23/3/2020 | 26/3/2020 | 9/4/2020 | 15/4/2020 | 23/4/2020 | 05/05/2020 | 25/05/2020 |
|---|---|---|---|---|---|---|---|
| VeDoWS | x | | | x | x | x | |
| Pig slurry | | | x | x | x | x | |
| Roadside grass | | x | x | | | | |
| Digestate | x | x | x | x | x | x | x |

Each batch of manure (both Vedows and pig slurry), as well as the roadside grass that was fed to the digester, was sampled shortly after delivery and then analysed for the following parameters at Inagro (not all parameters were analysed for the roadside grass):

- pH,
- Total nitrogen (TN) concentration [g/ kg],
- Total ammoniacal nitrogen (TAN) concentration [g N / kg],
- Dry matter content [%],
- Organic dry matter content [% DS],
- C/N
- FOS / TAC ratio where FOS (= volatile organic acids) and TAC (= total inorganic carbon)
- Total sulfur content [g / kg],
- Conductivity (EC) [mS / cm],
- Potassium content [g $K_2O$ / kg],
- Phosphor content [g $P_2O_5$ / kg]
- Additionally, following parameters were analysed at Innolab:
- Dry Matter content [%],
- Crude proteins [kg/ton],

- Crude fats [kg/ton],
- Carbohydrates
- Biogas potential [$m^3$ biogas/ton],
- Methane content [$m^3$ CH4/ton]
- Methane potential

One BMP test was also performed on both types of manure and on the verge grass during the start-up phase of the pilot test, which gives us an estimate of the desired residence time and the possible total biogas yield over this time period. The latter is expressed in $m^3$ biogas per kg fresh material, $m^3$ $CH_4$ per kg fresh material, $m^3$ biogas per kg ODM, $m^3$ $CH_4$ per kg ODM and subsequently converted into comparable units in $Nm^3$.

Digestate was sampled every week and analysed in the laboratory of Inagro and Innolab for the same parameters as mentioned for manure and grass clippings.

## Results and discussion

Characteristics of the VeDoWS manure, the pig slurry and roadside grass fed to the digester are found in Table 2. The digestion process is optimal when parameters are kept constant. Therefore, mean values and standard deviations are indicated.

*Table 2 Overview of the analyses of input material VeDoWs, pig slurry and roadside grass*

| **Parameter** | **Unit** | **VeDoWS** | **Pig slurry** | **Roadside grass** |
|---|---|---|---|---|
| pH | | 7.24 ± 0.43 | 7.63±0.03 | 5.14 |
| Ammonium N | *g NH3-N/kg FM* | 1.53±0.40 | 2.79±0.29 | 0.73±13.13 |
| Total N | *g/ kg FM* | 10.23±0.21 | 4.63±0.82 | 2.65±0.41 |
| Mineral N | *g/ kg FM* | 1.53±0.41 | 2.80±0.29 | |
| Kjeldahl N | *g/ kg FM* | 10.29±0.21 | 4.62±0.83 | |
| Potassium | *g/kg $K_2O$ FM* | 3.49±3.49 | 4.46±0.99 | |
| Phosphorous | *g/kg $P_2O_5$ FM* | 8.89±0.06 | 2.97±0.84 | 5.65 ± 0.41 |
| Dry Matter | *%* | 25.5±8.8 | 6.1±1.8 | 31.94±1.3 |
| OC | *g/ kg FM* | 117.70±4.2 | 25.68±7.58 | 134.393±12.24 |
| OM | *g/ kg FM* | 211.86±7.55 | 46.22±13.64 | 240.02±19.31 |
| C/N | | 11.45±0.18 | 5.45±0.67 | |
| FOS | *mg $CH_3COOH$/L* | 31610.50±2593.5 | 3369.5±580.5 | |
| TAC | *mg $CaCO_3$/L* | 15906.5±231.5 | 16038.0±2425.0 | |
| FOS/TAC | | 1.99±0.19 | 0.21 | |
| Conductivity | *mS/cm* | 6.11±0.3 | 23.42±1.64 | |
| Crude proteins | *Kg/ton* | 49.2±2.6 | 10.01±2.39 | 35.4 |
| Crude fat | *Kg/ton* | 23.1±2.1 | 1.38±0.40 | 14.6 |
| Carbohydrates | *Kg/ton* | 116±10 | 21.3±9.3 | 87.4±13.6 |
| Biogas potential[1] | *$M^3$ biogas/ton* | 135±7 | 15±1 | 96±5 |
| Methane content | *%* | 58±0 | 57±0 | 56.5±1.5 |
| Methane potential | *$M^3CH_4$/ton* | 78±4 | 9±0 | 56±3 |
| Biogas potential[2] | *$M^3$ biogas/ton* | 157.1 (rt = 42) | 33.2 (rt = 42) | 107.9 (rt = 39) |

[1] Theoretical calculation based on substrate characterization

[2] Experimental determination in optimal conditions

rt = retention time

Digestate was sampled and analysed 4 times during the experiment. Results are found in Table 3. In total, 72.5 ton of digestate was pumped.

*Table 3 Overview of the analyses of the digestate during the experiment*

| **Parameter** | **Unit** | **09/04/2020** | **15/04/2020** | **23/04/2020** | **05/05/2020 or 25/05/2020*** |
|---|---|---|---|---|---|
| pH | | 8.05 | 8.15 | 8.11 | 8.6 |
| ammonium N | *g NH3-N/kg FM* | 5.61 | 5.74 | 4.24 | 5.7 |
| Total N | *g/ kg FM* | 9.09 | 8.74 | 6.61 | 8.7 |
| Mineral N | *g/ kg FM* | 5.61 | 5.74 | 4.24 | 5.7 |
| Kjeldahl N | *g/ kg FM* | 9.09 | 8.74 | 6.61 | 8.7 |
| Potassium | *g/kg* $K_2O$ *FM* | 6.54 | 6.57 | 4.68 | 6.9 |
| Phosphorous | *g/kg* $P_2O_5$ *FM* | 7.58 | 6.39 | 4.88 | 6.6 |
| Dry Matter | *g/ kg FM* | 144.6 | 124.89 | 91.71 | 129 |
| OC | *g/ kg FM* | 56.71 | 49.09 | 38.73 | 50.6 |
| Organic matter | *g/ kg FM* | 102.08 | 88.37 | 69.72 | 91.2 |
| C/N | | 6.24 | 5.61 | 5.86 | 5.8 |
| /TAC | | 0.23 | 0.21 | 0.17 | 0.19 |
| conductivity | *mS/cm* | 8.16 | 8.06 | 6.33 | 7.8 |
| Dry matter | *%* | 14.16 | 12.38 | 9.56 | 13.44* |
| Organic dry matter | *% DM* | 71.8 | 70.5 | 70.56 | 74.45* |
| Crude fat | *kg/ton* | 4.29 | 4.35 | 6.72 | 4.31* |
| Crude proteins | *kg/ton* | 17.1 | 15.2 | 13.4 | 19.9* |
| Carbohydrates | | | | | 44.4* |
| Biogas potential | *$m^3$ biogas/ton* | 40 +- 2 | 50 +- 3 | 32+-2 | 39±3* |
| Methane content | *%* | 58 | 56 | 60 | 57* |
| Methane potential | *$m^3$ $CH_4$/ton* | 23 +- 1 | 28 +- 1 | 19+-1 | 22±1* |
| Biogas potential | *$M^3$ biogas/ton* | 36.3 (rt = 44) | 46 (rt = 44) | 30.4 (rt = 46) | |

Some important parameters are described in the following paragraphs.

**Dry Matter (DM) content**

The grass had a low initial dry matter content. After ensiling, DM% increased to 31.93%±1.3%. For wet digestion, a DM of <20% is advised to ease pumpability of input materials and digestate (20% is a standard for small scale digesters in Belgium). Due to the high DM of VeDoWS (26.76% ±1.44%) and roadside grass (31.93%±1.3%), pig slurry was used as a third input material. No problems were encountered with the grass fibres. The DM content of the digestate fluctuated from 14.16 % to 9.56 %.

**Temperature**

The mesophilic digestion (32-42 °C) implies a slower digestion process compared to thermophilic digestion (48-55 °C). Figure 5 shows that a mesophilic temperature was reached for the whole experiment (34.9-41.34°C), starting from the second start on 9/4. However, temperature was not kept constant during the experiment, with a standard deviation of ± 2.41. Due to the problems encountered in the period 23/3 – 8/4, the temperature strongly decreased. It took a while to reach 41°C, a mesophilic temperature that was already successful for co-digestion of pig manure. From 14th of April, the temperature increased again. In contrast to the temperature, the biogas production ($m^3/h$) kept quite stable during the trial (Figure 6). Once the problems with the digester were solved, biogas production increased from 2.4 (9th of April) to 9 (10th of April).

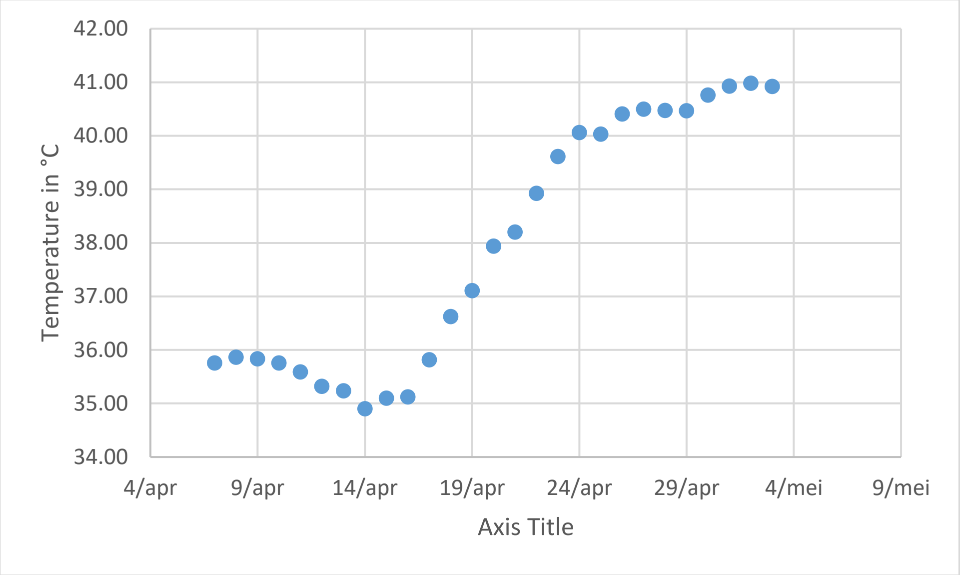

*Figure 5: Temperature during the trial*

**Biogas production**

Figure 6 shows the biogas production ($m^3/h$) during the trail. 7.5 to 9 $m^3/h$ was produced. As a comparison, Pocket Power obtained a biogas production ($m^3/h$) between 7 and 9 once the system had stabilised. The daily produced electricity (kWh) (Figure 11) further gives an indication on the productivity of the feed composition.

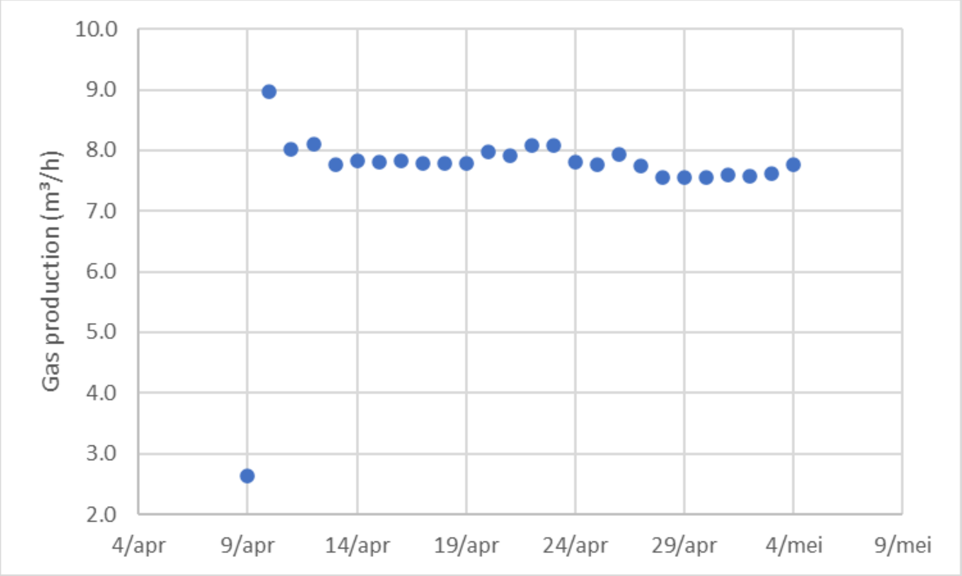

*Figure 6: Biogas production during trial ($m^3/h$)*

**Biogas and methane potential**

Based on the BMP-tests, the biogas potential of VeDoWS manure is the highest (157.1 $m^3$ biogas/ton). Pig slurry has the lowest biogas potential (33.2 $m^3$ biogas/ton). The biogas potential of roadside grass is situated in between (107.9 $m^3$ biogas/ton). The amount of carbohydrates has a direct link with the biogas potential, because these are easily degradable sugars. VeDoWS had the highest amount, 116±10 kg/ton, compared to 21.3±9.3 kg/ton and 87.4±13.6 kg/ton for pig slurry and roadside grass, respectively.

VeDoWS and pig slurry have a higher standard deviation compared to roadside grass. Roadside grass originated from the same ensilage. VeDoWS and pig slurry were delivered at different moments, which might explain the higher standard deviation. However, attention is paid to deliver similar manure during the experiment.

The biogas potential of the digestate decreased during the experiment. However, at the end of the experiment, the digestate still had a biogas potential of 39 $m^3$ biogas/ton, showing that the retention time should be longer to obtain a bigger gas production. This is in line with a previous experiment with VeDoWS and pig slurry. VeDoWS and pig slurry slowly reach their maximal biogas potenial. Roadside grass reaches 60% of its maximum after only three days. Longer retention times are not necessary for the grass: the ensilage process was already preparing the grass for further digestion. Figures 7 to 10 show the biogas production of the samples throughout the incubation periods at Innolab.

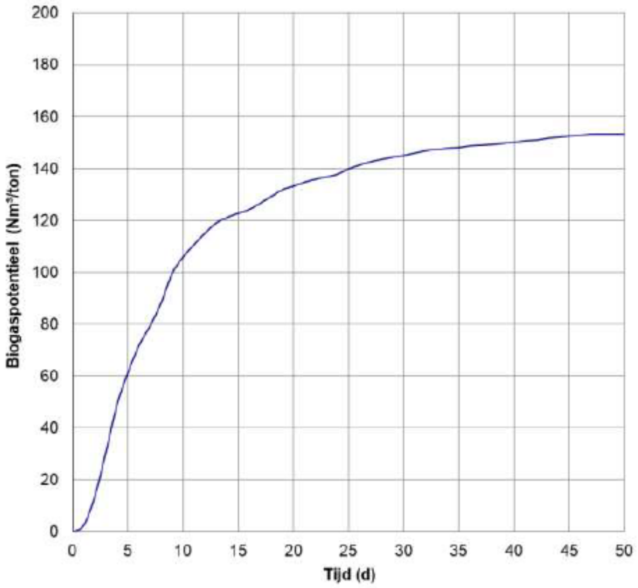

*Figure 7: BMP test VeDoWS manure - after 7 days, 50% of the biogas potential has been reached. After 24 days, 90% of the maximal biogas potential is reached.*

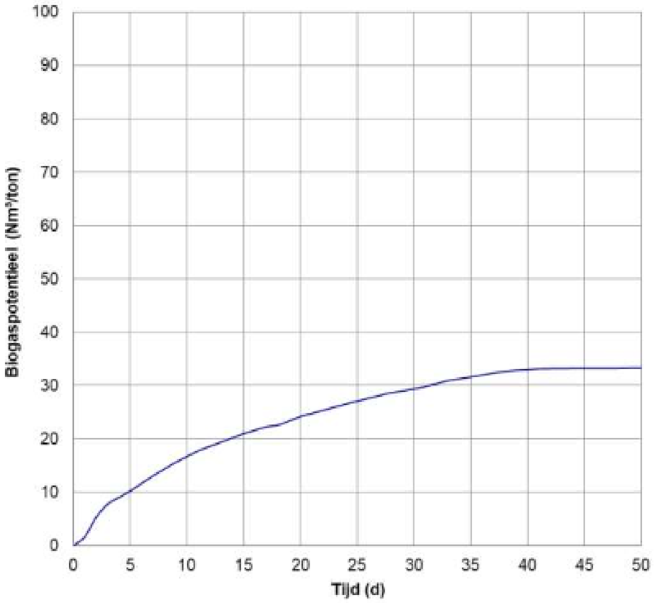

*Figure 8: **BMP test pig slurry - after 10 days, 50% of the biogas potential (33.2 Nm³/ton) has been reached. After 31 days, 90% of the maximal biogas potential is reached***

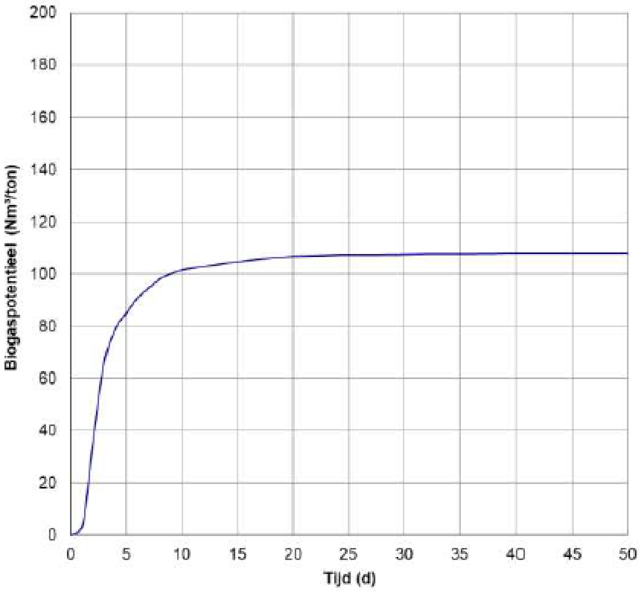

*Figure 9: **BMP test roadside grass - after 3 days, 60% of the biogas potential has been reached. After 8 days, 90% of the maximal biogas potential is reached***

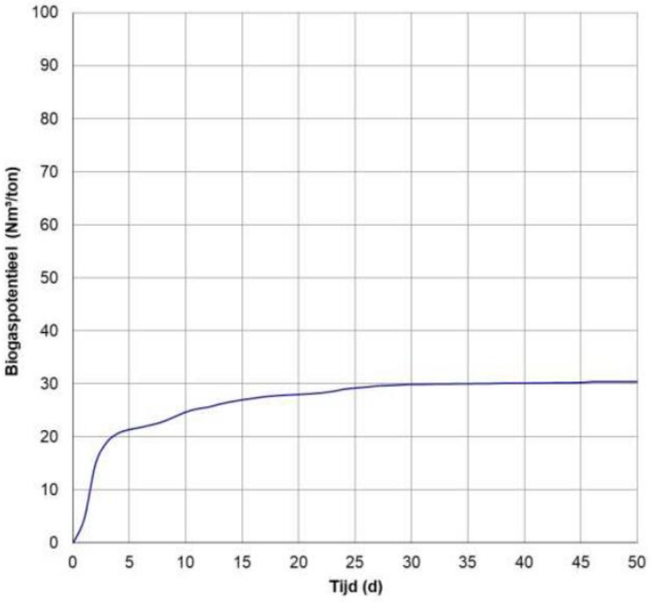

*Figure 10: BMP test digestate 23/4 - after 3 days, 50% of the biogas potential has been reached. After 14 days, 90% of the maximal potential is reached.*

**pH**

An ideal pH for wet digestion is situated between 7.5 and 8.2. An acidification of the reactor has a negative impact on the methanogenic bacteria, which are essential to convert volatile acids to biogas. A pH which is too low causes $CO_2$ release in the reactor, with consequences as a lower biogas quality and possible foaming.

The pH was stable during the digestion. Roadside grass had the lowest pH (5.14), followed by pig slurry (7.63 ± 0.03) and VeDoWS manure (7.24 ± 0.43). The digestate had a stable pH of 8.10 ± 0.04. The low pH of roadside grass shows that higher amounts of roadside grass might affect the bacterial equilibrium of the reactor. However, a lower pH was expected after grass ensilage. The pH of 5.14 might indicate that the ensiling process was not optimal. This could be related to the fact that the grass was ensiled in two different days. The cover had to be removed to ensile the second part, allowing oxygen to reach the grass and hamper the ensiling process.

**FOS/TAC ratio**

FOS/TAC ratio is an additional indicator for acidification, with FOS (volatile organic acids) as a measure for total fatty acids concentration and TAC (total inorganic carbon). FOS/TAC is ideally situated between 0.3 and 0.4. The digestate had a FOS/TAC of 0.2 ± 0.02, which is low. The FOS/TAC of the VeDoWS was high (1.99 ± 0.19), compared to that of pig slurry (0.21). FOS/TAC of grass was not measured. The low values of FOS/TAC in the digestate indicate that the feeding of the digester could be increased (Biogas-E, no date).

**C:N**

An ideal C/N ratio for input materials is 16/1 to 25/1. C/N of VeDoWS and pig slurry are rather low (11.45 ± 0.18 and 5.45 ± 0.67 respectively). Due to the low C/N ratio, mono-digestion of pig manure is not evidence. Adding substrates with higher C/N ratio to pig manure already showed that a stable AD process could be established. However, the C/N ratio of roadside grass is typically 10 to 25 (Steffen et al., 1998[1]; Bedoic et al., 2019[2]) . The digestate has C/N of 5.9 ± 0.26, which might explain the remaining biogas potential.

### Organic loading rate

The ideal organic loading rate is situated between 4 and 8 ODM/day.m$^3$. The organic loading rate in this experiment was calculated to be 2.83 ODM/day.m$^3$, which is low. However, this mainly impacts costs and does not necessarily hamper the digestion process. However, during the period with motor problems, the organic loading rate was lower (not calculated). The fluctuation had a big impact on the stability of the digestion process.

### Nitrogen, potassium and phosphorous

The amount of N, K and P in the digestate is comparable to the concentration of the input materials. Nutrients are not lost during digestion. The increase of mineral N in the digestate, compared to the input materials (VeDoWS and pig slurry), is a logical result of mineralisation. Nitrogen is made more easily available for crops after digestion.

The total ammonium nitrogen is an indication for the digestion process. Too high concentrations can hamper the digestion process. The digestate had an average value of 5.2 ± 0.68 kg $NH_3$-N/1000 kg FM, which is an appropriated concentration for mesophilic processes (max 6 kg $NH_3$-N/1000 kg FM) (source: Biogas-E).

### Electricity production

Figure 11 indicates the daily electricity production obtained during the pilot trial. During the trial the energy production increased starting from 9/4. Due to the problems with the digester in the period from 25/3 till 8/4, this is a logical trend. Stable values are only obtained from 19th of April, after the second start-up period. The period after feeding the grass, the daily production further increased till a plateau around 200-250 kwh.

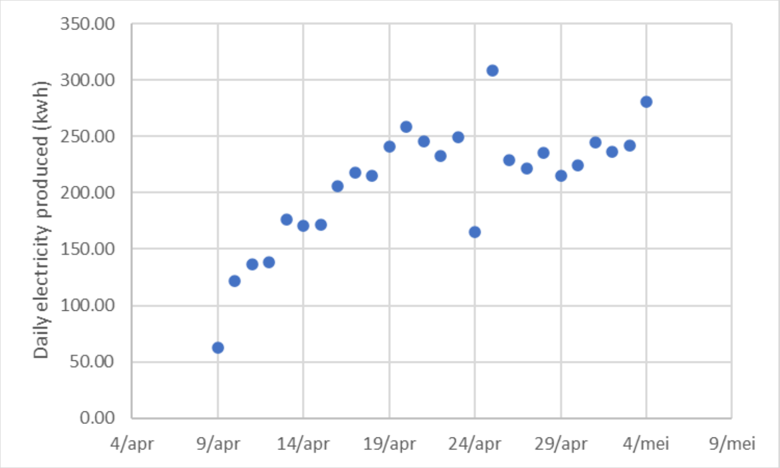

*Figure 11: Electricity produced in kWh during the trial*

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[1] Steffen, R., O. Szolar, and R. Braun. (1998). "Feedstocks for anaerobic digestion." Institute of Agrobiotechnology Tulin, University of Agricultural Sciences, Vienna

[2] Bedoić, Robert, et al. (2019). “Green Biomass to Biogas – A Study on Anaerobic Digestion of Residue Grass.” Journal of Cleaner Production, vol. 213, 2019, pp. 700–709.

**Gas composition**

Methane ($CH_4$) is the energy rich component of biogas and the higher the $CH_4$ content of the biogas, the more energy that can be produced. Figure 12 shows the variability of the $CH_4$ content throughout the test. However, starting from 13/4, a quite stable content is reached. This lower content at the beginning of the test might be explained by the problems In the previous period (25/3 – 8/4) due to which the biogas production had to start from 0. Although grass had a lower $CH_4$ content than VeDoWS and pig slurry (±54% versus ± 58%), the addition of grass does not result in a decrease of methane content.

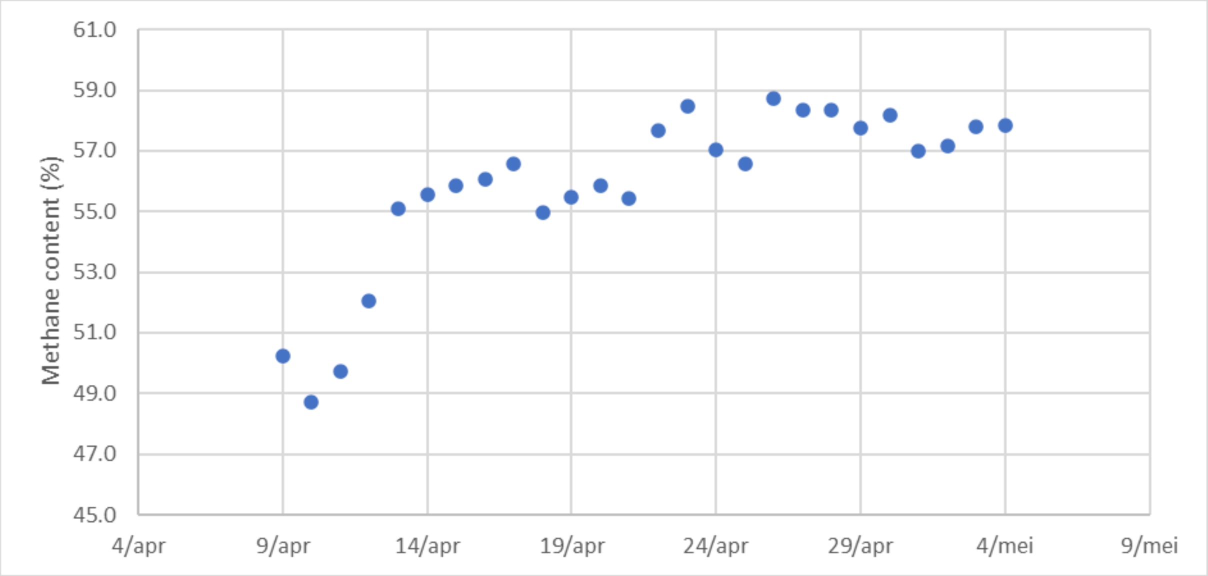

*Figure 12: Methane content of the biogas during the trial*

**Fats, proteins and carbohydrates**

The amounts of fats, proteins and carbohydrates are higher in VeDoWS > roadside grass > pig slurry. This follows the same trend as for biogas potential, as these are easily digested.

**General considerations**

In general we observe that the retention time was too short to obtain constant values and thus an optimal digestion process. By comparing the different parameter values, we see that values are still changing. In the beginning, the digester is still in a transition phase, in which micro-organisms are still adapting to the new environment. Additionally, due to motor problems, probably not all values are representative. Nevertheless, biogas production was successful and reached similar values as when the reactor was stably operating without the addition of grass.

**Bottlenecks**

The most important bottleneck for the wet anaerobic digestion of roadside grass is the presence of **litter and sand**. Sand and litter are inert materials and can accumulate in the digester, with negative consequences for pumping. Consequently, biogas production can decrease. **Figure 13** show the presence of bottles, cans, plastic packages, … The adapted mowing head used for this experiment might be better but litter is still captured. Dry anaerobic digestion might be a better option and was already studied in different grass projects such as Bermg(r)as.

*Figure 13:Examples of litter encountered in the delivered roadside grass before digestion (own pictures)*

An additional bottleneck is the **fibrousness** of the grass clippings. The fibrousness impacts degradability and might have a negative impact on biogas formation. The fibres can get stuck and cause damage to the digester. In this experiment, the fibres did not create blockages, nor foaming.

**Legislation**

Different legislations determine the possibility to co-digest roadside grass clippings. First, pathogens and weed seeds should be killed. Moreover, the digestate obtained after roadside grass digestion must undergo an integral additional treatment to reach required process conditions described on OVAM's website[3].

Second, in this experiment, the roadside grass was co-digested with manure. Therefore the digestate is also subjected to the Manure Decree[4]. This means that digestate of this combination of input materials needs to be treated by a facility meeting the hygienisation requirements, with a permit for manure treatment.

No facilities were found for the hygienisation of the obtained digestate. Therefore, Inagro asked OVAM for an exception and spread the digestate on own fields. For spreading the digestate on own fields, MAP6 is applicable. The digestate in this case is classified as type 2 fertilizer. Regulations for type 2 fertilizers are available on the website of VLM[5]. In general, the digestate can only be spread between 16th Feb until end of August.

**Other projects**

In the Graskracht project, roadside grass had a biogas potential of 274.2 Nm$^3$/ton and 59.5% CH$_4$, which was much higher. Graskracht searched for the most optimal silage technique.

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[3] https://www.ovam.be/voorwaarden-voor-het-vergisten-van-bermmaaisel

[4] https://www.biogas-e.be/kenniseninnovatie/wetgeving/digestaat

[5] https://www.vlm.be/nl/themas/Mestbank/bemesting/aanwenden-van-mest/uitrijregeling/uitrijregeling-volgens-type-meststof/Paginas/default.aspx

In Grassification, the grass had been ensilaged through a cover silo. Due to the ensiling in two times, grass probably lost some biogas potential. Additionally, spring grass clippings typically have a higher biogas potential (150-180 $Nm^3$/ton) compared to autumn grass clipping (60-150 $Nm^3$/ton) (Bermg(r)as project[6]). A correct ensilage is still important to preserve as much as possible the biogas potential of the fresh grass.

Information concerning the value chain and the economic and ecological implications are gathered in other work packages of the Grassification project, with focus on LCA (UGent) and TEA (VITO).

## Conclusion

It could be noticed that the addition of roadside grass did not disturb the process on the first sight.

Some other conclusions to account for in future tests:

- The ensilage process was not optimal, which is reflected in the pH of the roadside grass at the begin of the experiment;
- More grass should be ensiled for future trials to assure a longer retention time. Due to problems with the motor of the digester, the effective period for data analysis became short. However, this reflects the practice and other digesters could encounter those problems.
- As still some biogas potential was observed in the digestate, a longer retention time is advised for co-digestion with VeDoWS manure and pig slurry.
- Roadside grass is fastly digested, with 90% of the maximal biogas potential reached after 8 days.
- Litter is still an obstacle.

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[6] https://www.ows.be/wp-content/uploads/2014/09/Bermgras-openbaar-rapport.pdf

# GRASSIFICATION consortium

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www.interreg2seas.eu/en/grassification