
Biochar Production by Thermo-Catalytic Reforming

British Biochar 2014, 7th of July 2014 – Hawkwell House Hotel, Oxford



AGENDA

1. Motivation
2. The Biobattery Concept
3. Results
4. Outlook

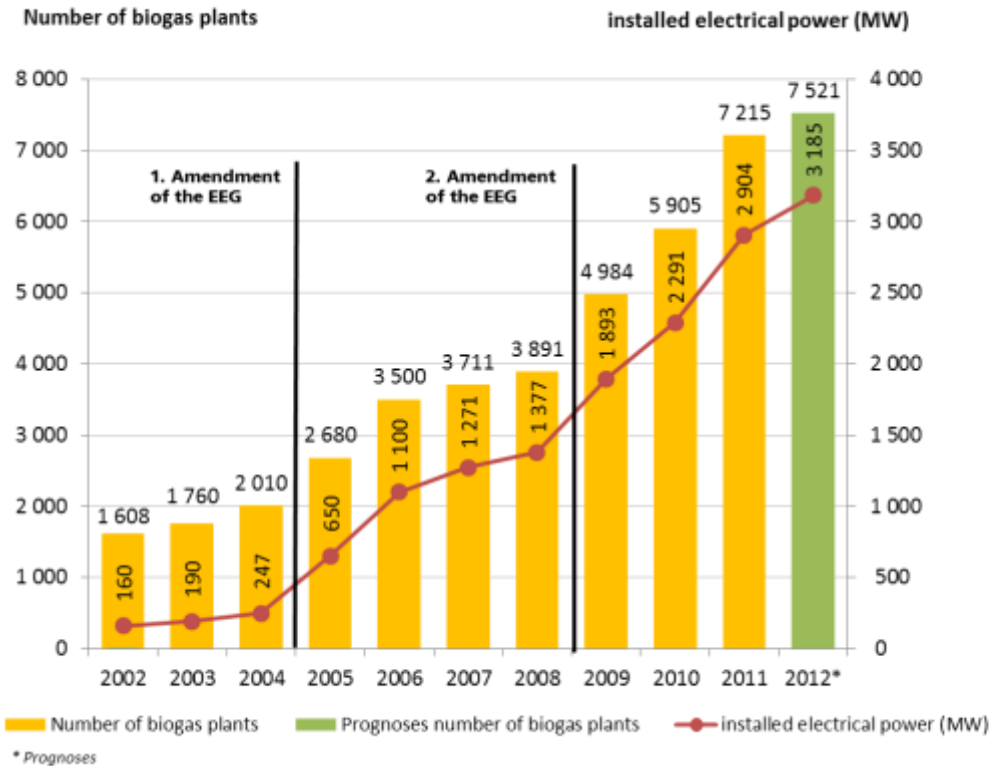
Motivation

- Biochar has excellent properties as soil amendment
 - Increasing of water holding capacity
 - Good soil aeration
 - Generation of nutrient reservoirs

- Utilization of biogenic residues for biochar production by Thermo-Catalytic Reforming
 - Low costs for feedstock
(revenues are partly generated by gate fees)
 - Specific utilization of nutrients (location and time)
 - High added value generated by heat and power production as well as sale of biochar

Motivation

Biogas plants in Germany

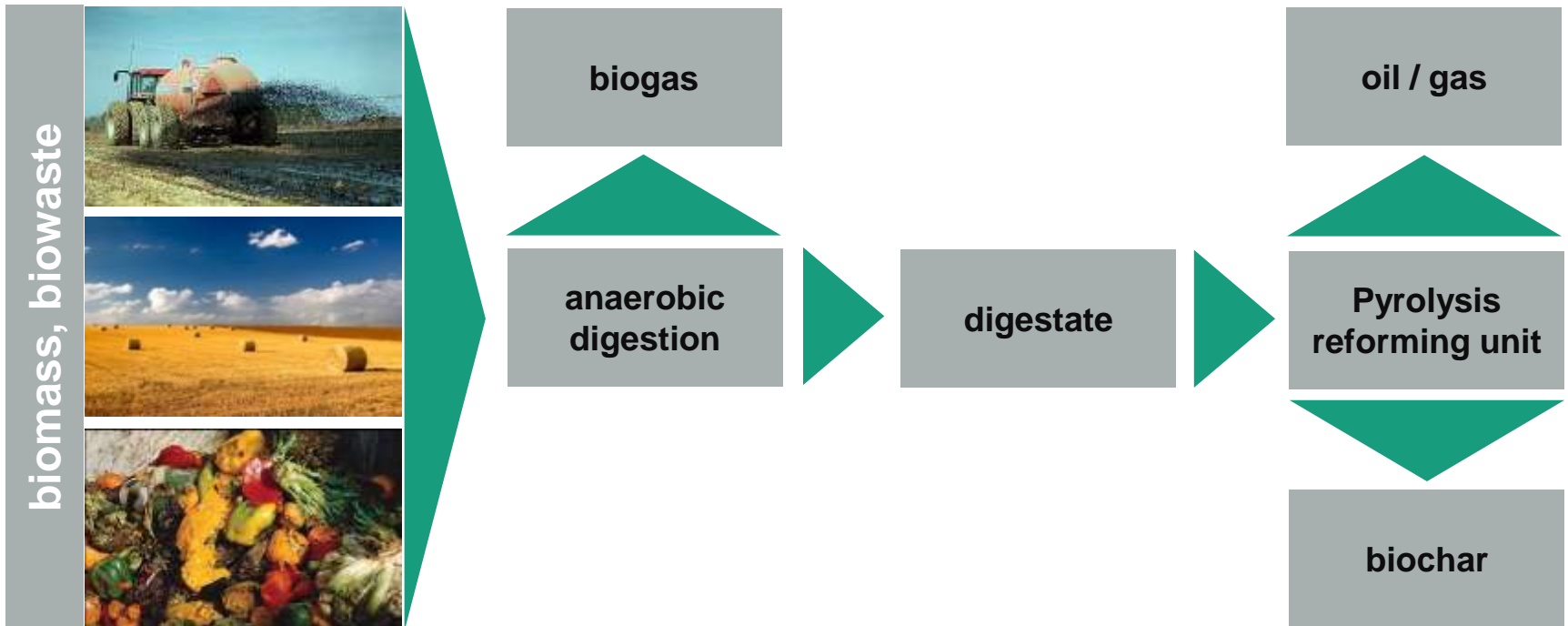


- Number of plants : 7,521
- Installed electrical power: 3,185 MW
- Amount of Digestate: 60 Mio. Mg
- Dry matter content: (10 %DM)
- HHV Digestate: 14 - 16 MJ/kg DM

Reference: FNR 2012

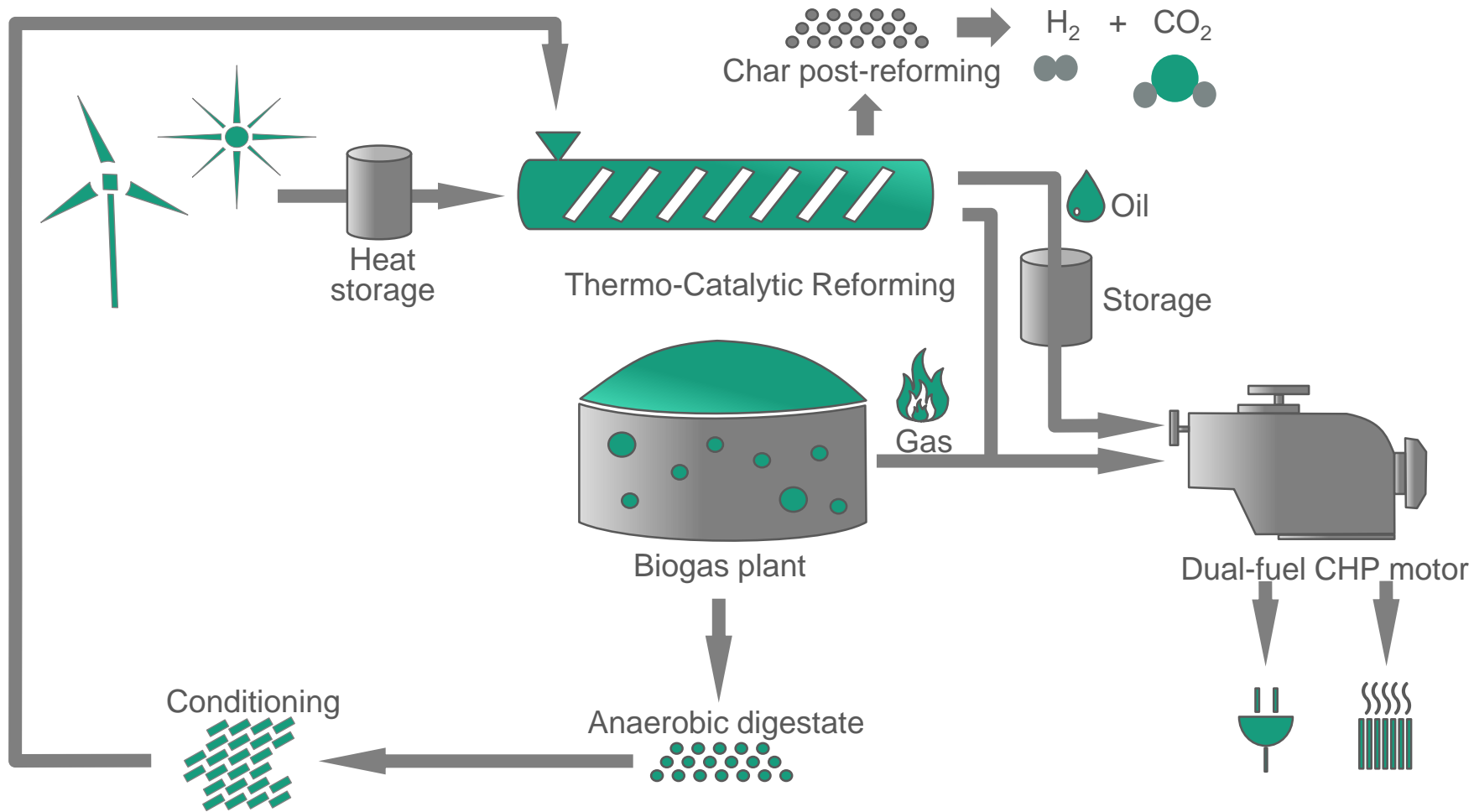
Motivation

Economic use for biomass and biowaste



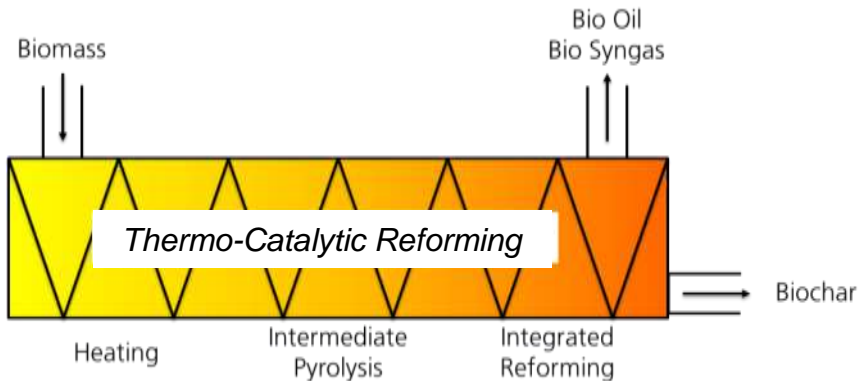
The Biobattery concept

Effective use of anaerobic digestate

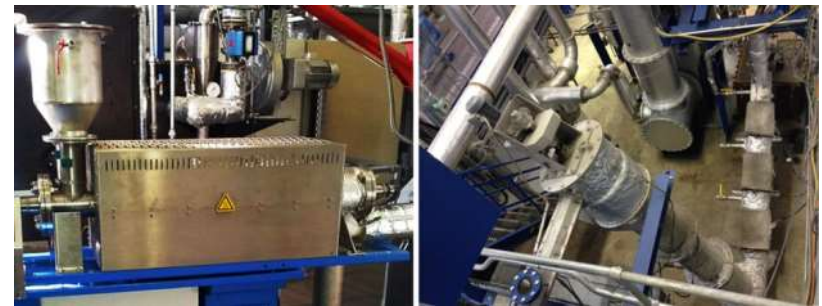


The Biobattery concept

Thermo-Catalytic Reforming



- Activated biochar catalyzes cracking of higher molecular weight organic compounds
- Integrated reforming of biooil and biochar using the water vapor present in the reactor
- Yielding high quality bioenergy products in variable composition
- Biooil with low total acidity



Pyrolysis Units at Fraunhofer UMSICHT (2kg/h and 60 kg/h)

The Biobattery concept

Application Scenario – Biogas Digestate

Illustrative Example

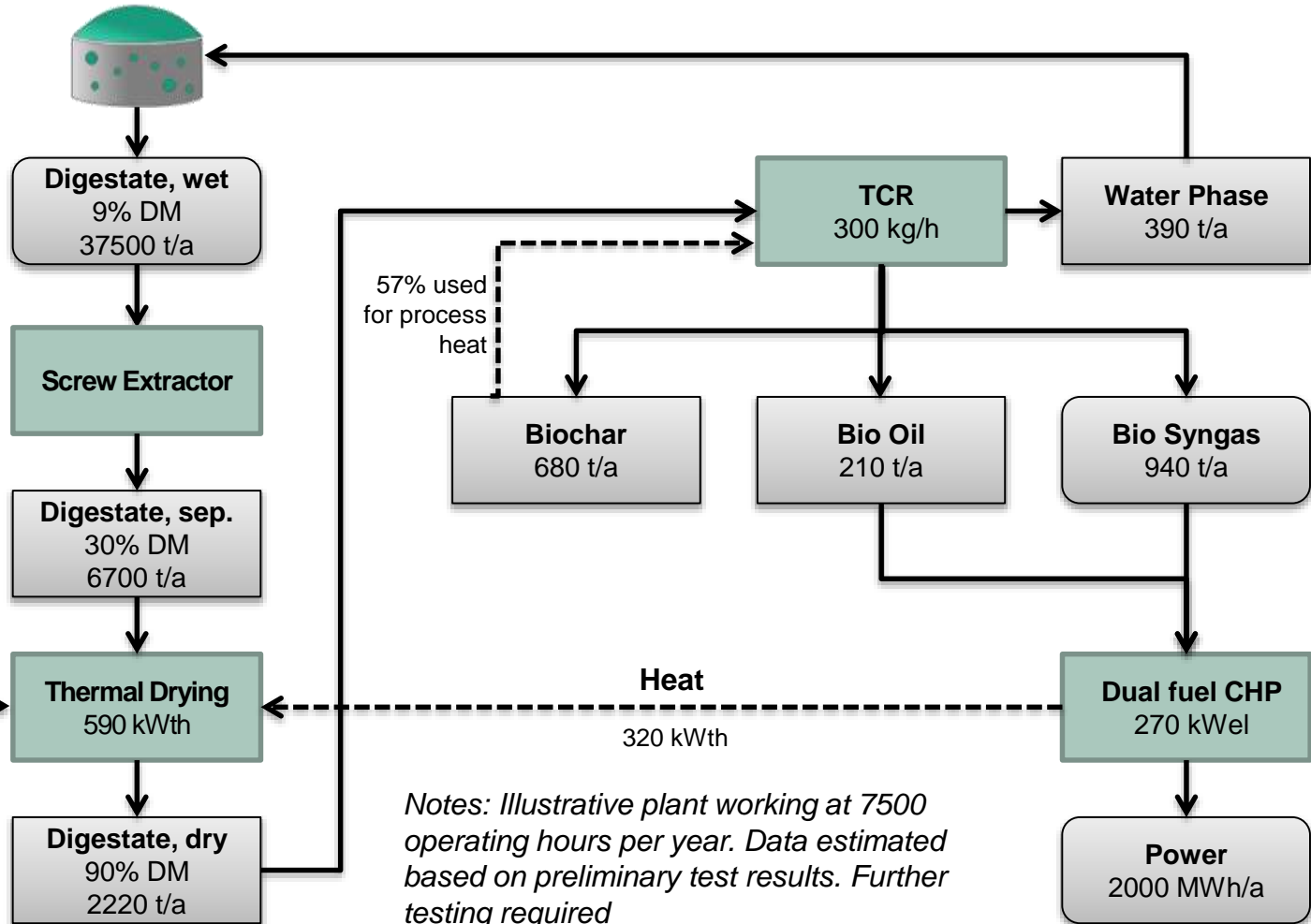


Biogas plants

Approx. 2,2 MWeI

37500 t/a wet digestate

from maize silage, cattle dung and gras silage



Notes: Illustrative plant working at 7500 operating hours per year. Data estimated based on preliminary test results. Further testing required

Results

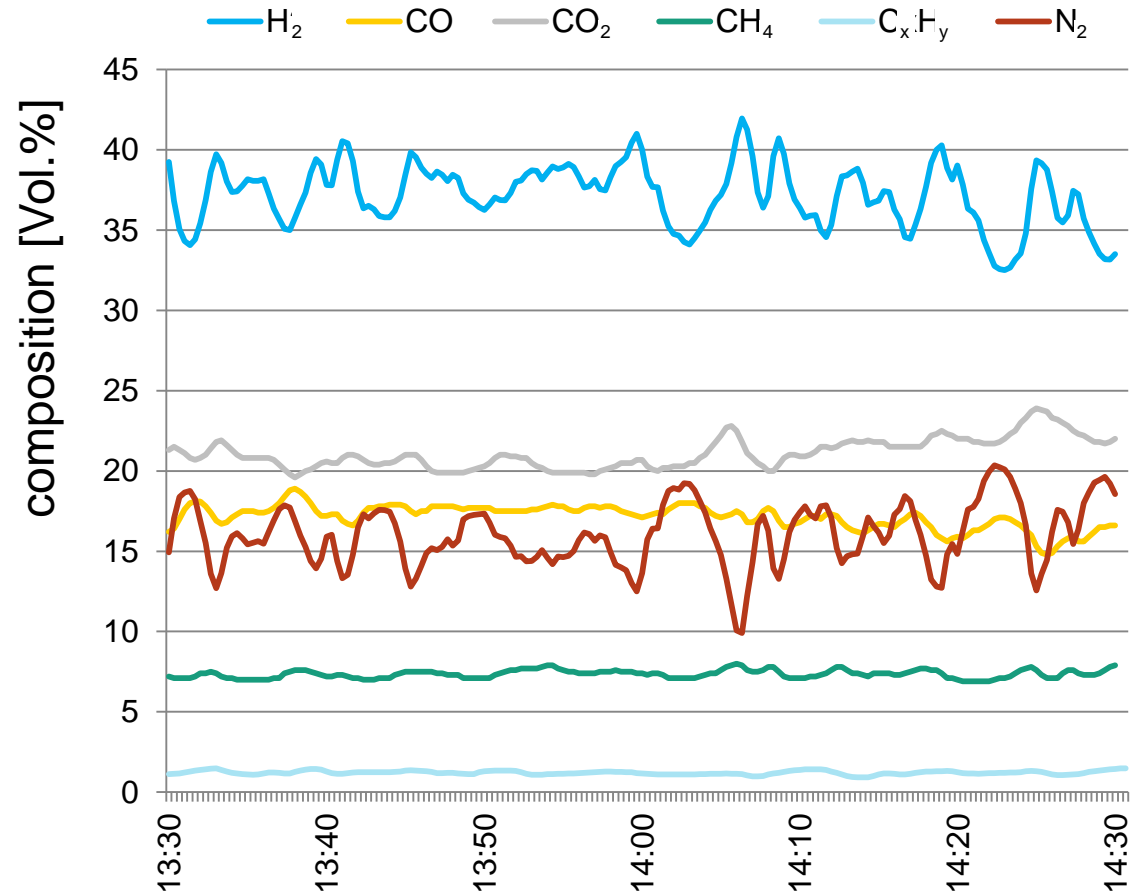
Analysis and heating values



Product gas

| | |
|-------------------------------|---------------|
| H ₂ | 32 - 42 Vol.% |
| CO | 15 - 19 Vol.% |
| CO ₂ | 19 - 24 Vol.% |
| CH ₄ | 7 - 8 Vol.% |
| C _x H _y | 2 Vol.% |
| N ₂ | 10 - 21 Vol.% |

Heating value 11 MJ/m³



Results

Analysis and heating values



Product oil

| | |
|---------------|----------------|
| C | 75,5 weight % |
| H | 10,5 weight % |
| N | 1,5 weight % |
| S | 0,5 weight % |
| O | 11 weight % |
| Water | 1 weight % |
| Ash | < 0,1 weight % |
| TAN | < 4 mg KOH/g |
| Heating value | 35,0 MJ/kg |



Results

Analysis and heating values



Biochar

Low in oxygen,

| | |
|--------------------------|--------------|
| C | 52 weight% |
| H | 2 weight% |
| N | 1 weight% |
| S | 0,5 weight% |
| O | 7 weight% |
| Ash | 37,5 weight% |
| heating value 19,5 MJ/kg | |



C/O 10

H/C 0,45

Results

Analysis – Biochar from digestate

Limit Values for Pollutants

| | Einheit | DüMV | IBI Test Cat. B | TCR Biokohle |
|--------------------|------------|------|-----------------|--------------|
| Arsenic | mg/kg TS | 40 | 12 - 100 | < 0,8 |
| Cadmium | mg/kg TS | 1,5 | 1.4 - 39 | < 0,2 |
| Chromium | mg/kg TS | 300 | 64 - 1200 | 5 |
| Chromium(VI)-Oxide | mg/kg TS | 2 | n.a. | n.a. |
| Copper | mg/kg TS | 900 | 63 - 1500 | 68 |
| Lead | mg/kg TS | 150 | 70 - 500 | < 2 |
| Mercury | mg/kg TS | 1 | 1 - 17 | < 0,07 |
| Nickel | mg/kg TS | 80 | 47 - 600 | 3 |
| Zinc | mg/kg TS | 5000 | 200 - 7000 | 300 |
| Thallium | mg/kg TS | 1 | n.a. | < 0,2 |
| Dioxin / PCB | ng WHO-TEQ | 30 | 9 / 200 - 500 | < 1 |

< below the detection limit

n.a. not applied

DüMV: German Fertilizer Ordinance

IBI: International Biochar Initiative – Biochar Standards

Results

Analysis – Biochar from digestate

Nutrient requirements according to German Fertilizer Ordinance

| NP Fertilizer | Requirements | Biochar |
|---------------|--------------|---------|
| Component | [%] | [%] |
| N | 3 | 1.34 |
| P2O5 | 5 | 5.80 |

| NK Fertilizer | Requirements | Biochar |
|---------------|--------------|---------|
| Component | [%] | [%] |
| N | 3 | 1.34 |
| K2O | 5 | 6.09 |

| PK Fertilizer | Requirements | Biochar |
|---------------|--------------|---------|
| Component | [%] | [%] |
| P2O5 | 5 | 5,80 |
| K2O | 5 | 6,09 |

| NPK Fertilizer | Requirements | Biochar |
|----------------|--------------|---------|
| Component | [%] | [%] |
| N | 3 | 1.34 |
| P2O5 | 5 | 5.80 |
| K2O | 5 | 6.09 |

- Phosphorous and potassium content meet the requirements of German fertilizer ordinance
- Nitrogen content must be adjusted by post treatment
- IBI Biochar Standards, Test Category C: Declaration of N, P, K contents is needed

Outlook

- Optimization of the biochar production process for further input materials
 - Requirements for nutrient content
 - Limit values for pollutants
- Systematic Investigation of the effectiveness of biochar as soil amendment (plant growth tests)
- Permission of biochar from biogenic residues as raw material for fertilizer and growing medium production
- Acceptance of biochar from biogenic residues in legal regulations
 - German Fertilizer Ordinance
 - EU Fertilizer Ordinance

FRAUNHOFER UMSICHT

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**Thank you for your kind
attention!**

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