Biochar commercialization and legislation in the EU

Improvement of comprehensive bio-waste transformation and nutrient recovery treatment processes for production of combined natural products

Edward Someus

Edward Someus Coordinator
FP7 REFERTIL (289785)

www.refertil.info
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(Edward Someus)
More than 40 million tonnes of animals (bovine, poultries and pigs) slaughtered in the EU 27 countries in 2008.

50% / 20M t/y → rendering industry

From which minimum 2-3 M t/y → high P animal bone

Animal bone is economical important high volume industrial accomodity and renewable resource with high P concentrated apatite mineral content.

<table>
<thead>
<tr>
<th>GEO</th>
<th>TOTAL Slaughtered</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU 27</td>
<td>41,776</td>
</tr>
<tr>
<td>Denmark</td>
<td>2,012</td>
</tr>
<tr>
<td>Germany</td>
<td>7,516</td>
</tr>
<tr>
<td>Ireland</td>
<td>857</td>
</tr>
<tr>
<td>Spain</td>
<td>5,518</td>
</tr>
<tr>
<td>France</td>
<td>5,501</td>
</tr>
<tr>
<td>Italy</td>
<td>3,781</td>
</tr>
<tr>
<td>Hungary</td>
<td>881</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2,435</td>
</tr>
<tr>
<td>Poland</td>
<td>3,456</td>
</tr>
<tr>
<td>Slovenia</td>
<td>127</td>
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<tr>
<td>Sweden</td>
<td>309</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1,247</td>
</tr>
</tbody>
</table>

Results from WP1 input waste survey
COMMENTS TO EU WASTE STATISTICS

• In contrast with other waste streams which are documented by public authorities, **this is not the case for several organic waste streams** such as green waste and manure.

• The share of waste from agriculture, forestry and fishery (NACE section A) is low in the Eurostat database because the considerable amounts of manure and slurry are not counted as waste when they are reused in agriculture as fertiliser or soil improver.

• In line with the 2008/98/EC the reused manure is not listed as waste and out of scope of national and European waste statistics.

• The real amounts of all the generated manure are much higher both in MS and EU27 level that currently listed in Eurostat under EWC-Stat 09.3.

Results from WP1 input waste survey
BACKGROUND: The Global Phosphorus situation

THE VULNERABILITY OF EU P-SUPPLY → THE AGRICULTURE and FOOD SECTORS ARE AT RISK

• Limited domestic P–reserves → almost entirely dependent on P-rock imports.
• Rising Global P-rock demand → higher prices and mounting competition.
• The security of P rock supply is under increasing pressure.

POLITICAL & ECONOMICAL RISK

• Main P-rock producers: China, USA and Morocco.
• USA & China consume almost all domestic production.
• China apply 135% export tariff!
• Morocco: chief exporter
• Stable supply from Tunisia, Jordan and Syria is no longer guaranteed (political instability). GAFSA production decreased to 30% of its total capacity in 2011!

TECHNICAL

Excessive fresh-water consumption by P-industry:

• Approx. 3 m3 / ton of phosphate concentrate.
• Compete with agriculture and drinking water
• WATER SHORTAGES in Western Sahara

Phosphate rock is an increasingly scarce resource
WHAT IS BIOCHAR?

Biochar is plant and/or animal waste biomass origin carboniferous material from Authority permitted industrial production operations with permitted applications in open ecological soil environment. Biochar is aiming carbon negative multi functional and eco-safe soil enhancement.

BIOCHAR APPLICATION DOSES:

**Bone char**: natural NPK fertilizer, PGP, biocontrol, water retention, carbon sequestration.

200 kg/ha – 1000 kg/ha

**Plant based biochar**: water retention, carbon sequestration.

5,000 kg/ha – 20,000 kg/ha
Biochar is **NOT a fine ground charcoal**, and/or

Biochar is **NOT labile carbon** material that application is rapidly promoting GHG developments, and/or

Biochar is not carbon material that does **NOT meet quality** to be put into open ecological soil environment, and/or

Made from input feed material, that is originating from primer and secondary land use products, and/or the feed material use is competing with human and/or animal food supply and/or food crop plant production nutrient supply, and/or

Made from input feed material that is not from living, or recently living organisms and containing any ecotox substances (IMPORTANT: when biochar is used in dose 10 t/ha, than the concentration limits of the possible exotox substances are 10x multiplied VS when dose is 1 t/ha only) and/or

The pyrolysis process is not towards zero emission performance, and/or
WHAT IS NOT BIOCHAR? – II.

- the pyrolysis process is **not energy self sustaining**, and/or
- the pyrolysis – biochar production - process is not Government Authority permitted and controlled operation, and/or
- the biochar material open ecological soil environment industrial scale application is not Government Authority permitted and controlled operation, and/or
- the overall life cycle of the process (input material, process, biochar use) is having more negative environmental impact than total benefit, and/or
- the biochar product having **no labelled producers responsibility performance**, and/or
- the output biochar product economical value and free market valorization is not based on common market demands and commercialization process, e.g. biochar economical valorization may not be based grants, subsidies, and/or unclear carbon trade programmes.

Biochar is **NOT a labile carbon**
REFERTIL FOCUS

- TRANSFORMATION OF THE EU ORGANIC BIO-WASTE STREAMS into safe biochar and compost products. WfD/EoW core element.

- REDUCING THE DEPENDENCE ON MINED AND NON RENEWABLE PHOSPHORUS AND ENERGY-INTENSIVE NITROGEN SUPPLY resources,

- CONTRIBUTING TO THE INTERNATIONAL STANDARDIZATION OF COMPOST/ BIOCHAR technology and products, incl BC made from 22 EWC main categories.

- Providing strong POLICY SUPPORT TO THE EUROPEAN COMMISSION DG Industry and Enterprise + other DG’s for regulation of compost and biochar products under the NEW FERTILIZER REGULATION revision and EU 28 law harmonization.

14 partners from 10 EU countries
7-30 years active BC S&T involvement background.
Work field: from BC applied science into BC industrial scale up & commercialization
Bringing together:
- Experts,
- Researchers
- SMEs industrial partners from a variety of sectors
- All stakeholders.

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### THE REFERTIL FP7 KEY BIOCHAR PARTNERS

<table>
<thead>
<tr>
<th>Participant organization</th>
<th>Country</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TERRA HUMANA - Coordinator &amp; biochar key tech RTD + designer</td>
<td>HU</td>
<td>Company</td>
</tr>
<tr>
<td>Plant Research International, Wageningen</td>
<td>NL</td>
<td>RES</td>
</tr>
<tr>
<td>Aarhus University</td>
<td>DK</td>
<td>University</td>
</tr>
<tr>
<td>The Knowledge Centre for Agriculture - VFL</td>
<td>DK</td>
<td>Advisory Centre</td>
</tr>
<tr>
<td>University of Torino, Agroinnova</td>
<td>Italy</td>
<td>University</td>
</tr>
<tr>
<td>Gottfried Wilhelm Leibniz Universitaet Hannover</td>
<td>DE</td>
<td>University</td>
</tr>
<tr>
<td>Biomasa del Guadalquivir S.A.</td>
<td>E</td>
<td>SME</td>
</tr>
<tr>
<td>TWI Ltd.</td>
<td>UK</td>
<td>RES</td>
</tr>
<tr>
<td>WESSLING Lab Hungary Kft.</td>
<td>HU</td>
<td>Company</td>
</tr>
<tr>
<td>KOTO d.o.o.</td>
<td>SLO</td>
<td>SME</td>
</tr>
<tr>
<td>Comune di Grugliasco</td>
<td>Italy</td>
<td>City Council</td>
</tr>
<tr>
<td>Renetech Bioresources Ltd.</td>
<td>IRL</td>
<td>SME</td>
</tr>
<tr>
<td>Profikomp Zrt</td>
<td>HU</td>
<td>SME</td>
</tr>
</tbody>
</table>

**TERRA HUMANA** (Edward Someus): Coordinator and BC key S&T development, design and engineering

**Dr. WESSLING Lab**: Central accredited biochar laboratory
- Biochar QTY and safety assessment.
- Development of accredited BC analytical methods.
- Biochar accreditation in early 2014.

**VFL**: Biochar economy + field trials

**Agroinnova**: Biochar field trial tests since 2005.

**WUR/DLO/ TERRA / University of Hannover**: Microbiological improvement of biochar since 2005.

**Aarhus University**: Evaluation of effects of biochar application to soil.

Wide range of Partners from different BC S&T sectors
ACCREDITED QUALITY AND SAFETY ASSESSMENT

• PRODUCT/NUTRIENT QUALITY EVALUATION.
• PRODUCT SAFETY EVALUATION: determination of the potential key contaminants (heavy metals, organics,..) having negative effects on the human, plant and the environment.
• ACCREDITED ANALYSIS IN WESSLING LABORATORY
  ✓ 57 biowaste / byproducts from 9 EU countries,
  ✓ 31 different biochar products, 120 samples from 7 EU countries
  ✓ 39 compost samples from 6 EU countries
  ✓ 13 soil samples
• AVAILABLE BIOCHAR TECHNOLOGY EVALUATIONS
  ✓ Comprehensive overview of the BC tech market.
  ✓ 7 BC technologies contracted for detailed evaluations
  ✓ Only 2 found sustainable by independent evaluator
    ✓ Plant based BC small/medium solution: PYREG
    ✓ ABC Animal Bone bioChar medium/large industrial solution: 3R

The applied BC tech performance is the key definition factor for BC qty
Recycling of animal bone into concentrated natural phosphate mineral bio-fertilizer

http://www.agrocarbon.com

"3R" ZERO EMISSION CARBONIZATION PROCESSING

BONE MEAL
BONE CHIPS

Process gas
CATALYTIC CONVERSION

BIOJETFUEL - kerozene
RECYCLED NITROGEN

NPK-C

BIOTECH
Solid State Fermentation

FORMULATED NPK-C
BONE CHAR-BIOCHAR

3R AGROCARBON EFFECTS:
- Full value NPK-C fertilizer.
- Enhanced agronomic food crop productivity.
- Nutrient & moisture retention.
- C-sequestration.
- N2O mitigation.
- Cation Exchange Capacity ↑

DIRECT SOIL APPLICATION
COMPOST ACTIVATOR

DROUGHT TOLERANT HORTICULTURE
LOW INPUT FARMING

http://www.agrocarbon.com
FIELD TRIALS:
Italy, Germany
The Netherlands
Danmark, Hungary
Spain, Ireland
Slovenia

RESULTS:
YIELD: +10-30% ▲
FRUIT QUALITY: ▲
FOOD SAFETY: ▲

• COST: highly depending on application strategy.
• The BC economy under market conditions is key definition factor.

Main drivers: BC SAFETY & ECONOMY

2. **NATIONAL PROVISIONS** for marketing of FM = ‘national fertilisers’

   - **ABSENCE** of a harmonized system for all FM.
   - The Fertiliser Regulation does not affect the ‘national fertilisers’.
   - **MS SPECIFIC Legislations** → Large differences
   - **PRODUCERS CAN CHOOSE:** ‘EC fertilisers’ **OR** ‘national fertilisers’.
   - **MUTUAL RECOGNITION** (Reg. (EC) No 764/2008) for intra-community movement of national registered fertilisers.
   - **National MS LEGISLATIONS ARE NOT IDENTICAL** throughout the EU28 → **POTENTIAL BARRIERS** to mutual recognition.

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WHY CHANGING THE EC 2003/2003 REGULATION?

- All fertilisers sub-categories should be covered = FULL HARMONIZATION

- More emphasis on ENVIRONMENTAL CONCERNS (limits for contaminants)

- More INNOVATION lengthy procedure for the introduction of new fertiliser types in Annex I

- RELUCTANCE of authorities and some economic operators to apply the Mutual Recognition Regulation for ‘national fertilisers’
LIKELY EXTENSION OF THE SCOPE TO...

- Organic fertilisers: digestates, manure ?,…
- **Soil improvers:** liming materials (including certain industrial by-products) peat, **composts**, manure, **bio-char**.
- The plant and waste derived biochar inclusion into the revised EU Fertilizer Regulation is still on pending proposal level.
- Growing media
- Plant biostimulants (improving nutrient uptake and nutrient use performance)
WHAT ARE THE MAIN CHALLENGES?

- Ensuring an **EQUIVALENT PROTECTION** of the **ENVIRONMENT, PLANT AND HUMAN HEALTH** throughout the EU with harmonised system of controls **covering all fertilising materials** including mineral fertilisers, organic fertilisers and soil improvers.

- **GUARANTEE** to farmers **fair information and reliability** about the efficiency and minimal nutrient content (product and producer’s responsibility)

- **INTRODUCE** more detailed **environmental and human health safety requirements**.

- Establishing **ESSENTIAL SAFETY and AGRONOMIC EFFICIENCY REQUIREMENTS** for all fertilizer and soil improvement materials.
SAFETY ISSUE

CURRENT LEGAL SITUATION:

- Article 14(c) of current Fertilisers Reg. (EC) No 2003/2003: “A type of fertiliser may only be included in Annex 1 if: […] (c) under normal conditions of use it does not adversely affect human, animal, or plant health, or the environment” but it **does not include a detailed methodology on how to address these risks.**

FURTHER REVISION IS NEEDED:

- to introduce more detailed environmental safety requirements.

PROBLEMS & CHALLENGES:

- The term ‘safety requirements’ is neither defined in the EU legislation nor is a common understanding in place.
- **ABSENCE** of an accepted risk assessment methodology.
- Complexity of the safety and a lack of common understanding of what safety assessments should include.

What is SAFETY?
THE 7 BIOCHAR POLICY OPTIONS

1. **BASELINE SCENARIO (NO POLICY CHANGE)** – national legislation coexists with the EU legislation. – not suitable for biochar regulation

2. **REPEAL** of the existing 2003/2003 Reg. reliance on other existing EU and national legislation. - not suitable for biochar regulation

3. **VOLUNTARY COMMITMENT BY INDUSTRY** in addition to existing legislative framework. - not suitable for biochar regulation


5. **FULL HARMONISATION** for all FM – AUTHORISED LIST OF INGREDIENTS AND ADDITIVES. – made for chemical industry and not suitable for bio-substances with substantial variations.

6. **FULL HARMONISATION** for all FM – NEW APPROACH, SAFETY REQUIREMENTS: Human and animal safety, respect of the environment, AGRONOMIC CRITERIA – best suitable for biochar adaptation and safe regulation

7. **COMBINATION OF 1-6.** - over-complex

Full harmonization proposed for the BC
DISTINCTION should be made BETWEEN ANIMAL BONE BIOCHAR (ABC) AND PLANT BIOCHAR

Plant biochar:
- >90% w/w **high carbon content** plant origin
- micro and meso porous (1 nm – 50 nm) carboniferous product,
- high water holding and nutrient retention capacity and C sequestration,
- no soil fertilization effects. Can be recognised as soil improver? **YES**

ABC: Animal Bone bioChar – slow release organic fertilizer
- The input **animal bone meal** is food grade category 3 rendering by-product with economical importance, produced in large industrial scale (2-3 million t/y) which **concentrated high P content apatite** is an critically and strategically important inside EU natural and RENEWABLE RESOURCE.
- <20% w/w low carbon and high calcium phosphate/ **apatite mineral content**
- macro porous (50 nm – 63k nm)
- **Containing significant amount of MINERAL nutrients.**
- Can be recognised as organic fertiliser? **YES**
1. **SAFETY & QUALITY**: There should be no overall adverse environmental, ecological and human health impact from the use of biochar products in the open soil environment:
   - Clear and strict definition of the biochar product quality.
   - Clear and strict definition of the limit values for contaminants:
     - **PAHs**: *Target pollutants - key indicator.*
     - **TEOC**: Total Extractable Organic Compounds *Marker Index* - biochar production performance key indicator.
     - **Heavy metals**: Heavy metal target pollutants key indicator.
     - **PCB_{7}**: indicator also for PCDD/F.

2. **MARKET REGULATION**: Poor quality biochar products must exclude from the soil improver/organic fertiliser market.

3. **AUTHORITY CONTROL**: Authority permits (according to EU/MS regulations) + REACH for production and use biochar over 1 t/y capacity.

4. **BIOCHAR PRODUCTION** criteria for safe biochar production.

5. **BIOCHAR ECONOMY**: Realistic and commercial market demanded economical scenario.

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## BIOCHAR QUALITY PARAMETERS & NUTRIENTS (SUMMARY)

<table>
<thead>
<tr>
<th>Parameters to be fulfilled</th>
<th>ECBC organic fertilizer Proposed Minimum limit value for ABC animal bone biochar</th>
<th>ECBC soil improver Proposed Minimum limit value for Plant Biochar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum organic matter content (expressed on dry matter)</td>
<td>Total Organic Carbon 7 %</td>
<td>Total Organic Carbon 50 %</td>
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<tr>
<td><strong>Marker index and production performance indicator.</strong> TEOC Marker index Total Extractable Organic Compounds (marker index)</td>
<td>500 mg/kg (preliminary)</td>
<td>500 mg/kg (preliminary)</td>
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<tr>
<td>Molar H/C ratio</td>
<td>-</td>
<td>&lt;0.7</td>
</tr>
<tr>
<td>pH</td>
<td>6.5 - 9.0</td>
<td>6.5 - 9.0</td>
</tr>
<tr>
<td>Dry substance content</td>
<td>&gt;80%</td>
<td>&gt;80%</td>
</tr>
<tr>
<td>Particle size distribution, mm</td>
<td>Preferably &lt; 5 mm</td>
<td>Preferably &lt; 20 mm</td>
</tr>
<tr>
<td>Water holding capacity, ml/g</td>
<td>declaration</td>
<td>declaration</td>
</tr>
<tr>
<td>Bulk density</td>
<td>declaration</td>
<td>declaration</td>
</tr>
<tr>
<td><strong>Nutrient content indicator.</strong> Minimum nutrient content on dry matter N-P-K</td>
<td>N Total: declaration P$_2$O$_5$ total &gt; 25% K$_2$O total declaration</td>
<td>No minimum limit value, declaration</td>
</tr>
<tr>
<td>Minimum nutrient content Ca-Mg</td>
<td>No minimum limit value, declaration</td>
<td>No minimum limit value, declaration</td>
</tr>
<tr>
<td>Total N (% of dry mass)</td>
<td>declaration</td>
<td>declaration</td>
</tr>
<tr>
<td>Total P (% P2O5 dry mass)</td>
<td>ABC &gt;25 % p2o5</td>
<td>declaration</td>
</tr>
<tr>
<td>Total K (% dry basis)</td>
<td>declaration</td>
<td>declaration</td>
</tr>
<tr>
<td>Total Ca (% dry basis)</td>
<td>declaration</td>
<td>declaration</td>
</tr>
<tr>
<td>Total Mg (% dry basis)</td>
<td>declaration</td>
<td>declaration</td>
</tr>
</tbody>
</table>
NUTRIENT CONTENT OF BIOCHARS

Animal Bone bioChar
ABC total P substitution potential EU28 = <20%, in realistic potential 5-10 %.

Plant base biochars
No nutrient content with economical value

NUTRIENT CONTENT OF BIOCHARS

Plant based biochars
No nutrient content with economical value

Animal Bone bioChar

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REFERTIL RECOMMENDED LIMIT VALUES FOR HEAVY METALS AND ORGANICS
ORGANIC FERTILIZER AND SOIL IMPROVER PRODUCT LEGISLATIONS

1. At the EU level there is no legislation which maximizing the heavy metal and organic content of biochar products.

2. Sewage Sludge Directive (86/278/EC) includes limit values for 7 heavy metals. Does not include PAHs, PCBs and PCDD/F. Several MS have implemented stricter limit values for heavy metals and set requirements for other contaminants.

3. EU Eco Label Regulation (voluntary) and Organic Farming Regulation are setting up threshold values only for the heavy metal content of fertilizer materials.

4. End-of-waste criteria on Biodegradable waste subject to biological treatment (JRC 2013) is setting up limit values for 7 heavy metals and PAH$_{16}$ in the compost/digestate products.

5. Both EU and world wide level different private voluntary standards (IFOAM accredited) are existing for setting up threshold values for the heavy metal content of organic fertilizers which can be used for organic farming production.

Several legislations to be considered
<table>
<thead>
<tr>
<th>LEGISLATION/STANDARD</th>
<th>Cd (tot)</th>
<th>Cr VI</th>
<th>Cu</th>
<th>Hg</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage Sludge Directive 86/278/EEC (Several MS have enacted and implemented stricter limit values)</td>
<td>20-40</td>
<td>x</td>
<td>1000-1750</td>
<td>16-25</td>
<td>300-400</td>
<td>750-1200</td>
<td>2500-4000</td>
</tr>
<tr>
<td>Sewage Sludge Directive Revision Working document on sludge and biowaste (2010)</td>
<td>10</td>
<td>1000</td>
<td>x</td>
<td>1000</td>
<td>10</td>
<td>300</td>
<td>500</td>
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<tr>
<td>EU ECO Label</td>
<td>1</td>
<td>100</td>
<td>x</td>
<td>100</td>
<td>1</td>
<td>50</td>
<td>100</td>
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<tr>
<td>EoW (Draft final report) Compost/digestate</td>
<td>1.5</td>
<td>100</td>
<td>x</td>
<td>200</td>
<td>1</td>
<td>50</td>
<td>120</td>
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<td>Organic farming Reg. (EC) No 889/2008, Reg. (EC) No 834/2007</td>
<td>0.7</td>
<td>70</td>
<td>0</td>
<td>70</td>
<td>0.4</td>
<td>25</td>
<td>45</td>
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<tr>
<td>Chemical Risk Reduction Ordinance, ChemRRV, SR 814.81)2005 Switzerland</td>
<td>1</td>
<td>x</td>
<td>x</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>120</td>
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<tr>
<td>Compost Quality Assurance (RAL-GZ 251), Germany</td>
<td>1.5</td>
<td>100</td>
<td>x</td>
<td>100</td>
<td>1</td>
<td>50</td>
<td>150</td>
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<td>Fertiliser Ordinance (DÜMV, 2003) Germany</td>
<td>1.5</td>
<td>x</td>
<td>2</td>
<td>x</td>
<td>1</td>
<td>80</td>
<td>150</td>
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<tr>
<td>Fertiliser Act Netherlands “Clean”</td>
<td>1</td>
<td>50</td>
<td>x</td>
<td>60</td>
<td>0.3</td>
<td>20</td>
<td>100</td>
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<td>BSI PAS 100:2011 BSI Specification for composted material UK</td>
<td>1.5</td>
<td>100</td>
<td>x</td>
<td>200</td>
<td>1</td>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td>Naturland Private organic labels standard, DE+ Worldwide Compost</td>
<td>0.75</td>
<td>75</td>
<td>x</td>
<td>50</td>
<td>0.5</td>
<td>30</td>
<td>75</td>
</tr>
<tr>
<td>Soil Association organic standards (private voluntary standard) Compost from source separated greenwaste, UK</td>
<td>1.5</td>
<td>x</td>
<td>100</td>
<td>200</td>
<td>1</td>
<td>50</td>
<td>200</td>
</tr>
</tbody>
</table>

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## SUMMARY OF THE REFERTIL RECOMMENDED LIMIT VALUES FOR TOXIC CONTAMINANTS

<table>
<thead>
<tr>
<th>Parameters to be fulfilled</th>
<th>ECBC organic fertilizer Proposed Minimum limit value for ABC animal bone biochar</th>
<th>ECBC soil improver Proposed Minimum limit value for Plant Biochar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination Inhibition Assay</td>
<td>mandatory no germination inhibition</td>
<td>mandatory no germination inhibition</td>
</tr>
<tr>
<td>Phytotoxicity</td>
<td>mandatory not phytotoxic</td>
<td>mandatory not phytotoxic</td>
</tr>
<tr>
<td>Limited content of macroscopic impurities</td>
<td>mandatory declaration</td>
<td>mandatory declaration</td>
</tr>
<tr>
<td><strong>Target pollutants.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited content of heavy metals</td>
<td>Zn: 600 mg/kg dm Cu: 100 mg/kg dm Ni: 50 mg/kg dm Cd: 1 mg/kg dm Pb: 120 mg/kg dm Hg: 0.5 mg/kg dm Cr (VI) 0.5 mg/kg</td>
<td>Zn: 600 mg/kg dm Cu: 100 mg/kg dm Ni: 50 mg/kg dm Cd: 1 mg/kg dm Pb: 120 mg/kg dm Hg: 0.5 mg/kg dm Cr (VI) 0.5 mg/kg</td>
</tr>
<tr>
<td><strong>Product and environmental quality indicator.</strong></td>
<td>6 mg/kg dm Target organic pollutant. Maximum allowable dose input per ha area recommended on regional MS level.</td>
<td>6 mg/kg dm Target organic pollutant. Maximum allowable dose input per ha area recommended on regional MS level.</td>
</tr>
<tr>
<td><strong>Target pollutants.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAH&lt;sub&gt;16&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contamination indicator.</strong></td>
<td>0.1 mg/kg dm</td>
<td>0.1 mg/kg dm</td>
</tr>
<tr>
<td>PCB&lt;sub&gt;7&lt;/sub&gt;</td>
<td>&lt;20 ng/kg l-TEQ mandatory only if PCB &gt;0.07 mg/kg not target pollutant.</td>
<td>&lt;20 ng/kg l-TEQ mandatory only if PCB &gt;0.07 mg/kg not target pollutant.</td>
</tr>
</tbody>
</table>
Comparison of the limit values for heavy metals and organics in the different EU legislation-legislation proposals and Biochar standards

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Org. Farm</th>
<th>Eco Labels</th>
<th>Directive 86/278/EEC Sewage Sludge</th>
<th>EoW (final draft)</th>
<th>Proposal Sludge</th>
<th>IBI (USA)</th>
<th>BQM (UK)</th>
<th>EBC (CH)</th>
<th>ECBC</th>
<th>REFERTIL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>high grade</td>
<td>Standard</td>
<td>base</td>
<td>premium</td>
</tr>
<tr>
<td>As</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12-100</td>
<td>10</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cd</td>
<td>0.7</td>
<td>1</td>
<td>20-40</td>
<td>1.5</td>
<td>10</td>
<td>1.4-39</td>
<td>3</td>
<td>39</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>Cr (total)</td>
<td>70</td>
<td>100</td>
<td>-</td>
<td>100</td>
<td>1,000</td>
<td>64-1,200</td>
<td>15</td>
<td>100</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>Cr (VI)</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cu</td>
<td>70</td>
<td>100</td>
<td>1,000-1,750</td>
<td>200</td>
<td>1,000</td>
<td>63-1,500</td>
<td>40</td>
<td>1500</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Hg</td>
<td>0.4</td>
<td>1</td>
<td>16-25</td>
<td>1</td>
<td>10</td>
<td>1-17</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ni</td>
<td>25</td>
<td>50</td>
<td>300-400</td>
<td>50</td>
<td>300</td>
<td>47-600</td>
<td>10</td>
<td>600</td>
<td>50</td>
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<td>Pb</td>
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<td>120</td>
<td>500</td>
<td>70-500</td>
<td>60</td>
<td>500</td>
<td>150</td>
<td>120</td>
</tr>
<tr>
<td>Zn</td>
<td>200</td>
<td>300</td>
<td>2,500-4,000</td>
<td>600</td>
<td>2,500</td>
<td>2,000-7,000</td>
<td>150</td>
<td>2,800</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>PAH</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>6</td>
<td>6-20</td>
<td>20</td>
<td>20</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>PCB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.8</td>
<td>0.2-0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>PCDD/F5 (ng/1TEQ/kg)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>9</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

IBI, BQM, EBC = VOLUNTARILY CERTIFICATIONS  ECB = FR proposal mandatory

Different BC standard concepts
PAH is fingerprint of the technology design and performance
TARGET ORGANIC POLLUTANT: PAHs

• The PAHs primarily derive from:
  1. obsolete, low grade and inefficient pyrolysis condition
  2. contaminated and/or improper selected feedstocks.
• The sub-optimal pyrolysis conditions reduce the product benefits and enhance the risk of land and water contamination.
• If the nutrient content is low (plant biochar), there is a risk that large amounts of respective product could be used for a certain area to supply the plants with sufficient nutrient.
• Higher application dosage = higher PAH loads to the agricultural land.

Reducing the risk of PAH contamination by:
• tight control on pyrolysis condition
• standardized biochar production (pyrolysis).
• specific condition and rules for biochar application.
• Setting up a safe application rate (t/ha dosage) for plant base biochar (= LIMIT BASED ON AMOUNT) to prevent negative impacts from the contaminants.

http://www.refertil.info
PCBs and PCDD/F are not target contamination in any type of biochar, but PCB is contamination indicator.
CONCLUSIONS & RECOMMENDATIONS I.

1. Plant based biochar is a soil improver, doses expected at 5 t/ha but max. 20 t/h. The economy is the key driver.

2. ABC animal bone biochar is organic fertilizer 200 kg/ha up to max. 1000 kg/ha recommended doses.

3. There is need for tight policy and regulations in respect to sustainable biochar feed material supply – biochar production – biochar import - handling – application.

4. Recommendation for minimalization of toxic contaminants:
   - setting up a safe application rate mg/kg on EU level and
   - specific targeted area kg/ha dosage and background contamination determination is based on MS level for minimizing the risk from heavy metal in soil and PAH loads with water pollution potential.

Q: will plant based BC included into the new FR or need further considerations?
CONCLUSIONS & RECOMMENDATIONS – II.

4. PCBs and PCDD/F are not target contamination in any type of biochar, but PCB is contamination indicator.

5. PAHs - TEOC are target contaminations, BC QTY key indicators.

6. The BC technology design and processing performance are the most important ultimate definition factors for biochar quality and safety.

7. Low tech biochar technology processing performance and conditions resulting low quality carbon product with high PAH/TEOC load.

8. The REFERTIL consortium is not recommending the nutrient recovery as biochar from any sewage sludge. For waste derived BC DG-ENV is the key partner.

Q: will plant based BC included into the new FR or need further considerations?

10. All biochar that meets the ECBC European Community BioChar criteria, also fully meet the European Ecolabel criteria system and can be registered as Ecolabel product.

11. All biochar material (manufactured, imported or used) in > 1 t/year quantity (2018), has to be registered under Article 6 of the REACH Regulation, which is to be applied together with the other EU regulations.
FERTILIZER REGULATION REVISION

• Initiated 2010. Preparations 2010-2013
• Important EU top level meeting and decision November 20, 2013. If green light OK for FP proposal than legal formulate 2014.

• **If all goes well FR completed around 2016.**

• **If the high carbon content plant based BC soil improver will not be included into the mandatory new FR legislation now in 2013 and before mid 2014, than there is a risk that plant based BC case industrial applications will be pending for long time.** Voluntarily BC certificates are far less powerful under market conditions and from MS Authority permit point of view than mandatory EU Regulation.

• ABC is clear case with long application references.
HIGH CARBON CONTENT PLANT BASED BIOCHAR ECONOMY: INTEREST AND BENEFITS FOR THE SME and FARMERS

- Farmers’ behaviour
- Selling points
- Actual char prices
- Needed yield effect
- Conclusions
Why should the farmer buy plant based Biochar?

Increased yield:
- Better utility of nutrients
- Soil improvement
  - Increased water holding capacity
  - Easier and better establishment of crops

Reduce costs of:
- Mineral fertilisers
- Liming
- Pesticides

Qualify for environmental subsidy (?)

Long term: Maintaining soil fertility, Potential for C sequestration
Application rates and current price level of chars

Application rates

Literature: Jeffrey et al.*
- Tested: 782 replicates from 1.5 t/ha to 100 t/ha
- In average: +10% extra yield (-55% to +65%, year 1)

REFERTIL - field trial 2013/14
- 3 - 25 t/ha from wood
- Price: 500 Euros/t
- No effect on yield year 1

Current prices, excl. transport and application costs
- 100 Euros per ton – 1,000 (>2,000) Euros per ton
- Application of 3 to 10 t/ha: An investment of 300 – 10,000 Euros per ha

* Jeffrey et al./Agriculture, Ecosystems and Environment 144 (2011)
High C content plant based biochar costs of 300 – 10,000 Euros per ha compared to current costs of input

Yearly costs in the conventional agricultural cereal production:

- Fertilisers: 250 – 400 Euros per ha
- Pesticides: 40 – 100 Euros per ha
- Liming: 20-30 Euros per ha per year (every 6-7 year)
- Other C-sources: Straw, catch crops

How big is the effect on the yield? And for how long a period can we calculate a yield effect from biochar?
How much is the farmer willing to invest?

- The farmer usually invests in his fields on a short-term basis: The farmer expects to obtain full yield value of the costs for nutrients and spraying every year (approx. 400 Euros/ha).

- Unless very well documented yield effect to similar soil types, he will not spend more than 100 -150 Euros per ha on a new product.
Calculations of PBCwood (BCDK1)

Needed yield effect to pay the char at different time frames and application doses

- P: 0.2 kg/t
- K: 1.2 kg/t
- C/N: 320
- Char price: 500 Euros/t
- Cereal: 202 Euros/t

<table>
<thead>
<tr>
<th>Dose</th>
<th>2.9 t char (2.5 t C/ha)</th>
<th>5.75 t char (5 t C/ha)</th>
<th>11.5 t char (10 t C/ha)</th>
<th>23 t char (20 t C/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years</td>
<td>Extra yield, t per hectare</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest on dept. (ex. repayment)</td>
<td>0.36</td>
<td>0.71</td>
<td>1.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Depreciation</td>
<td>10</td>
<td>0.9</td>
<td>1.8</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.54</td>
<td>1.1</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.42</td>
<td>0.83</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Rate of interest : 5%
Calculations of PBCstraw (BCDK2)

Needed yield effect to pay the char at different time frames and application doses

- P: 5 kg/t
- K: 4.2 kg/t
- C/N: 120
- Char price: 100 Euros/t
- Cereal: 202 Euros/t

<table>
<thead>
<tr>
<th>Dose</th>
<th>3.2 t char (2.5 t C/ha)</th>
<th>6.4 t char (5 t C/ha)</th>
<th>12.7 t char (10 t C/ha)</th>
<th>25.5 t char (20 t C/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years</td>
<td>Extra yield, t per hectare</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest on dept (ex. repayment)</td>
<td>0.07</td>
<td>0.14</td>
<td>0.27</td>
<td>0.54</td>
</tr>
<tr>
<td>Depreciation</td>
<td>10</td>
<td>0.17</td>
<td>0.34</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.10</td>
<td>0.20</td>
<td>0.41</td>
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<tr>
<td></td>
<td>30</td>
<td>0.08</td>
<td>0.16</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Rate of interest: 5%
Conclusions:
Soil improvement is a long-term investment, fertilising is a short time investment

1. Soil improvers:
   - High C input material: Wood, straw etc.
   - If the problem is acid soils, liming is far the cheapest
   - Is as soil improvement probably only interesting at sandy soils with very low water holding capacity
   - Max. price for field crops 100 Euros per ton. Catch crop/straw/manure are alternatives
   - Wood char at current prices might be used as growth media in intensive horticulture
Conclusions

2. Soil improvers and fertilisers:
   - Char from: Slurry fibres, manure, deep litter from chickens etc.
   - From an economic point of view the max. price for field crops is 100 – 200 Euros per ton, relevant for both conventional and organic farming.
   - Higher prices can be justified when used as fertiliser/growth media in intensive horticulture.
Conclusion

There is a need for further documentation of the value of high C content chars in different crops on different soil types and under different climatic conditions for soil improvement. Also the practical handling needs to be solved

- Formulation?
- How to apply?
- Depth of incorporation?
- Technique?
- Etc.
ABC Animal Bone bioChar Economy

• ABC is not under the WfD/EoW.
• EU GVT Authority permitted industrial process.
• EU GVT Authority permitted product (permit 2005 – 2009).
• Input is food grade animal bone meal.
• Premium slow release organic fertilizer in many different “as Customer needed” formulations incl soil biotech formulated substance.
• Target applications are the added value horticultural industry and adsorption techniques.
• Developed for both for soil and soilless cultivations. Same grain size as usual fertilizer 1-4 mm, dose rate from 200 kg/ha, average 400 kg/ha.
• Manufacturing of ABC requires far higher and advanced technological science-technology-industrial engineering level than to make plant based biochar.
• Meet 2010/75/EU (industrial emission, Jan 7, 2014 and BAT.
• Standard industrial scale 20,000 t/y input food grade bone meal.
• Return on investment for production and applications <3 years.

€€ - $$ ABC ROI = <3 years €€ - $$
INVITATION:
REFERTIL INTERNATIONAL CONFERENCE
June 2015, Brussles
www.refertil.info
E-mail: biochar@3ragrocarbon.com
http://www.agrocarbon.com

The REFERTIL (289785) Collaborative project is co-funded by the European Commission, Directorate General for Research, within the 7th Framework Programme of RTD, Theme 2 - Food, Agriculture and Fisheries, and Biotechnology.
THANK YOU!

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