European Sustainable Phosphorus Platform (ESPP)

ESPP proposed outline for product criteria for "Biochars" for the (revised) EU Fertiliser Regulation

1. Context and objectives of this document

Under the currently proposed **(revised) EU Fertiliser Regulation ("EUFR")**, as published 17th March 2016 (http://ec.europa.eu/DocsRoom/documents/15949), a product will only be able to be placed on the market with a CE label if both:

- It fulfils relevant EUFR criteria for Annex I = PFC - Product Function Category (e.g. organic fertiliser, soil improver, growing media). Depending on the PFC, **these criteria include: contaminant limits for heavy metals, biuret and pathogens (but NOT limits for other organic contaminants),** minimum nutrient contents …
- and it is made only of (one or more) materials listed in Annex II CMC – Component Material Categories
- product conformity is carried out according to the procedures specified in Annex IV – Conformity Assessment Procedures

CMC's already proposed in the draft EUFR include: virgin materials (i.e. products not originating from wastes or by-products) ; non-processed (or only mechanically processed) plants and plant extracts ; composts and digestates (with certain specifications, in particular exclusion of sewage sludge as an input material) ; certain narrowly defined food industry waste streams ; certain animal by-products (table not yet available in first published draft 17/3/16)

The present document aims to define outline criteria for validation of biochars as an additional 'Component Material Category' (under Annex I) in the EUFR.

These proposed outline criteria will be transmitted by ESPP to the European Commission (DG GROW) with the objective of providing input to the preparation by JRC (European Commission Joint Research Centre) of an Annex II 'Component Material Category' for "Biochars", hopefully to be implemented in the EUFR after completion of the currently-underway EUFR revision process.

These proposed outline criteria have been agreed by most biochar stakeholders across Europe which ESPP has been able to identify and contact. In any case, all stakeholders will be able to submit their own proposals or comments independently directly to the European Commission / JRC.

Beyond these proposed (revised) EU Fertiliser Regulation (EUFR) criteria, certain quality specifications of biochar (e.g. additional quality criteria, use of only "organic farming" input materials, specific positive list of input materials, sustainability labelled inputs or process, higher biochar organic carbon content, clean production process …) can be defined by industry and provided as **information for marketing purposes, or be defined in EcoLabel schemes or Voluntary Certification Schemes**. The emissions, industrial safety and other criteria (e.g. waste management …) of the production process are not covered by the Fertiliser Regulation but by operating licencing (under Industrial Emissions Directive or nationally).

It is noted that conformity to the future EUFR criteria for "Biochars" does not exempt from REACH. ESPP suggests that companies producing or intending to produce biochars at an industrial scale, or selling processes to manufacture biochars, should establish a pre-consortium to discuss how to share technical work and costs to understand and to address REACH obligations and also to possibly make joint proposals to adapt the REACH Regulation to be more accessible to this type of inherently variable, organic-material based, recycled product.

To our understanding of the EUFR, a biochar NOT conform to the EUFR biochar criteria could still be either

- placed on the market under NATIONAL fertiliser regulation or case-by-case authorisation - as a product
- or could be used in agriculture under local waste spreading regulation - as a waste (in this case, REACH would not be applicable)

2. General definition of biochar and examples

A definition of "biochar" is considered to be necessary. The following is proposed:

"*Biochar is produced from various types of biomass, under controlled pyrolysis or gasification: a thermal process whereby organic substances are transformed (partly decomposed) in a low-oxygen (reductive) conditions. The pyrolysis also results in gas and/or oil products (pyrolitc oils or bio-oils), useable for energy production or chemical industry feed, in addition to biochar.*"

Torrefaction, hydrothermal carbonisation and coke production are other carbonisation processes whose end products are not covered by this definition of biochar.

For illustration only, and non exclusively, examples of biochar production processes include

- Traditional charcoal stacks
- Rotary kilns
- PYREG patented process
- Wood gasifier (e.g. AGT, Spanner RE^2)
- 3R Technology (c.f. REFERTIL project)
- EPRIDA
- Kon-Tiki
- …..

NOTE: inclusion of a process in this list does NOT imply that these processes necessarily produce EUFR Biochar – for this, the specified criteria must be met

3. Market potential

The volume of biochar sold globally strongly increased from 827 tonnes in 2013 to 7,457 tonnes in 2014 (International Biochar Initiative). An average end consumer retail price of US$3.08 per kg of biochar is indicated in the report for the year 2014, which would translate into a global biochar market volume of approximately US$23 million at this point in time (International Biochar Initiative). Although the cited retail prices are very high (for comparison: wholesale retail prices for biochar of around 0,6 € per kg of biochar are common in the EU in 2016), it is likely that there will be future growth both for the global and European biochar markets if the factors cited above are taken into account (see Meyer, Geneio, Vogel, Schmidt, Someus, Shackley, Verheijen, Glaser "Biochar standardization and legislation harmonization" J. Environmental Engineering and Landscape Management, currently under review 5/2016).

4. Accepted input materials

4a. General approach – principles

- The criteria should be as open (wide) as possible, whilst excluding materials posing unacceptable risks, because limitations on input materials can prevent or delay possible future innovations such as new biochar products based on currently not-identified biomass materials, wastes or byproducts; or new biochar processes which enable economic production of quality-conform products from various secondary materials.

- The criteria must ensure avoidance of sanitary risks (complete elimination of pathogens including prions) and of organic contaminants (such as pharmaceuticals or

consumer chemicals), both for technical risk reasons and for reasons of consumer / farmer / supermarket acceptance. The $H/C_{org} < 0.7$ ensures this, because it effectively guarantees pyrolysis of organic input materials converting all kinds of organic molecules into polycondensed aromatic moieties[1]

The $H/C_{org} < 0.7$ requirement means that:

- Process temperature / time requirements are not necessary.

- A wider set of input materials can "safely" be accepted for biochar than for compost or digestate.

The $H/C_{org} < 0.7$ requirement does not guarantee absence of temperature-related contaminants potentially generated in the process (in presence of chlorine): PAHs, PCBs, dioxins. Therefore, specific criteria are proposed below to address this.

4b. Excluded input materials

The following types of waste are EXCLUDED as inputs:

- Hazardous chemical wastes, hospital wastes, radioactive materials: must not have been deliberately added at any point to the input material
- Municipal Solid Waste (MSW) = any waste stream with >5% by weight mixed, unsorted or residual (after separation of organics) municipal solid refuse

4c. Organic nature of input materials

In order to ensure that the product corresponds to the specified definition "…*produced from various types of biomass …*" at least >95% (dry mass) of input material must be biomass, that is material of plant or animal origin, un processed or "mechanically processed" as specified in the EU Fertilisers Regulation proposal[2] :

- >95% dry weight of input materials must be of plant or animal origin or bio-wastes as listed in the types of admissible input materials below.

- Other materials (not plant or animal origin, not specified bio-wastes), must not exceed
  - 5% (dry mass) in total, including inert minerals
  - 1% of non-organic waste such as petro-chemical plastic, minerals, rubber.

Chemically processed bio-materials may be present up to 5% in input materials, e.g. bio-sourced polymers.

Chemically treated bio-materials (e.g. painted wood, paper industry sludge …) are admissible on condition that:
- hazardous treatment chemicals are <0.5% dry mass in total in the biomass
- all hazardous chemicals used in treatment are expected to be destroyed or to be no longer hazardous in the biochar production process

[1] See e.g. Schimmelpfennig, S., & Glaser, B. (2012). One step forward toward characterization: Some important material properties to distinguish biochars. Journal of Environmental Quality, 41(4), 1001–1013. http://doi.org/10.2134/jeq2011.0146

[2] CMC2, CMC3(a) and CMC7. At present the definitions in these CMCs are not coherent. ESPP suggest the following definition: washing with water, freezing, drying, grinding, centrifuging and filtration, solid/liquid separation, heating and sanitation (to temperatures not susceptible to destroy or pyrolyse organic carbon), pickling, salting, smoking or other non-chemical food conservation processes

NOTE: the conformity of the above to the final EUFR Product Function Category proposals must be verified, e.g. the 17/3/16 EUFR draft specifies that organic fertiliser must contain nutrients and carbon "of solely biological, excluding material which is fossilised or embedded in geological formations".

4d. Accepted input materials

i. Animal by-products:
Cat. 1, 2, or 3 (NOTE: 1 requires modification of Animal By Products Regulation)

ii. Animal manures and slurries

iii. Municipal sewage biosolids

iv. Plants, plant parts, including after non-chemical processing and including after extraction or purification processes, e.g.:
- agricultural crops and crop byproducts (straw, maize foliage …), forestry crops and by-products (toppings, stumps, bark …)
- collectivity green wastes (e.g. from parks and gardens, not from households)
- biomass from freshwater or saltwater maintenance (e.g. extracted or harvested algae, water plants …)
- biomass from industries such as paper, textile … ONLY IF this is collected before any chemical processing
- by-product streams from biorefineries or biofuel production where input is clean biomass
- plant by-products and bio-sourced materials with comparable properties

v. Organic-based used growing media, such as mushroom soil, peat

vi. Food and beverage industry waste (see above regarding animal byproducts), e.g. sugar factory molasses, beer or whisky industry liquors or sludges … This does not include wastes from non-organic food ingredient production, such as from production of chemical food additives.

vii. Bio-waste within the meaning of Directive 2008/98/EC resulting from separate bio-waste collection at source, including collectivity kitchen and canteen food wastes

viii. Mechanically separated organic fraction of municipal wastes, subject to ensuring
- conformity to (4c) above
- <0.01% dry mass materials of potentially hazardous nature (such as electronic waste)

ix. Industry biomass wastes or biomass by-products, subject to conformity to (4c) above, e.g. paper industry sludges, separatively collected used textile fibres, wood from demolition susceptible to contain paints or treatments …

x. Any material which is conform to EUFR Component Material Category criteria, e.g. virgin materials, compost, digestates, ash-based products (underway).

xi. Any material generated by mechanical processing, heat processing, washing, drying, extraction or refining, composting, anaerobic digestion or pyrolysis of the above materials or of mixtures of these

5e. Labelling for certain input materials

Product labelling should specify if any of the following are used as input materials:

- Municipal sewage sludge
- Animal by-products
- Manure

5f. Additives

The following organic or inorganic additives, added before processing (to the input material) or after processing (mixed into the biochar product) may be used if necessary to facilitate the process or ensure the final product agronomic or other characteristics (e.g. granulation), for example:

- Process catalysts or additives
- Minerals such as calcium, sulphur, lime, natural minerals
- Polymers or cohesives to prevent dusting
- Mineral acids such as phosphoric, sulphuric

Maximum total of such additives is 5% in input material[3].

5. Input material contaminant limits

In order to avoid "dilution", the heavy metal limits proposed in the EUFR for the Product Function Category digestate should be applicable to all input materials used for EUFR CMC biochar production.

However, testing should be exempted for contaminants where producers can justify that they are not expected to be found in significant levels.

In particular, this contaminant testing should be required where sewage sludge or the organic fraction of municipal solid waste (including these materials after e.g. drying, digestion) are used as input materials.

Testing should be carried out on different sources or types of input materials, not after blending, again to avoid "dilution".

6. Biochar production process criteria

Production process minimum requirements (temperature, time) are not necessary (to guarantee product safety: elimination of pathogens and of organic contaminants) because this is effectively ensured by the $H/C_{org} < 0.7$ criterion. See on this point the summary of scientific justification in annex A.

7. Biochar product criteria

7.1. Carbon

% carbon (C/dry matter) ≥ 30%

This minimum carbon level is defined in order to ensure that the product is in fact a biochar and not an ash. The 30% minimum is coherent with the International Biochar Initiative criteria for Class 2 biochars (see Meyer et al. 2016 referenced above)

[3] 5% in input is the level fixed for composts and digestates in the EUFR 17/3/16 draft

DIN 51732:2014-07 - Testing of solid mineral fuels - Determination of total carbon, hydrogen and nitrogen - Instrumental methods

7.2. Respirable dust:

Product must not contain > 10% of particles diameter < 100µm (note this is the REACH hazard definition)

Or product should be wetted to 30% - 40% moisture content or should be pelletised to avoid dusting. This is important both for user health safety and for greenhouse impact (ref. “Black carbon aerosol from biochar threats its negative emission potential”, L. Genesio et al., Global Change Biology, in press)

7.3. Hydrogen : organic carbon ratio

The molar H/C_{org} ratio is an indicator of the degree of carbonisation and therefore both of the biochar's stability (Schimmelpfennig and Glaser 2012, referenced above) and of the effective sanitisation (guarantee of elimination of pathogens and or organic contaminants such as pharmaceuticals, consumer chemicals …). See justification above.

$H/C_{org} < 0.7$

Test: DIN 51732:2014-07 - Testing of solid mineral fuels - Determination of total carbon, hydrogen and nitrogen - Instrumental methods

7.4. Heavy metals, pathogens, seeds, macroscopic impurities, stones

Proposal is to not specifically limited for biochars – the (proposed) limits of the EUFR would apply as for other products, depending on the Product Function Category (organic fertiliser, soil improver, growing media) under which the biochar is sold: Cd, CrVI, Hg, Ni, Pb, As, and also limits requiring labelling for Cu, Zn.

7.5. PCBs, dioxins and furans

It is important to ensure that dioxins and furans are not present in the product, because they are a contaminant potentially generated by heat processes with organic input in the presence of chlorine. Chlorine can be significant in a range of input materials, e.g.: some forestry by-products, food wastes, straw, marine/seawater vegetation …

The REFERTIL project www.refertil.info and the WESSLING Group laboratory have investigated seven different biochar series from five EU countries. Even in low end technology performance cases PCDD/F limits were significantly below the targeted < 20 ng/kg (I-TEQ OMS) limit. Therefore, REFERTIL recommends:

a) PCBs: <0.2 mg/kg DM (PCB7 sum of PCBs 28, 52, 101, 118, 138, 153 and 180. Indicator for PCDD/F). TEST: EN 16167:2013

b) PCDD/F: <20 ng/kg (I-TEQ OMS) (mandatory measurement only if PCB >0.07 mg/kg). TEST: CEN/TS 16190:2012

The application of PCBs as PCDD/F indicator is efficient, reliable and cost-effective, because PCDD/F measurements are rather expensive.

7.6. PAH

It is proposed to apply the same limits as in the draft Fertiliser Regulation revision for composts, organic fertilisers and organic soil improvers: PAH_{16} < 6 mg/kgDM[4]

However, for biochars extraction with toluene should be specified because PAHs can be strongly adsorbed to the biochar matrix, so that PAH analysis methods adapted for soils may not accurately detect PAH present in biochars.

Proposed text method: DIN EN 15527: 2008-09 (with toluene extraction); DIN ISO 13877:1995-06 – Principle B with GC-MS.

8. Biochar labelling criteria

Labelling or accompanying transport and delivery documentation shall specify:

- Producer data, identity and location of production site
- Production site operating permit number or reference
- EPR Extended Producer Responsibility certificate number or reference
- Production series number
- REACH registration reference number
- Bulk density
- Particle size distribution
- pH (test: DIN 10 390
- Water content: (test:)DIN 51718; TGA 701 D4C)
- Specific surface area (test: BET measurement ISO 9277)
- Total of each of: P, N, K, Mg, Ca, Fe, Mn (as % dry matter)
- Salinity (Na, Cl)
- % of P which is water soluble, NAC soluble
- User information concerning transport, storage and application recommendations

9. Control and monitoring

To be defined

10. Annex A: Biochar production process criteria

Production process minimum requirements (temperature, time) are not necessary to guarantee product safety because elimination of pathogens and of organic contaminants is effectively ensured when H/C_{org} < 0.7 is achieved. This can be easily seen on a van-Krevelen-diagram (Fig. 1). All organic molecules such as pathogens and organic contaminants are being converted to polycondensed aromatic moieties if the atomic H/Corg ratio is smaller than 0.7 (Fig. 1).

[4] Using the same specifications and test method as in the EUFR, that is : “Sum of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene and benzo[ghi]perylene”. Test method not specified in EUFR

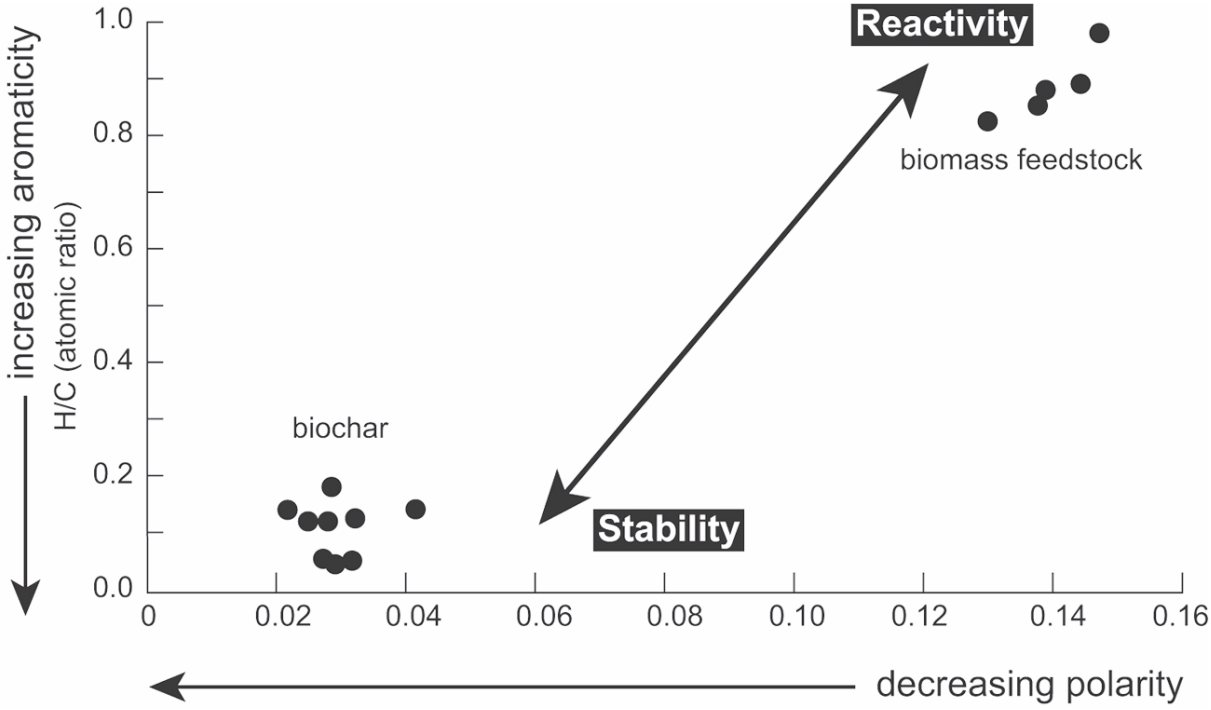

Figure 1. van-Krevelen-diagram showing the atomic H/Corg ratio vs. the atomic O/Corg ratio of biomass feedstock including pathogens and organic contaminants and other organic components. During pyrolysis or gasification, organic molcules loose water (H_2O) and carbon dioxide (CO_2) so that the resulting biochar molecule is characterized by decreased polarity and increased aromaticity. Please note that the structure of biochar is completely different from the original biomass structure and that this is only an average molecular structure (Lopez-Capel, E., Postma, R., Zwart, K., Shackley, S., Stenstrom, J., Rasse, D., Budai, A., Glaser, B. Biochar properties. In: Shackley, S., Ruysschaert, G., Zwart, K., & Glaser, B. (2015). Biochar in European Soils and Agriculture).