



Knowledge for Resource Added-value Conversion

Knowledge Based Bio-Economy

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Converting trash into cash: carbon refinery, recovery and recycling of added value organic Phosphate products

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Practice training for ABC-BioPhosphate products

The ABC (Animal Bone Char) BioPhosphate critical raw material and biochar products are the outputs of the breakthrough, evidence-based and innovative 3R zero emission carbon refinery technology, which focus on cheapening the value chain by reducing the cost and time of water and agricultural related large infrastructural investments. The project is based on large scale EU Commission co-financed RTD projects I have coordinated and implemented 2002-2019 (trusted EU references). The recovered and high concentrated Phosphorus products are targeting social and environmental impacts, such as elimination of contamination from food chain and improvement of food safety for less cost. The impacts are well-defined and integrated into the business model and systematically measured. The project demonstrating sustainable growth of the business to deliver impact through a promising and realistic business planning, and a significant growth potential at a relatively modest capital investment, with a realistic exit strategy capable of supporting financial and non-financial returns.

The company 3R-BioPhosphate Ltd. is truly Consumer focused for the ABC-BioPhosphate commercialisation strategy, based on 4P (Product policy, Price policy, Place policy, Promotion & exploitation policy) marketing mix, for creating awareness and customer/user loyalty. The formulation of multiple ABC fertilizing products is suitable to meet the most varied and difficult needs of the land. The use of these new ABC and formulated BIO-NPK-C-micronutrient and microbiological organic matrixes, combinations and mixes are highly market competitive under different scenario in the targeted temperate climatic zone country markets, EU, Australia, Japan and USA.

Practitioners and Users are highly welcome to contact us with any questions, suggestions and specific requirements to meet and optimise local specific demands in most effective manner, all in order to support sustainable, economical and price competitive food crop productions.



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1. EXECUTIVE SUMMARY

All in order to support the EU/MS Authority permitted, legalized ABC-BioPhosphate applications under market competitive and economical industrial scale, defined application methods and good practice guide set up. ABC-BioPhosphate can have several applications in agriculture: such as soil improvers, growing media, organic fertilizers. Application methods depend mainly on the type of product, soil and crop, as described in this deliverable.

2. Application methods and good practice guide for the ABC-BioPhosphate products

2.1. ABC-BioPhosphate and Biochar products definition and quality criteria

ABC-BioPhosphate and Biochar products are specific products with quality and material performance that are primarily manufactured for agricultural food crop production or forestry nursery soil applications. There are overlapping reductive thermal processing production and agri application scenarios between **ABC (Animal Bone Char) – BioPhosphate** and **Biochar** products, with differences such as:

- a) **ABC-BioPhosphate organic fertiliser** = animal bone by-product input material reductive thermal processed, resulting high Phosphorus nutrient content pure calcium-phosphate products. This is processed under true value reductive thermal conditions at 850°C material core temperature and used with application dose ≈ 0.2 t/ha to 1.5 t/ha as blank or BIO-NPK-C formulated.
- b) **BIOCHAR soil improver** = biomass plant based input material reductive thermal processed, resulting high Carbon content stabile carboniferous substance products, but with no any fertiliser content in economical scale/importance. This is processed under true value reductive thermal conditions at 450°C material core temperature and used with application dose ≈ 5 t/ha to 20 t/ha as blank or compost combined. In some cases the input materials may be alternative organic waste streams as well.

Both types of biochar products processed under true value reductive thermal conditions with >1 t/y commercial capacity or more for fit for use agricultural applications; which manufacturing, product quality and safety, applications and use, import and placing on the market lawfully meet the mandatory EU/MS Authority permit and regulatory requirements, while such products produced up to <1 t/y capacity is research sample and/or test materials not for commercial use. **This training material is for the ABC-BioPhosphate organic fertiliser applications only.**



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Both types of biochar products are made by a specific pyrolysis (reductive thermal) process with designed quality, environmental and ecological safety, performance and character for food crop production agri applications. Plant based biochar is soil improver; and ABC BioPhosphate is organic P/Ca fertiliser and growing media. Both are interconnections between life in the soil with complex functional interactions of soil's living (biotic) and non-living (abiotic) components, clean water and above ground economical agricultural productivity in a linked, coherently integrated and harmonized ecological system.

Commercial Biochar materials are qualified as products when fully meets both the technical and legal requirements together, such as:

- 1) **TECHNICAL**: meets all the quality, safety, labelling and performance requirements that are mandatory specified in the EU/MS regulations for fit for use application.
- 2) **LEGAL**: originating from legally permitted above 1 t/y capacity production; having lawful permit for application; EU REACH and Extender Producer Responsibility certified. EU producer or importer is the full and sole responsible organization to safeguard and fully guarantee biochar quality, safety and performance under permitted legal conditions.

What is not biochar product:

- a) **the product quality is not lawful**, e.g. does not meet the valid and legally EU/MS Authority permit defined minimum product quality/safety for fit for use in agriculture as specific purpose (or does not fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products, including high risk for adverse environmental or human health impacts), and/or
- b) **energetic carbons and/or charcoal and/or labile hydrothermal carbon HTCs are not biochar**, and/or
- c) **the production is not lawful**, e.g. does not have valid and identified EU/MS Authority permit for production and agriculture specific purpose placing on the market in the EU or certification according to REACH, and/or
- d) **the use is not lawful**, e.g. does not have valid and identified EU/MS Authority permit for the agriculture specific purpose use, and/or
- e) **produced from non-sustainable feed material**, e.g. the feed material is not biomass and/or the feed material is competing with human food, animal feed and plant nutrition supply, and/or



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2.2. Mandatory permits for import, manufacturing, placing on the market and use

Manufacturing/ import/ placing on the market and using of all types of biochar products in the EU above 1 t/y capacity require mandatory EU/MS Authority permits and certificates with Circular Economical aspects:

1. **Member State Authority permits for biochar production is mandatory according to the EU regulations.**
2. **Member State Authority permit for biochar applications is mandatory according to the EU regulations.**
 - New Fertilising Product Regulation EU 1009/2019 will be implemented from July 16, 2019 as EC Fertilisers (material safety, quality and labelling)
 - Mutual Recognition (EC 515/2019) procedure extended to other MS.

All relevant information shall be in a language which can be easily understood by end-users, as determined by the Member State concerned, and shall be clear, understandable and intelligible.

3. **REACH registration** for any import, placing on the market and manufacturing above >1 t/y capacity.
4. **Extended Producer Responsibility** certificate. Biochar producers having extended responsibility for both production and product quality. As biochar product application is irrevocable, therefore producers full responsibility is key legal element above 1 t/y biochar import, manufacturing and placing on the market capacity.

The voluntarily biochar certifications are not accepted by the EU/MS regulations and do not have any technical/legal effect and validity in the EU.

The PAH key indicator provides prompt information on biochar product quality.

- ✓ **REJECTED (PAH₁₆ >6mg/kg):** PAH₁₆ number is higher than 6 mg/kg than the product is not applicable as biochar product in the EU.
- ✓ **ACCEPTABLE (PAH₁₆ <6mg/kg):** PAH₁₆ number is lower than 6 mg/kg than the biochar product is standard product for EU application.



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- ✓ **APPLIED IN PRACTICE (PAH₁₉ <1mg/kg):** PAH₁₉ number is lower than 1 mg/kg than the biochar product is MS approved. Such norm is already applied since 2006 in cases when the environmental risk is high, especially in water protected areas, that is the majority of the EU high population density area.

It is important to highlight that different MS having different PAH regulations for soil improvers between PAH₁₆ <6 mg/kg and PAH₁₉ <1 mg/kg, that is a big difference.

2.3. ABC-BioPhosphate use according to specific applications

This is a technical recommendation, but the market competitive economical use and economical viability is to be investigated case by case.

- Generally all ABC-BioPhosphate is economical viable already in short term in all dosis at all low input and organic horticultural applications, and organic field crop cases with higher plant value.

2.3.1. ABC-BioPhosphate applications in Product Functional Categories “PFC”

ABC-BioPhosphate is used with as high as 30% P₂O₅ content and high Calcium, usually between 200 kg/h – 1500 kg/ha, but already at 300 kg/ha good effect can be reached.

- ✓ PFC1: Solid organic fertilizer
- ✓ PFC2: Liming material
- ✓ PFC3: Organic soil improver
- ✓ PFC4: Growing medium
- ✓ PFC6: Plant biostimulant, microbial and non microbial
- ✓ PFC7: Fertilizing product blend

Wide range BIO-NPK-C formulations and compost blends are all available for the ABC-BioPhosphate applications as of specific demand of medium and large Users.



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2.3.2. Plant disease suppression

Organic amendments are important for managing biodiversity in soil, improve his microbial populations that are critical to soil function and ecosystem services. That amendments have implications for soil structure, nutrients, water retention, disease resistance and C storage capacity.

Even though biochar does not have a microorganisms mix, there are lot of ways in which ABC-BioPhosphate may induce systemic plants resistances such as improve nutrient supply.

ABC-BioPhosphate is initially sterile and does not have an indigenous population of microorganisms that can potentiate disease suppression. Yet, ABC-BioPhosphate does influence microbial populations and communities, and these changes may include an increase in beneficial microorganisms that directly protect against soil pathogens by producing antibiotics, by outcompeting the pathogens, or by grazing on the pathogens.

The use of ABC-BioPhosphate for suppressing plant disease is case specific, and there's not a single way of application. Biochar formulated with microbial antagonists is more efficient and reliable.

2.4. BioPhosphate good practice guide

The feedstock management and transport logistics is one of the most critical economical, production security, environmental and production efficiency issues of biochar operations. Storage infrastructure is an indispensable component of biochar supply chains. Storage is therefore unavoidable while at the same time one of the major sources of risk in the supply chain. The risk arises from technical issues during storage (such as fire) as well as the opportunity cost of tied-up capital. In a geographically dispersed area, feedstock prices increase as distance to biochar production plant increases because transport costs increase. A whole-of-the-chain perspective is therefore critical to balancing the reliability of transport and the location and size of storage facilities. Feedstock management and transport logistics organization varying from biochar case by case, but it is most certain that in all biochar cases careful planning must be done before anything else.



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Table 1. Best management practices for storage, handling, and transportation of materials

Best management practices for biochar storage, handling, and transportation		
	Plant based biochar	ABC BioPhosphate
Fire risk	Very high risk	Low risk
Dust explosion risk	Very high risk	Low risk
Self ignition	Very high risk, especially at fresh biochar	Low risk
Wetting during transport	Yes, ~40%	Not needed
Special regulation for transport of risk material	yes	no

Table 2. Best management practices for material applications

Best management practices for applications		
	Plant based biochar	ABC-BioPhosphate
Wind loss , wind erosion by field application	Very high risk, wetting is needed	No risk
Water erosion by field application	Very high risk, proper soil incorporation needed	No risk
High dose	The higher dose 5 – 20 t/ha resulting higher toxic element input/ha	No risk at any standards doses 0.2 – 1.5 t/ha
Formulation	Only by-products and pure organics	Only by-products and pure organics
Microbiological formulation efficiency	low	Very high
Organic certificate	yes	yes
Reduced and no-till systems	yes	yes



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Best management practices for applications		
	Plant based biochar	ABC-BioPhosphate
Carbon sequestration	yes	no
Soil improver	yes	yes (but case specific because of the low dose)
Growing media	Yes (specific conditions)	Yes (specific conditions)
Organic fertilizer	No (as no fertilising nutrient content with importance)	yes
Soil remediation	yes	yes
Liquid manure processing	yes	yes
Compost combination	yes (5-10% w/w)	yes (1-3% w/w)

The following guidelines (Table 3 - 7) summarize the methods for use according to specific applications.

Table 3. Guideline for product use according to the specific applications (All uses)

Uses	Methods	Crops
All	<ul style="list-style-type: none"> All types of biochar products above 1 t/y may only be applied when all mandatory EU/MS Authority permits are available for manufacturing, import, placing on the market application and use, and the product labelling is available according to regulations. All types of biochar products above 1 t/y may only be applied when the used product is having Extended Producer Responsibility certificate. Product activation: if the products not formulated, it is important to activate it before use, mixing it with compost or other organic materials. Doses are highly different for plant biochar or ABC BioPhosphate. Microbiological and other nutrient formulation strategy is to be advised from the manufacturer. Wetting biochar is also useful to prevent the formation of dust. 	All



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Uses	Methods	Crops
All	<p>IMPORTANT FOR ALL TYPES OF BIOCHAR USE:</p> <ol style="list-style-type: none"> 1) All in order to ensure the high functionality in shorter time of the biochar, the product should be formulated, activated, blended and/or at least wetted before use. 2) Legally purchased EU made biochar (that meet the regulation quality specifications) from EU/MS Authority permitted supplier with Extended Producer Responsibility certificate is high quality and always safe to use according to labelling instructions. 3) As biochar use in soil is irrevocable action, User is having full responsibility before purchase and use of biochar, to make sure that the product is having the full set of mandatory Authority permits available documented, including the Extended Producer Responsibility certificate. 4) Illegal biochar with above 1 t/y capacity and no mandatory permits and certificates, e.g. no proper documents of safety available, should not be used for agricultural purposes. 	All

ABC-BioPhosphate and compost can be used separately or combined together to make synergistic effects. These are not competing products and usually made of different by-product streams as well. While input feed materials to make ABC-BioPhosphate are dry, the feed materials to compost usually of high moisture content. ABC-BioPhosphate add-on to composting may result in shorter composting time, reduced rates of GHG emissions, reduced ammonia losses, and reduced odor. a.s.o. At the same time ABC-BioPhosphate will retain moisture and nutrients.

ABC-BioPhosphate with compost integrated application positively influences soil structure, including reduction of bulk density; increase of aggregate stability; improvement of pore volume and hydraulic conductivity; improved water retention; improved air balance; reduction of soil erosion and run-off; stimulating microbial growth and respiration rates; improved heat balance of soils and increase of Cation Exchange Capacity.



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Table 4. Guideline for biochar use according to the specific applications (Soil improver)

Uses	Methods	Crops
<p align="center">Soil improver</p>	<ul style="list-style-type: none"> Careful and gentle soil preparation by mechanical ploughing up to 20-30 cm depth. However tilling destroys large amounts of the fungal hyphae, therefore full tilling is not recommended. Spreading of material with fertilizer-spreader or by hand at 5-20 t/ha in case of plant based biochar, at 200-1500 kg/ha in case of ABC BioPhosphate, according to crop uptakes and soil conditions. To be carried out in autumn or, if already activated, 3-5 days before sowing. Tilling with a mechanical cultivator and sowing. 	<p align="center">Field and cereal crops</p>
	<ul style="list-style-type: none"> Careful and gentle soil preparation by mechanical ploughing up to 20-30 cm depth. However tilling destroys large amounts of the fungal hyphae, therefore full tilling is not recommended. Spreading of biochar with fertilizer-spreader or by hand at 5-20 t/ha in case of plant based biochar, at 200-1500 kg/ha in case of ABC BioPhosphate, or on the row, according to crop uptakes and soil conditions. To be carried out in autumn or, if already activated, 3-5 days before sowing/transplanting. Tilling with a mechanical cultivator and sowing/transplanting. 	<p align="center">Vegetable crops</p>
	<p>Pre-planting:</p> <ul style="list-style-type: none"> Soil preparation by mechanical ploughing up to 20-30 cm depth. Spreading of biochar with fertilizer-spreader or by hand at 5-20 t/ha in case of plant based biochar, at 200-1500 kg/ha in case of ABC BioPhosphate, or locally, on the row, according to crop uptakes and soil conditions. To be carried out in autumn. Tilling with a mechanical cultivator and sowing/transplanting. <p>After planting:</p> <ul style="list-style-type: none"> Spreading of biochar locally, on the row, according to crop uptakes and soil conditions. 	<p align="center">Fruit crops and grape</p>



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Table 5. Guideline for ABC BioPhosphate use according to the specific applications
(Organic Fertiliser)

Uses	Methods	Crops
Organic fertilizer	<ul style="list-style-type: none"> Only ABC-BioPhosphate can be considered. Careful and gentle soil preparation by mechanical ploughing up to 20-30 cm depth. Spreading of ABC BioPhosphate with fertilizer-spreader at 200-1500 kg/ha according to crop uptakes and soil conditions. To be carried out in autumn or, if already activated, 3-5 days before sowing. Tilling with a mechanical cultivator and sowing/transplanting. BIO-NPK-C and microbiological formulations considered case by case and advised by the manufacturer. 	Field crops
	<ul style="list-style-type: none"> Mix it to the growing media up to 10% v/v, at least 48 hours prior to sowing/transplanting. BIO-NPK-C and microbiological formulations considered case by case and advised by the manufacturer. 	Greenhouse crops

Table 6. Guideline for ABC BioPhosphate use according to the specific applications
(Growing media)

Uses	Methods	Crops
Growing media	<ul style="list-style-type: none"> Analyse pH and E. C. If E.C. is lower than 1000 $\mu\text{S}/\text{cm}$, it is possible to mix it to the growing media up to 20% v/v, at least 48 hours prior to sowing. If E.C. is higher than 1000 $\mu\text{S}/\text{cm}$, it is recommended to mix it to the growing media at maximum 10% v/v, at least 48 hours prior to sowing. 	Vegetable crops
	<ul style="list-style-type: none"> Analyse pH and E. C. If E.C. is lower than 1000 $\mu\text{S}/\text{cm}$, it is possible to mix it to the growing media up to 20% v/v, at least 48 hours 	Ornamentals and flower crops



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	<p>prior to sowing.</p> <ul style="list-style-type: none"> • If E.C. is higher than 1000 $\mu\text{S}/\text{cm}$, it is recommended to mix it to the growing media at maximum 10% v/v, at least 48 hours prior to sowing. • If pH is higher than 7.5 and acidophilus plants are considered, it is recommended to mix it to the growing media at maximum 5% v/v. 	
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Table 7. Guideline for ABC BioPhosphate use according to the specific applications
(Plant Disease Supression)

Uses	Methods	Crops
Plant disease suppression	<ul style="list-style-type: none"> • Careful and gentle soil preparation by mechanical ploughing up to 20-30 cm depth. • Spreading of ABC BioPhosphate with fertilizer-spreader or by hand at 200-1500 kg/ha, according to crop uptakes and soil conditions. • Tilling with a mechanical cultivator and sowing/transplanting. • Do not disinfest the soil after the application. • It is possible to integrate it with soil solarization, biofumigation, grafting and other agronomical practices. • It is better to use ABC BioPhosphate microbiologically formulated with fungus microbials. 	Field crops
	<ul style="list-style-type: none"> • Mix it to the growing media up to 20% v/v, at least 48 hours prior to sowing/transplanting. • Do not steam sterilize it. • It is better to use ABC BioPhosphate that is microbiologically formulated with fungus microbials. 	Greenhouse crops