Nutrient Management and Nutrient Recovery Thematic Network

Case presentation of fertilizing technologies and products obtained from bioeconomy processes:
BioPhosphate (ID:192)
Biochar (ID:1571)"

NUTRIMAN BIOCHAR CASES
Edward Someus
3R-BioPhosphate Ltd.
May 27, 2021

NUTRIMAN FARMER PLATFORM
3R technology based biochar cases

BIO PHOSPHATE
100% NATURAL

- **ID1571**: **Terra-Preta biochar product** recovered from wood chips and processed by “3R” high temperature pyrolysis process
- **ID192:** High nutrient dense **Bio-Phosphate products** recovered from food grade animal bone grist with over 30% P2O5 content by "3R zero emission pyrolysis" process
  - **NUTRIMAN FP LINK:** https://nutriman.net/farmer-platform/product/id_192
- **ID193:** 3R Recycle-Reuse-Reduce **zero emission pyrolysis technology** for phosphorus recovery from food grade animal bone grist for production of Bio-Phosphate products
  - **NUTRIMAN FP LINK:** https://nutriman.net/farmer-platform/technology/id_193
  - **NUTRIMAN FP LINK:** https://nutriman.net/farmer-platform/product/id_1571

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INTRODUCTION

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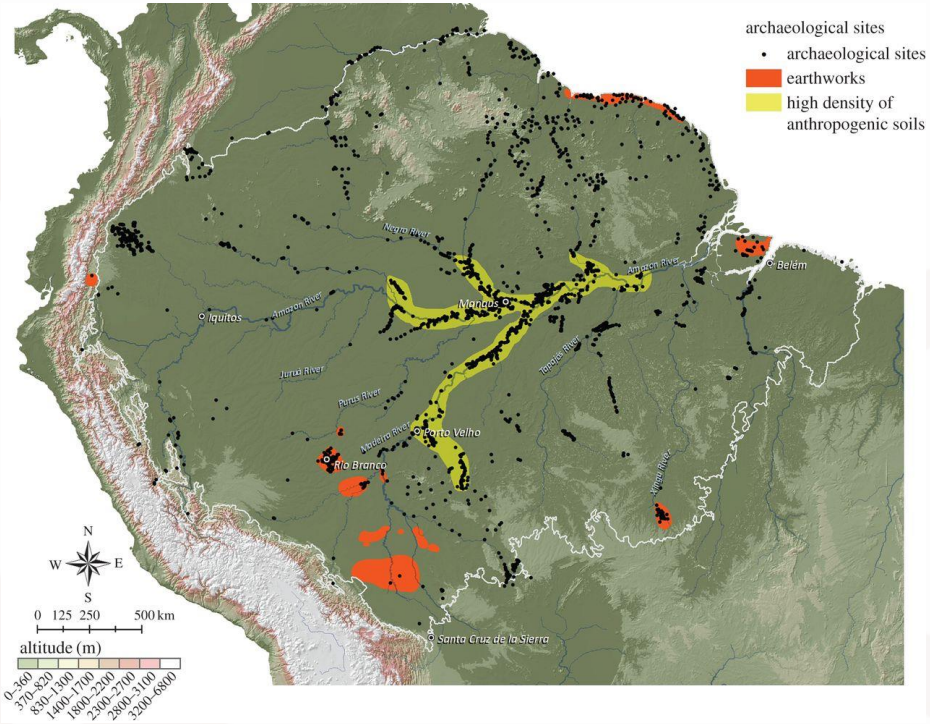
- **3R-BioPhosphate Ltd.** is a **pyrolysis – carbon refinery specialized deep-tech** SME company since 1989, originally ALSTOM subsidy JV. **CORE focus:**
  - Added value utilization of unexploited agricultural and food industrial by-products.
  - Recovery of Phosphorus critical raw material.
  - Conversion of science into industrial and commercial practice.
  - Continuous policy support for Circular Economy/Fertilizers Regulation….

What is Terra Preta de Indio – Biochar

Known as “Black Earth” Amazonian dark earth. High char content soil, that is created by Amazonian farming communities between 450 BC and 950 AD.



Creating soil: amending ferralsoil with charcoal for greatly increased productivity

What is TERRA PRETA BIOCHAR?

BIOCHAR MATERIAL is:

- plant and/or animal bone biomass origin carboniferous material,
- Authority permitted for lawfully marketing and
- eco-safe carbon negative applications.

BIOCHAR PRODUCT have specific quality requirements and

- a labeled and full value chain safe product,
- with producers responsibly guarantees,
- meet the EU industrial and environmental norms/standards.

INPUT SUSTAINABLILITY CRITERIA, the feed material is:

- not from primarily and secondarily land use.
- not competing with human food and animal feed.
- logistics is sustainable.

What is NOT TERRA PRETA BIOCHAR? – I.

- Biochar is **NOT a fine ground charcoal, not activated carbon,** and/or
- biochar is **NOT labile carbon hydrochar** material that application is rapidly promoting GHG developments, 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/or

What is NOT TERRA PRETA BIOCHAR? – II.

- the **pyrolysis process is not towards zero emission performance**, and/or
- the pyrolysis process is **not energy self sustaining**, and/or
- the pyrolysis – **biochar production – manufacturing process is not Government Authority permitted and controlled** operation, and/or
- the **application of biochar materials in open ecological soil environment above 1 t/y capacity is not Government Authority permitted** and contolled operation for lawfully marketing, (voluntarily biochar cetificates have no legal value or validity), + **from July 16, 2022 FPR EU 2019/1009** and/or
- All biochar products must be **REACH certified** above 1 t/y capacity, manufacturing, import, use, …

What is NOT TERRA PRETA BIOCHAR? – III.

- the overall life cycle of the process (input material, process, biochar use) is **having more negative environmental impacts than total benefit**, and/or
- the biochar product having **no labeling and 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 unlcear carbon trade programmes.

Sustainability of feed material for biochar production

1. **Biochar feed materials** **does not compete with human food, animal feed and plant nutrition supply**. Production biochar from low economical value by-product biomass should not create competition for land use for human and animal food production.
2. **Low feedstock production costs and inputs** needed.
3. **Feedstock availability**: seasonal and yearly round availability.
4. **Environmentally sustainable feed material logistics**. The environmental and human health impact of logistics storage should be minimized.
5. **Economically sustainable feed material availability**: price and long term supply contract and logistical cost.
6. **Feedstock quality and safety**: no Potential Toxic Element Content.

Plant based biomass vs. animal bone feedstocks

	PLANT BASED	ANIMAL BONE BASED
Density	Low: 100 – 300 kg/m3	High: 650 – 670 kg/m3
Biochar yields	Low: 15-30%	High: 50-60%
Feedstock cost	Low	High
Transportation cost per ton	High	Low
Alternative feed supply	Multi feed strategy	Multi feed strategy
Material handling	Costly: large volume, bulky and high storage requirement	Medium cost
Fire protection system cost	High	Low

Reductive thermochemical phosphorus recovery (ID 193)

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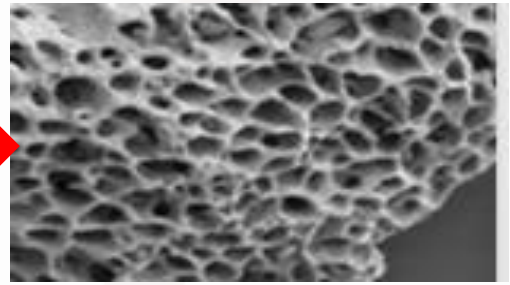
Origins: 3R-BioPhosphate Ltd. www.biophosphate.net

Technological process: Pyrolysis – carbonization process in reductive (indirectly heated) conditions, 750°C - 850°C (material core). **Raw materials: pressure sterilised** category 3 food grade animal bone grist.

Products obtained: "ABC-BioPhosphate" organic P fertilizer, "BIO-PNK-C" PNK compound fertilizer and absorbents.

Production capacity: > 12,500 t/year of ABC-BioPhosphate



Low value input:
Unexploited biomass
Food Grade bone materials

Unique processing:
Massive competitive benefits
Maximum high efficient

High added value:
Bio-Phosphate
Green energy
Absorbents

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ID192 - ID193 STATUS & TRL Level

BIO PHOSPHATE
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BASIC RESEARCH

TRL 1 – basic principles observed

TRL 2 – technology concept formulated

TRL 3 – experimental proof of concept

TRL 4 – technology validated in lab **1980's**

APPLIED S&T RESEARCH pilot plant

TRL 5 – technology validated in industrially relevant enviro **1990-1995**

TRL 6 – technology demonstrated in industrially relevant environment

EU FP5 MULTI FUEL 2002-2005

APPLIED S&T RESEARCH field demo plant

TRL 7 – system prototype demonstration in operational environment

EU FP6 PROTECTOR 2005-2009

TRL 8 – system complete and qualified **EU FP7 REFERTIL 2011-2020**

Full industrialization **2021 - 2022**

TRL 9 – full industrial commercial and market competitive manufacturing from standard 20,800 t/y throughputs and above.

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ID193 – BIO-PHOSPHATE processing technology

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3R TECHNOLOGY (ID193):

- ✓ **Unique high processing temperature** (850^{0}C).
- ✓ **Zero emission**
- ✓ **Surplus bioenergy**
- ✓ **Full legal compliance beyond 2022**

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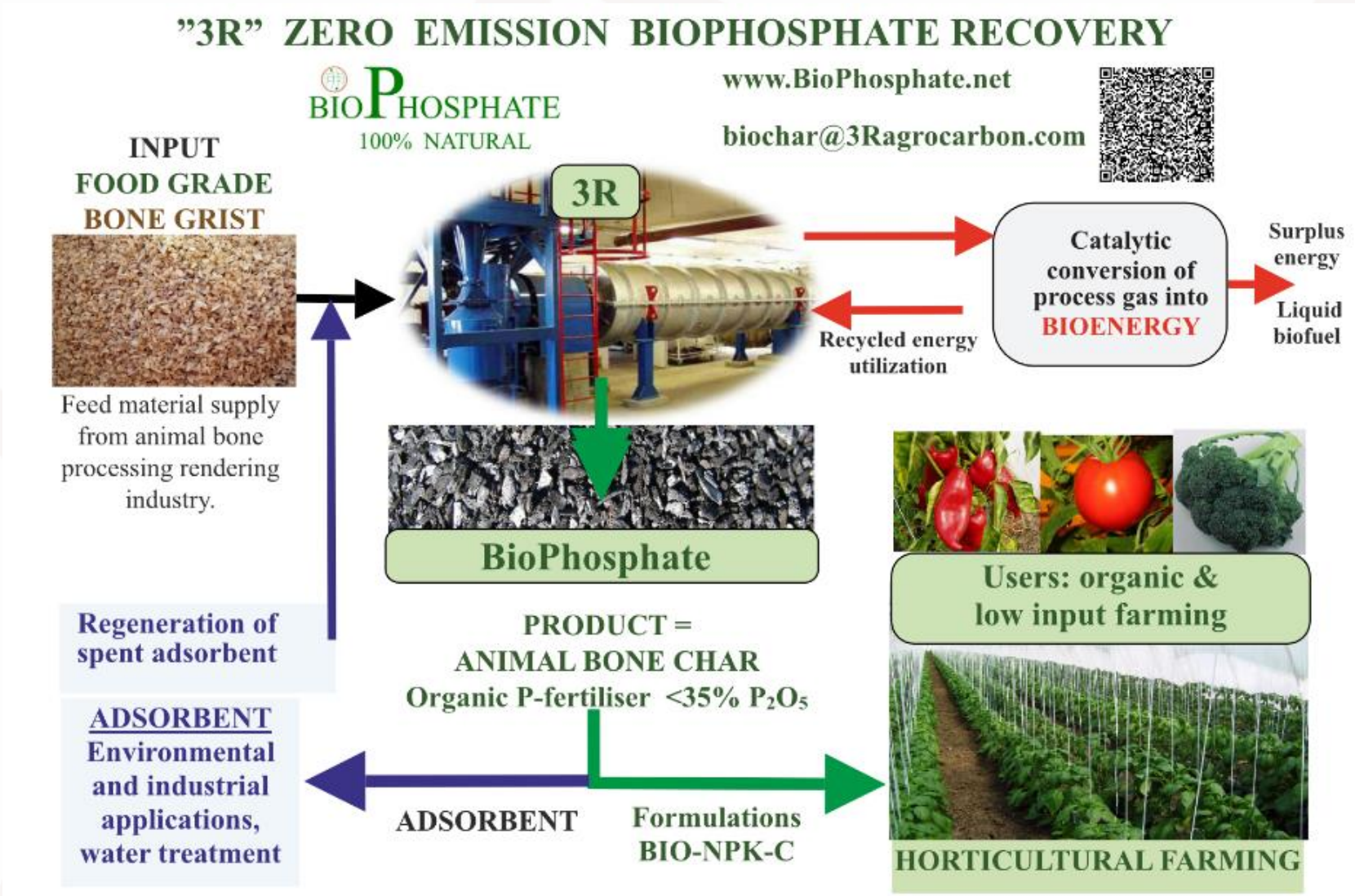
Reductive thermochemical phosphorus recovery (ID 193)



BIO-PHOSPHATE (ID192)

BIO PHOSPHATE
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- RECOVERED & RENEWABLE organic PHOSPHORUS FERTILISER, soil improver, growing media and special adsorbent.
- **UNIQUE CHARACTERISTICS:**
  - >30% P_2O_5 + 40 **%** CaO (92% mineral + 8% Carbon).
  - Made from food grade category 3 cattle bones.
  - BIO-NPK-C formulated as of Users need.
  - No any contamination.
  - **Natural - organic – pure - safe.**

- **CONCENTRATED & ECONOMICAL**
- Recommended dose: 0.2 t/ha - 1.5 t/ha.
- **The Bio-Phosphate is the only concentrated organic P product available that meet the new EU regulations >2022.**

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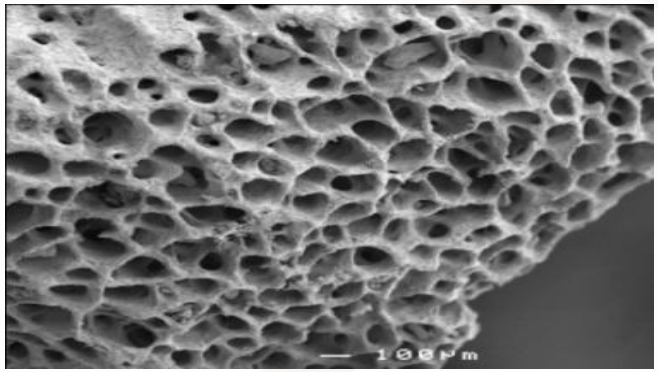
ID192 Proven field demonstrated
IT – IL - DE - NL - DK - SI - ES - HU - IRL - UK



BioPhosphate inside

Efficiency tests

International tests in different conditions, drought tolerance test

High food safety and security

Successful in different and wide range of climatic & soil conditions

ID192: USP Unique Selling Points

BIO PHOSPHATE
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- **Prime EU Markets: DE, FR, IT, ES, A, CH.**
- **EU organic farm land: 15 M ha (7.2%)**
- **EU organic sales: >€37 Billion/year.**
- **Organic fruits/vegetables: >35%.**
- **Organic sales growth: >11%/year.**

USER BENEFITS:

- ✓ Fully organic certified
- ✓ Yield improvement: >10%
- ✓ Improved fruit quality: >50%
- ✓ Decreased production costs by 15% - 25%.

concentrated + **pure + natural +** User efficient + **economical**

BIO-PHOSPHATE PRODUCT (ID192) APPLICATION AUTHORITY PERMIT

BIO PHOSPHATE
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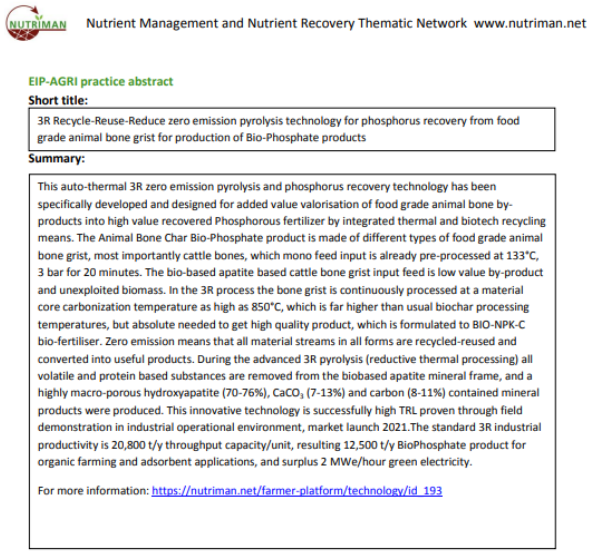
- **National Authority: National Food Chan Safety Office**
- MS Authority permit number: 6300/2407-2/2020 as of EU for horticultural applications & lawful marketing in the EU27. EC REACH >1000 t/y capacity: under progress. Meets the new EU Fertilising Products Regulation (EU 1009/2019) 2022 and EC Mutual Recognition Regulation 2019/515.
- **REACH: under progress**

NUTRIMAN – Farmer Platform: 3R Technology (ID 193)

Documents in 8 languages (EN, DE, FR, IT, NL, ES, HU, PL) – available/downloadable

https://nutriman.net/farmer-platform/technology/id_193



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EIP-AGRI practice abstract

Short title:

3R Recycle-Reuse-Reduce zero emission pyrolysis technology for phosphorus recovery from food grade animal bone grist for production of Bio-Phosphate products

Summary:

This auto-thermal 3R zero emission pyrolysis and phosphorus recovery technology has been specifically developed and designed for added value valorisation of food grade animal bone by-products into high value recovered Phosphorous fertilizer by integrated thermal and biotech recycling means. The Animal Bone Char Bio-Phosphate product is made of different types of food grade animal bone grist, most importantly cattle bones, which mono feed input is already pre-processed at 133°C, 3 bar for 20 minutes. The bio-based apatite based cattle bone grist input feed is low value by-product and unexploited biomass. In the 3R process the bone grist is continuously processed at a material core carbonization temperature as high as 850°C, which is far higher than usual biochar processing temperatures, but absolute needed to get high quality product, which is formulated to BIO-NPK-C bio-fertiliser. Zero emission means that all material streams in all forms are recycled-reused and converted into useful products. During the advanced 3R pyrolysis (reductive thermal processing) all volatile and protein based substances are removed from the biobased apatite mineral frame, and a highly macro-porous hydroxyapatite (70-76%), $CaCO_3$ (7-13%) and carbon (8-11%) contained mineral products were produced. This innovative technology is successfully high TRL proven through field demonstration in industrial operational environment, market launch 2021.The standard 3R industrial productivity is 20,800 t/y throughput capacity/unit, resulting 12,500 t/y BioPhosphate product for organic farming and adsorbent applications, and surplus 2 MWe/hour green electricity.

For more information: https://nutriman.net/farmer-platform/technology/id_193

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NUTRIENT RECOVERY TECHNOLOGY Info Sheet

3R Recycle - Reuse – Reduce

zero emission pyrolysis technology for phosphorus recovery from food grade animal bone grist for production of Bio-Phosphate products.

BIO P HOSPHATE

phosphorus recovery • pyrolysis • zero emission • biophosphate• biofertiliser

Key facts:

- **Category of the technology**: reductive thermo-chemical (zero emission pyrolysis) phosphorus recovery.
- **Input:** food grade cattle and other types of bone grist
- **Output product(s):** ABC-BioPhosphate organic/low input farming innovative fertilizer, BIO-NPK-C formulations and adsorbents.
- **Available capacity:** >12,500 t/y ABC Bio-Phosphate output.
- **Focusing geographical areas:** EU27, UK, USA, Australia, Japan
- **Technology status:** beyond >TRL8 / IRL8
- **EC/MS Authority permits:** Industrial scale pyrolysis plant installation/operation permit: FES/01/0851-33/2015.

Summary of the technology:

The specific objective of 3R Recycle-Reuse-Reduce zero emission pyrolysis and phosphorus recovery key enabling technology is the added value upgrading and valorisation of food grade animal by-products into safe and high value recovered organic Phosphorous fertilizer by integrated thermal and biotechnological recycling means. The Animal Bone Char (ABC) **Bio-Phosphate product is made of food grade animal bone grist**, most importantly cattle bones. This mono feed basic material is already processed at 133 degree Celsius for 20 minutes under 3 bar processing conditions. The **high Phosphorous content animal bone grist** input feed streams are low value utilized by-products. In the 3R process the bone **grist is processed at as high as 850 degree Celsius material core carbonization temperature, which is far higher than usual biochar processing temperatures, but absolute needed to get high quality product.** During the advanced pyrolysis (reductive thermal processing) all volatile and protein based compounds are removed from the mineral frame, and a highly macro-porous hydroxyapatite (70-76%), $CaCO_3$ (7-13%) and carbon (8-11%) content mineral material produced. The output products are high quality and safe **Bio-Phosphate** and its BIO-NPK-C bio-formulated variations used for wide range of organic/low input farming and environmental (adsorbent) applications.

Competitive position and advantages:

- **High material core temperature 850°C reductive thermal processing** with specific treatment conditions, which is resulting output products with unique surface and material composition characteristics.
- **Mono feed: the 3R is specialized on animal bone high temperature and added value processing.** The high economically value can be obtained by the 3R processing and the following wide range of bio-formulations.
- **Zero emission environmental & climate impact performance:** all material streams in all states are recycled, reused and converted into useful and safe products.
- **Added value innovative technical content:** the 3R technology is an IP protected original invention, complex and original industrial design and solution in all elements, with revolutionary innovative engineering solutions, that has been specifically designed for animal bone processing to recover concentrated Phosphorus.

Contact

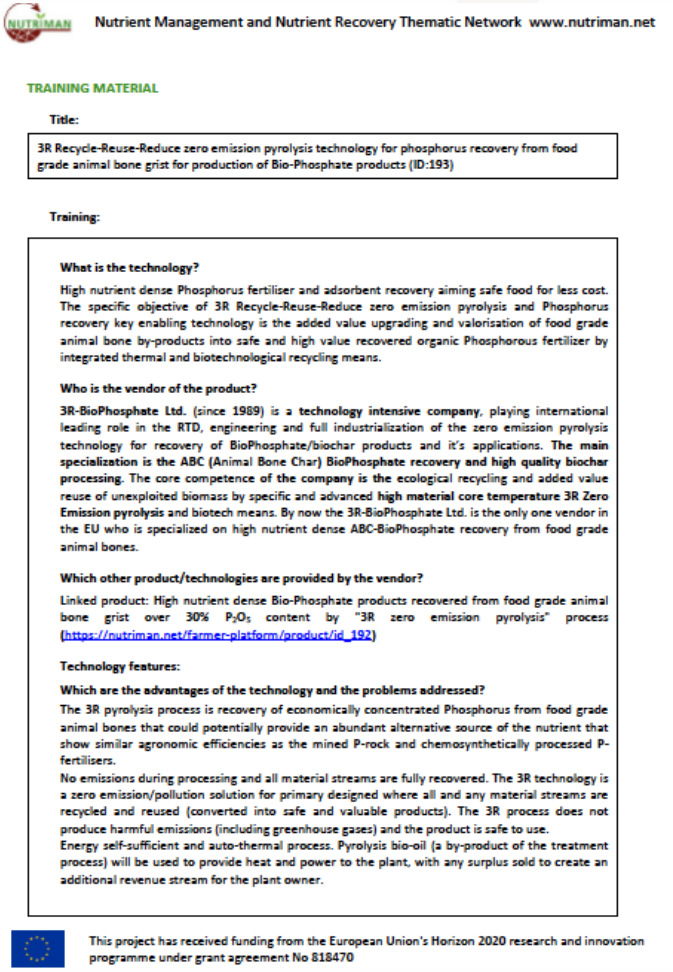
Name: Edward Someus

Company: 3R-BioPhosphate Ltd.

Web: www.BioPhosphate.net

e-mail: biochar@3Ragrocarbon.com

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818470



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TRAINING MATERIAL

Title:

3R Recycle-Reuse-Reduce zero emission pyrolysis technology for phosphorus recovery from food grade animal bone grist for production of Bio-Phosphate products (ID:193)

Training:

What is the technology?

High nutrient dense Phosphorus fertiliser and adsorbent recovery aiming safe food for less cost. The specific objective of 3R Recycle-Reuse-Reduce zero emission pyrolysis and Phosphorus recovery key enabling technology is the added value upgrading and valorisation of food grade animal bone by-products into safe and high value recovered organic Phosphorous fertilizer by integrated thermal and biotechnological recycling means.

Who is the vendor of the product?

3R-BioPhosphate Ltd. (since 1989) is a **technology intensive company**, playing international leading role in the RTD, engineering and full industrialization of the zero emission pyrolysis technology for recovery of BioPhosphate/biochar products and it's applications. **The main specialization is the ABC (Animal Bone Char) BioPhosphate recovery and high quality biochar processing.** The core competence of the company is the ecological recycling and added value reuse of unexploited biomass by specific and advanced **high material core temperature 3R Zero Emission pyrolysis** and biotech means. By now the 3R-BioPhosphate Ltd. is the only one vendor in the EU who is specialized on high nutrient dense ABC-BioPhosphate recovery from food grade animal bones.

Which other product/technologies are provided by the vendor?

Linked product: High nutrient dense Bio-Phosphate products recovered from food grade animal bone grist over 30% P_2O_5 content by "3R zero emission pyrolysis" process (https://nutriman.net/farmer-platform/product/id_192)

Technology features:

Which are the advantages of the technology and the problems addressed?

The 3R pyrolysis process is recovery of economically concentrated Phosphorus from food grade animal bones that could potentially provide an abundant alternative source of the nutrient that show similar agronomic efficiencies as the mined P-rock and chemosynthetically processed P-fertilisers.

No emissions during processing and all material streams are fully recovered. The 3R technology is a zero emission/pollution solution for primary designed where all and any material streams are recycled and reused (converted into safe and valuable products). The 3R process does not produce harmful emissions (including greenhouse gases) and the product is safe to use.

Energy self-sufficient and auto-thermal process. Pyrolysis bio-oil (a by-product of the treatment process) will be used to provide heat and power to the plant, with any surplus sold to create an additional revenue stream for the plant owner.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818470

Practice Abstract - Info sheet – Training material

NUTRIMAN – Farmer Platform: Bio-Phosphate Product (ID 192)

Documents in 8 languages (EN, DE, FR, IT, NL, ES, HU, PL) – available/downloadable

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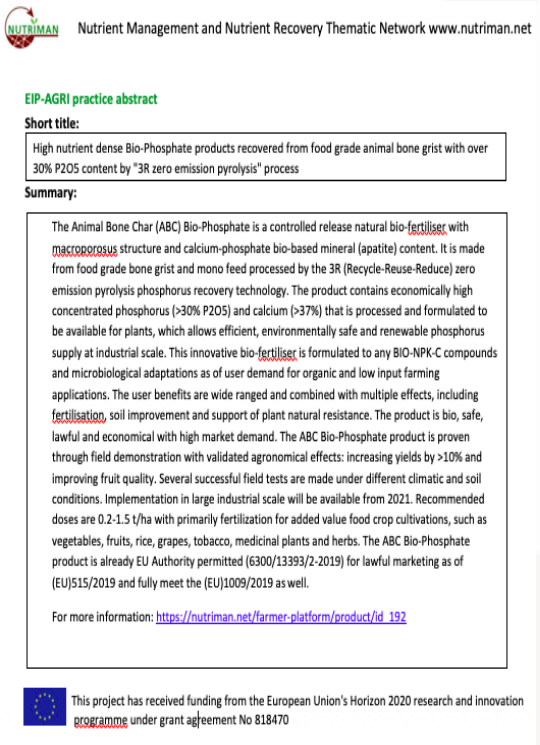

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EIP-AGRI practice abstract

Short title:

High nutrient dense Bio-Phosphate products recovered from food grade animal bone grist with over 30% P2O5 content by "3R zero emission pyrolysis" process

Summary:

The Animal Bone Char (ABC) Bio-Phosphate is a controlled release natural bio-fertiliser with macroporosus structure and calcium-phosphate bio-based mineral (apatite) content. It is made from food grade bone grist and mono feed processed by the 3R (Recycle-Reuse-Reduce) zero emission pyrolysis phosphorus recovery technology. The product contains economically high concentrated phosphorus (>30% P2O5) and calcium (>37%) that is processed and formulated to be available for plants, which allows efficient, environmentally safe and renewable phosphorus supply at industrial scale. This innovative bio-fertiliser is formulated to any BIO-NPK-C compounds and microbiological adaptations as of user demand for organic and low input farming applications. The user benefits are wide ranged and combined with multiple effects, including fertilisation, soil improvement and support of plant natural resistance. The product is bio, safe, lawful and economical with high market demand. The ABC Bio-Phosphate product is proven through field demonstration with validated agronomical effects: increasing yields by >10% and improving fruit quality. Several successful field tests are made under different climatic and soil conditions. Implementation in large industrial scale will be available from 2021. Recommended doses are 0.2-1.5 t/ha with primarily fertilization for added value food crop cultivations, such as vegetables, fruits, rice, grapes, tobacco, medicinal plants and herbs. The ABC Bio-Phosphate product is already EU Authority permitted (6300/13393/2-2019) for lawful marketing as of (EU)515/2019 and fully meet the (EU)1009/2019 as well.

For more information: https://nutriman.net/farmer-platform/product/id_192

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RECOVERED FERTILISER Info Sheet

High nutrient dense Bio-Phosphate products recovered from food grade animal bone grist with over 30% P_2O_5 content, processed by "3R zero emission pyrolysis" process

recovered P fertiliser • biophosphate • biofertiliser •total product safety •high nutrient density

Key facts:

- **Product Category:** PFC 1 Solid organic fertilizer, PFC 2 Liming material, PFC 3 Organic soil improver, PFC 4 Growing media, PFC 6 Plant bio-stimulant, PFC 7 Fertilising products blend.
- **Input material:** food grade cattle and other types of bone grist.
- **General appearance:** 1-5 mm grain size granulated or powdered 0-1 mm fractions.
- **Nutrient Content (N-P-K %):** basic >30% P_2O_5+ >38% CaO. Any BIO-NPK-C compound formulations as of user demand.
- **Product status:** prior to market introduction.
- **Limitation of application:** no technical limitations.
- **Permit availability:** MS Authority permit number: 6300/2407-1/2020 as of EU for horticultural applications & lawful marketing in the EU27. EC REACH >1000 t/y capacity: under progress. Meets the new EC 1009/2019 Fertilising Products Regulation (2022) and EC Mutual Recognition Regulation 2019/515.
- **Geographical area:** EU27, UK, USA, Australia and Japan.
- **Price range:** BIO-NPK-C formulated from 500 €/ha.

Summary:

The Animal Bone Char (ABC) Bio-Phosphate is a natural bio-product with macroporosus structure and economically high concentrated recovered Phosphorus content. The Bio-Phosphate commercial products are formulated to BIO-NPK-C in any compounds as of user/market demands for both organic and low input farming application cases. The BioPhosphate contains high amount of Phosphorus (>30% P_2O_5) and Calcium (>37%) that are processed to be available for plants, which allows efficient, environmentally safe and renewable phosphorus supply. Beside the highly available recovered phosphorus/calcium content the BioPhosphate also contains other important recovered trace elements, and other nutrients, such as potassium and magnesium.

The product is a fully safe and economical innovative fertilizer with primarily application in the horticultural organic/low input farming cultivations with combined beneficial and multiple effects. The market competitive BioPhosphate product is proven field demonstrated with validated agronomical effects. Several open field and green house cultivation tests have been performed in IT, IL, HU, DE, NL, SI and DK under different temperate climatic and soil conditions. Both the 3R (Recycle–Reuse- Reduce) zero emission pyrolysis/nutrient recovery process and the Animal Bone Char Bio-Phosphate products are EU Authority permitted.

How to use:

- **Type of farming:** organic, low input, conventional.
- **Cultivation methods:** open field, greenhouse
- **Recommended crops:** Fresh vegetables and strawberries, permanent crops (fruit trees), grapes, rice, tobacco.
- **Application doses:** 0.2-1.5 t/ha.

Contact

Name: Edward Someus
Company: 3R BioPhosphate Ltd.
Web: www.3Ragrocarbon.com
e-mail: biochar@3Ragrocarbon.com

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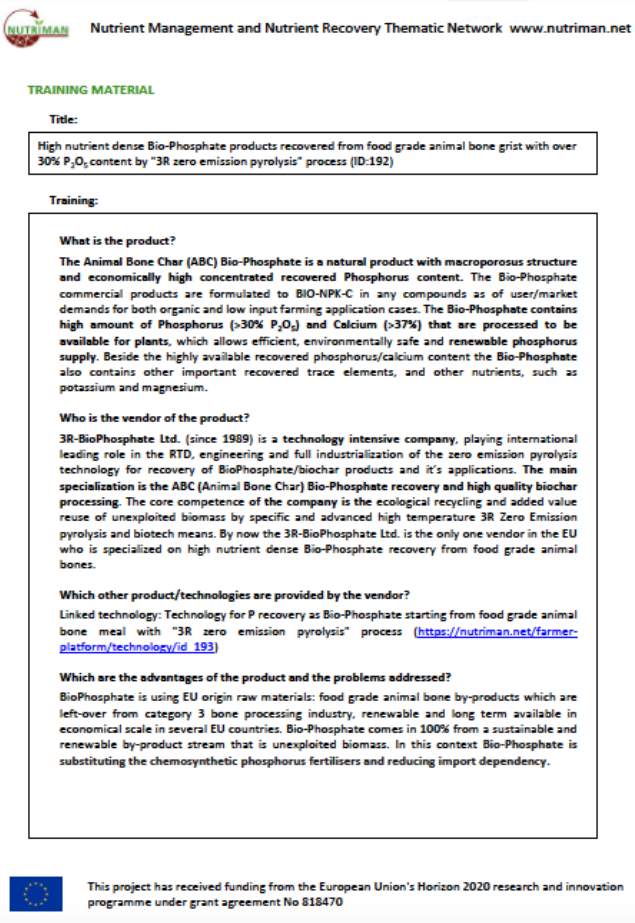

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TRAINING MATERIAL

Title:

High nutrient dense Bio-Phosphate products recovered from food grade animal bone grist with over 30% P_2O_5 content by "3R zero emission pyrolysis" process (ID:192)

Training:

What is the product?

The Animal Bone Char (ABC) Bio-Phosphate is a natural product with macroporosus structure and economically high concentrated recovered Phosphorus content. The Bio-Phosphate commercial products are formulated to BIO-NPK-C in any compounds as of user/market demands for both organic and low input farming application cases. **The Bio-Phosphate contains high amount of Phosphorus (>30% P_2O_5) and Calcium (>37%) that are processed to be available for plants**, which allows efficient, environmentally safe and **renewable phosphorus supply**. Beside the highly available recovered phosphorus/calcium content the **Bio-Phosphate** also contains other important recovered trace elements, and other nutrients, such as potassium and magnesium.

Who is the vendor of the product?

3R-BioPhosphate Ltd. (since 1989) is a **technology intensive company**, playing international leading role in the RTD, engineering and full industrialization of the zero emission pyrolysis technology for recovery of BioPhosphate/biochar products and it's applications. **The main specialization is the ABC (Animal Bone Char) Bio-Phosphate recovery and high quality biochar processing. The core competence of the company is the** ecological recycling and added value reuse of unexploited biomass by specific and advanced high temperature 3R Zero Emission pyrolysis and biotech means. By now the **3R-BioPhosphate Ltd.** is the only one vendor in the EU who is specialized on high nutrient dense Bio-Phosphate recovery from food grade animal bones.

Which other product/technologies are provided by the vendor?

Linked technology: Technology for P recovery as Bio-Phosphate starting from food grade animal bone meal with "3R zero emission pyrolysis" process (https://nutriman.net/farmer-platform/technology/id_193)

Which are the advantages of the product and the problems addressed?

BioPhosphate is using EU origin raw materials: food grade animal bone by-products which are left-over from category 3 bone processing industry, renewable and long term available in economical scale in several EU countries. Bio-Phosphate comes in **100%** from a sustainable and renewable by-product stream that is unexploited biomass. In this context Bio-Phosphate is substituting the chemosynthetic phosphorus fertilisers and reducing import dependency.

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Practice Abstract - Info sheet – Training material

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