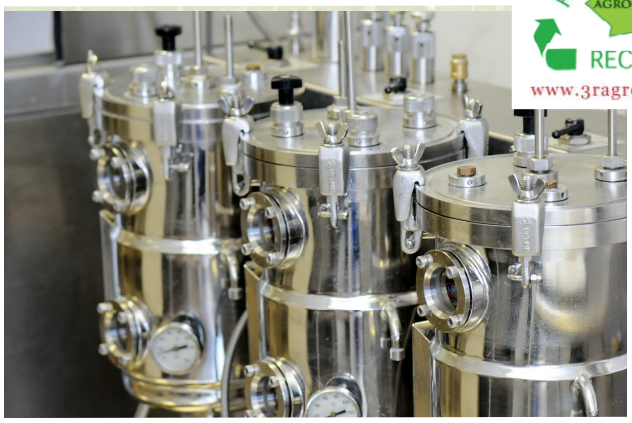
3R: Recycle - Reduce - Reuse

Converting Trash into Cash

TERRA HUMANA LTD.

COMPANY INFO



The "3R" Recycle-Reduce-Reuse zero emission pyrolysis technology and carbon refinery providing high added value recovery of BIO-PHOSPHATE, nutrients and new materials with different carbon structures for safe and cost efficient applications in the agriculture and adsorbent industrial sectors.

www.3Ragrocarbon.com • www.refertil.info • biochar@3Ragrocarbon.com

SPECIALIZATION FOR CARBON REFINERY AND BIO-PHOSPHATE RECOVERY

TERRA HUMANA LTD.
COMPANY HISTORY

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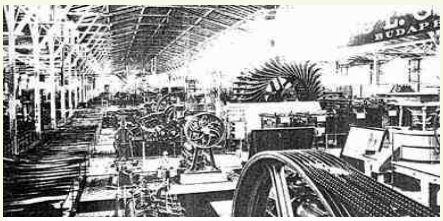
Terra Humana Ltd. (since 1989) is a technology intensive company, playing international leading role in zero emission pyrolysis technology. Applied scientific research and technology development, engineering, phosphorus recovery and biochar industrial production. The company originally has been an joint venture with Lang Machine Works (since 1870, ALSTOM subsidy) and has been independent SME organization since 2001.

The **core profile** is carbon refinery by new generation thermo-chemical and biotechnological means, that is objective driven for recycling and reuse of agricultural and food industrial by-products for industrial scale manufacturing of added value, safe and economical carbon based natural products, such as biochar.

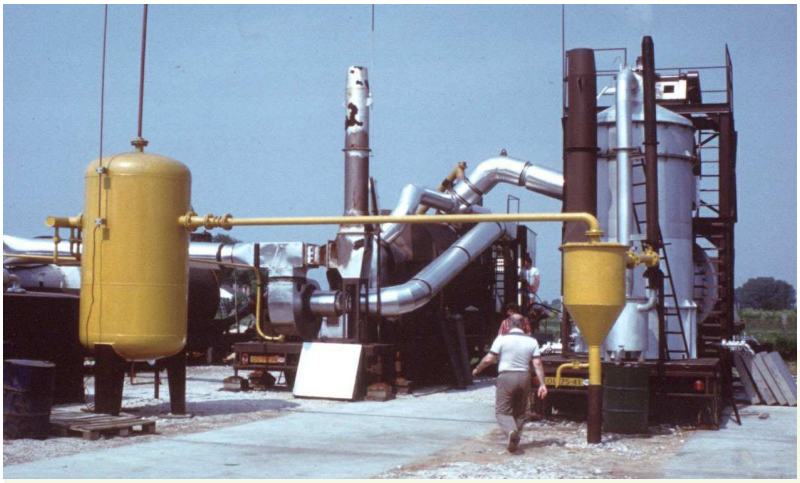


Lang Machine Work in 1895

Terra Humana is the **original source and inventor of the"3R" Recycle-Reduce-Reuse zero emission advanced pyrolysis technology.** The "3R" technology and biochar concept is an unique original solution that has been invented in the 80's by Edward Someus, graduated at the University of Lund.

The "3R" development has been financed by the Terra Humana Ltd. up until 2002, thereafter the European Commission contributed with significant co-finance to convert biochar science into industrial practice in European dimension.

The "3R" is an European Commission priority selected research and development programme since 2002 and by 2016 has reached proven demonstrated industrial and commercial scale level. Since 2002 Terra Humana Ltd. has coordinated and key technology designed multiple international EU RTD programs in the specific field of carbon refinery, biochar and phosphorus recovery. By 2016 the R&D stages were successfully completed, finalized and the "3R" technology is ready for market uptake in full industrial scale. During the past years Terra Humana Ltd. has built up a wide range of network of stakeholders both in scientific and industrial sectors to bring together different stakeholders around the full phosphorus value chain with **high product safety and supply security.**



"3R" pyrolysis pilot plant in 1991

DEMONSTRATED +30 YEARS CARBON REFINERY SCIENCE AND TECHNOLOGY EXPERIENCE

"3R" DEVELOPMENT MILESTONES

MILESTONES

1983	The innovative 3R technology idea: horizontally arranged indirectly heated system.
1983-1986	**TRL4 Technology Readiness Level:** technology validated in laboratory. First generation laboratory unit of the "3R".
1989	**TRL5**: pilot technology validated in industrially relevant environment. Second generation pilot plant scale up unit of the "3R".
1990-1995	**TRL5** pilot research plant tests: confirmed proof of evidence for main components for the technical and economical efficiency of the innovation.
1994-2001	Full scale basic engineering design and work out of alternative industrial applications.
2002-2005	**TRL6:** technology demonstrated in industrially relevant environment. Third generation field demonstration industrial plant, EU FP5 NNE5/363/2001.
2005-2009	**TRL7**: system prototype demonstrated in operational environment. Successful implementation of the business and application oriented scientific RTD project EU FP6 514082 PROTECTOR.
2008-2012	EU FP7 EUPHOROS 211457: Reducing the need for external inputs for horticultural crops**.**
2009-2012	**TRL8:** EU-CIP-Ecoinnovation: market replication of Agrocarbon biotechnology.
2011-2016	**TRL8:** "3R" system completed and qualified. EU FP7 REFERTIL 289785: Reducing mineral fertilizers and chemicals use in agriculture by treated compost and biochar.
2017	**TRL9:** industrial pyrolysis replication with 20,800t/y throughput capacity.

"3R" industrial pyrolysis plant 2016

THE "3R" CONCEPT IS DESIGNED BY THE NATURE

THE "3R" (RECYCLE - REUSE - REDUCE) ZERO EMISSION CARBON REFINERY TECHNOLOGY CONCEPT

3R TECHNOLOGY

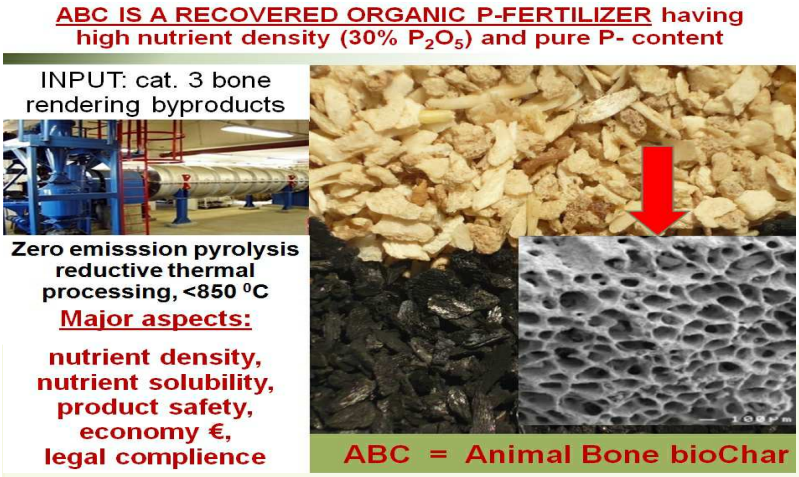
Whatever technical, environmental and/or climate challenge the applied scientific research and technical development faces, it is considered that most probably one or more of the world's millions of creatures and natural processes has not only already faced the same challenge during the past millions of years, but has also evolved effective strategies to solve it as well.

Carbon product biotech formulation laboratory

Due to the new environmental improvements and strict regulations, new technologies and methods need to be developed. *"The significant problems we face cannot be solved at the same level of thinking we were at when we created them"* Albert Einstein. In this context the "Stone Age" did not ended because there were no more stones, but rather because of **new technologies come up in practice**, that rapidly open wide range of new technical, economical and environmental opportunities. This is what the "3R" do.

The "3R" Recycling-Reduce-Reuse zero emission carbon refinery technology is a typical case example for advanced technology revolution in modern age. The "3R" is safer, better, less costly and more environmental friendly best available technology than any known solutions. The new "3R" technology and its high added value refined carbon products opening new technical, economical, market and environmental opportunities. This highly innovative "3R" technology is a horizontally arranged indirectly heated rotary kiln system.

The "3R" technology is a new generation original solution for carbon refinery of organic by-product/waste streams and added value conversion into safe carbon products. It is providing high efficient and up to 850 °C material core temperature reductive thermal decomposition to separate organic material streams into refined carbon and bio-oil. The "3R" is a comprehensive solution and including all pre and post processing with wide range of product formulations.



GENERATES NEW RESOURCES AND ADDED VALUE PRODUCTS

ABC ANIMAL BONE BIOCHAR: BIO-PHOSPHATE PRODUCTS

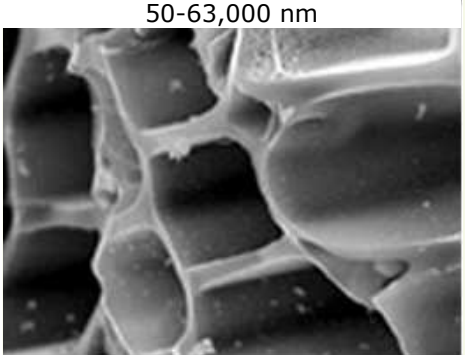
Animal Bone bioChar **"ABC" is a recovered organic Phosphorus fertiliser, made from food grade animal bone grist, having high nutrient density (30% P_2O_5) and pure P-content.**

The rendering industrial origin food grade category 3 animal bone grist processed ABC is a macroporous organic fertilizer with as high as 92% pure calcium phosphate and 8% carbon content only. ABC is a BIO-NPK formulation optimised, enhancing of soil microbiological life, having high water holding and macromolecular organic nutrient retention. The fully safe ABC is used at low doses (100–600 kg/ha) and in cases when justified even up to 1,000 kg/ha.

Therefore the **ABC product functionalities are organic fertilizer, soil improver, growing medium** and/or fertilising product blend. The substitution of phosphate import by recovered Phosphorus is an important goal for the European agriculture already in short term. **The imported mineral Phosphorus agri substitution potential by bio ABC in European dimension is >5% (>75,000 t/y P_2O_5) in short term (<2025) and up to >20% in long term (>2030).**

ABC IS A BIO-PHOSPHATE

ABC: macroporous
50-63,000 nm



Animal Bone bioChar (ABC)
Organic Phosphorus fertiliser, soil improver, growing media:

- Made from food grade category 3 bones.
- 92% mineral content and 8% Carbon.
- 30% P_2O_5 and 38 – 42 %CaO + Mg, K.
- Controlled release direct organic fertiliser with different formulation options.
- **Dose: 0.1t/ha - <1 t/ha.**

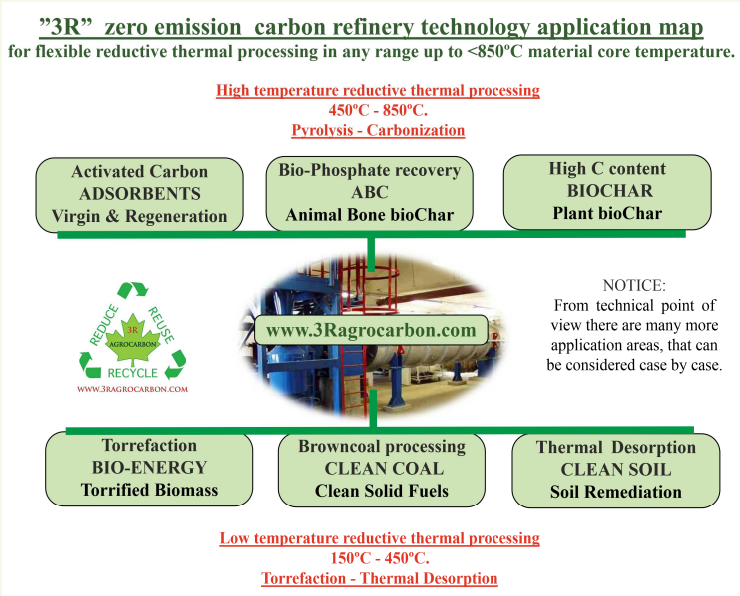
MARKET DEMANDED AND WIDE PRODUCT APPLICATIONS AND ADAPTATION SCENARIOS

ABC: Animal Bone bioChar

ADDED VALUE CARBON REFINERY FOR NATURAL PRODUCT APPLICATION FUNCTION, SAFETY AND SUPPLY SECURITY

TECHNOLOGY APPLICATIONS

The "3R" Recycle-Reduce-Reuse zero emission pyrolysis technology and carbon refinery is for high added value recovery of BIO-PHOSPHATE, nutrients and materials with different carbon structures, and safe application in the agriculture, adsorbent (water treatment) and bio-energy sectors. ABC (Animal Bone bioChar) is strengthening the activity of the soil; restoring of soil natural balance; increasing its drought tolerance and productivity.



The ABC economic benefits for farmers is the safe use as organic and low input fertilizer in horticultural sector (fruit and vegetables); improving soil quality in physical, chemical and biological terms. Among the many "3R" application alternatives the natural phosphate recycling sector (ABC) has been prime selected, which is having the most advantageous and rapid economical and business valorisation scheme.

"ABC" Animal Bone bioChar is a recovered organic phosphorus fertiliser produced from food grade category 3 animal bones between 600°C – 850°C reductive thermal processing and under advanced zero emission environmental performance ("3R" Recycle-Reuse-Reduce technology). ABC contains ~92% calcium-phosphate (with 30% P_2O_5) which makes it a significant phosphorus resource, therefore being a significant alternative of currently used mineral phosphate fertilizers. ABC is usually formulated for different types of BIO-NPK + micronutrients.

MEMBER OF THE EU DG GROW-JRC STUBIAS EXPERT GROUP

BIOCHAR STANDARDIZATION AND LAW HARMONIZATION EU28 POLICY SUPPORT WORK

REFERTIL recommended Biochar parameters	ORGANIC P-FERTILISER	SOIL IMPROVER
Potential toxic elements (mg/kg)		
As	10	10
Cd	1.5	1.5
Cr	100	100
Cu	200	200
Pb	120	120
Hg	1	1
Ni	50	50
Zn	600	600
Organic pollutants		
PAH_{16} (mg/kg)	6	6
PCB 7 (mg/kg)	0.2	0.2
PCDD/F (ng/kg I-TEQ)	20	20
Bulk density	declaration	declaration
Dry matter content	>80%	>60%
pH	6 - 10	6 - 10
Total Organic C	declaration	20%
N and K total	declaration	declaration
Total P (P_2O_5)	>25%	declaration
Total Ca, Mg	declaration	declaration
Germination inhibition assay	No inhibition	No inhibition
Phytotoxicity	No phytotoxicity	No phytotoxicity
Agronomic efficiency	Should be proved	Should be proved

When biochar is irrevocable applied to open and complex soil ecological system, there is also a direct interlink to subsurface water systems, therefore only qualified, safe and legally Authority permitted biochar must be applied. The aim is to ensure that the proposed biochar quality and safety criteria are fully consistent with EU Directives and MS Regulations for long term. **Any biochar manufacturing and product applications require mandatory EU/MS Authority permits**. Moreover any biochar manufacturing, import, placing on the market and use above 1 t/year capacity require approved REACH registration. Voluntary biochar certificates having no any legal effects.

BIOCHAR STANDARDIZATION

Fertilisers Regulations (Reg. EC 2003/2003) is only regulating the mineral fertilizers and not applicable for biochar products. Since 2011 a strong policy support provided to the EU Commission in revision of the Fertiliser Regulation and inclusion of biochar as safe organic fertiliser/soil improver. **Legal and market based economical sustainability of the biochar have been evaluated**. **Harmonized and standardized analytical measurements have been developed** for determination of the biochar physical-chemical properties, Potentially Toxic Elements (PTEs) and Organic Pollutants such as PCBs and PAHs. **EU quality and safety criterion system for biochar products has also been set up** which is maximizing the PTEs and Organic Pollutant content for safe applications. In 2016 Terra Humana Ltd. **Edward Someus has been selected as a Member of the EU DG Grow-JRC STRUBIAS (struvite-biochar-ash) Expert Group, a sub-class of the Commission Working Group on fertilisers.**

3R PROJECT REFERENCES

www.3ragrocarbon.com/project-reference

REFERTIL (289785): Reducing mineral fertilisers and chemicals use in agriculture by recycling treated organic waste as compost and bio-char products. (2011-2015). **Objective**: EU legislation support by definition of improved compost and biochar standards in the EU28. **Project website**: www.refertil.info
Role: Coordinator, science and technology core works, senior engineering.
Programme: European Union 7th Framework Programme, FP7-KBBE-2011.1.2-02.

ECO-ZEO (282865): Developing a pool of novel and eco-efficient applications of zeolite for agriculture sector (2012-2016). **Role:** Partner.
Programme: European Union Seventh Framework Programme.

EUPHOROS (211457): Efficient use of inputs in protected horticulture. (2008-2012). **Role:** Partner. **Programme:** European Union Seventh Framework Programme, FP7-KBBE-2007-1.

PROTECTOR (ECO/08/238984/ SI2.532247)
Programme: CIP Eco-innovation. **Role:** coordinator and key technology scientific RTD and industrial designer for Phosphorous recycling.(2009-2012).

PROTECTOR (514082): Recycling and upgrading of bonemeal for environmentally friendly crop protection and nutrition, (2005-2008).
Programme: European Union Sixth Framework Programme.
Role: Coordinator and key technology designer, science and technology core works.

TDT-3R MULTI FUEL (EU FP5-NNE5-363-2001): Multi Fuel Operated Integrated Clean Energy Process: Thermal Desorption Recycle-Reduce-Reuse Technology, (1998-2002). **Programme:** European Union Fifth Framework Programme and Sustainable Development specific programme.
Role: Coordinator and key technology designer, science and technology core works.

www.3ragrocarbon.com

TERRA HUMANA Ltd.

Edward Someus (Biochar S&T senior engineer)

biochar@3Ragrocarbon.com • edward.someus@gmail.com

http://www.3Ragrocarbon.com • http://www.refertil.info

Skype: edwardsomeus