

REFERTIL

Investigating
biochar technologies
in agriculture



Improving soil fertility

Edward Soméus is coordinating **REFERTIL**, a European project designed to simultaneously tackle climate change and improve soil fertility through efficient transformation of organic waste into high quality and environmentally safe compost and biochar products

To begin, could you outline the key objectives of REFERTIL?

The key objectives are to improve current compost treatment systems and develop zero emission biochar technologies at the industrial scale for safe and economic nutrient recovery processes. Beyond the industrial compost and stable carbon-based biochar technology development, with liquid transport biofuel byproducts, the REFERTIL project also provides strong policy support to the EC for the new fertiliser regulations that standardise and harmonise EU law on compost/biochar technologies and products.

Biochar has been a hot topic in the environmental and agricultural research realms of late. How does REFERTIL seek to apply knowledge gained on biochar to aid its use as a soil improver?

Many, if not most, traditional carbon processing technologies are unsuitable for safe biochar production under the EU 'End of Waste' legislation criteria.

Biochar is plant and/or animal biomass-originating carboniferous material that is specifically produced for soil and environmental improvement. Biochar production by

carbonisation processing, including transformation of crude bio-oil byproducts into refined liquid biofuels, and open ecological biochar applications must meet EU and major international industrial and environmental norms and standards. Both biochar industrial production and commercial applications require official authority permits.

What are the benefits of biochar in terms of its carbon-negative value?

Plant and animal biomass material is converted into stable carbon product – biochar – by a carbonisation process that prevents the release of carbon dioxide into the atmosphere from the decaying biomass. Plant biochar products have more than 90 per cent w/w carbon content. This makes them suitable for soil carbon sequestration. In this context, carbon-negative means biomass-bounded atmospheric CO₂ is converted into a stable carbon-based biochar product. This is safely sequestered in the soil long term.

How does biochar address soil damage resulting from increasingly-intensive agricultural production?

The mineral phosphate industry and use of chemosynthetic mineral fertilisers cause

environmental damage, including irrevocable cadmium build-up in soil, greenhouse gas and fluorine emissions and phosphorus run-off in subsurface water.

Compost and biochar natural products re-fertilise depleted agricultural soils and improve drought tolerance. Animal bone-based biochar or 'bone char' is free from heavy metals and has approximately 30 per cent phosphorus pentoxide content. This high phosphorus content makes it suitable as a safe slow-release natural organic fertiliser product, as opposed to chemosynthetic and non-renewable mineral phosphate fertilisers.

Can you outline the main successes of REFERTIL's efforts so far?

REFERTIL is an application and bioeconomy development orientated science, technology and engineering design system. Although this four-year project is still only in year two, highly promising results have been achieved. In year one, we carried out detailed analytical assessment of EU-27 input organic waste streams and evaluated several available industrial biochar/composting technologies with economical application options, that clearly demonstrated there is no 'one-size-fits-all' solution. Extensive field trials with selected biochar and compost products are progressing. We have conducted a



detailed technical, legislative and cost-efficiency analysis of available biochar/compost production technologies and materials. The REFERTIL team also set up a biochar/composting technology and product matrix database for analysing and ranking recycling technologies for economical industrial-scale biochar and compost production. Dissemination and visibility programmes are in progress, aimed towards stakeholders including farmers, industrial partners, consumers, investors, academic organisations and policy makers.

What has been the response from end-users to biochar?

Farmers expect increased economical and ecological benefits, including soil fertility improvements, higher yields, higher fruit quality, better soil structure and water retention, and better utility of natural nutrients at lower cost from biochar, but are primarily interested in

short-term profitability. The application of high doses (5-20 t/ha) required for compost- and plant-based biochar products may not be realistic from the end user's economic perspective. The situation is different with bone-based biochar, which already has a full organic NPK-C fertiliser value in low doses between 200 and 1,000 kg per hectare, and provides extra yields with extra quality and rapid economical benefits. It is also highly profitable in the short term (one to three years).

Are you working with agricultural experts and policy makers to ensure that the outcomes from REFERTIL are implemented in a meaningful way?

The REFERTIL expert team is an application-orientated knowledge centre. Beyond our core competence, REFERTIL has built up a stakeholder forum platform for active participation in

the REFERTIL policy support work. The forum directly interconnects to an EC-initiated compost/biochar standardisation programme. The stakeholders are farmers and other end-users, organic waste industrial producers and professional processors, government authorities, academics, investment and business interests, environmental professionals and policy makers from the EU and Australia.

Beyond continuous contact and discussion with EU Directorate Generals, workshops are frequently organised in Brussels for joint evaluation of results together with EU policy experts and at the same time highlighting bioeconomy development scenarios for compost and biochar production and practical use. REFERTIL has also been specifically selected for an important presentation to the European Economic and Social Committee for Agriculture, Rural Development and Environment.

Economical development by ecological restoration

The **REFERTIL** project is contributing to the transformation of the organic bio-waste streams from Europe's agriculture and food industries and will also contribute to the international standardisation of compost/biochar products, while providing strong policy support to the EC

THE EUROPEAN AGRICULTURE and food industries produce hundreds of millions of tons of organic waste per year, with over 30 per cent of food produced in the EU ending up as refuse. There is urgent need for finding improved valorisation for this huge organic waste stream.

Moreover, intensive agriculture in Europe presently faces a number of major challenges: soil quality is rapidly degrading, so demand for natural and cost-competitive fertilisers is rising; demand for agricultural products is increasing with population growth; and at the same time, the application of synthetic fertilisers is coming under steady pressure because of their energy-intensive manufacture, exploitation of non-renewable sources and their deleterious effects on ecosystems. There is a strong need for increased sustainability of all production systems, such as agriculture, plant health and crop protection. In this context, reducing mineral fertilisers and chemical use in agriculture are key EU priorities.

Edward Soméus, Project Coordinator and key technology developer and designer of the European collaborative REFERTIL project, explains the scale of the issue: "Human activities have disturbed the natural nitrogen and phosphorus cycles on a large scale; the nitrogen amount has doubled since the industrial revolution, while the amount of the available phosphorus has been tripled". Rapid reduction of the use of synthetic mineral fertilisers in agriculture is an important goal. This can be

achieved economically by recycling and reuse of the treated organic waste as compost and biochar products creating a virtuous cycle.

Soméus' development activities include biochar science, technology and industrial engineering, related to pyrolysis processing, integrated bio-refinery for competitive liquid transport biofuel production and biochar soil biotech adaptations. He developed the '3R Agrocabon' process for added value recycling of carboniferous materials, a process that, importantly, is a highly advanced zero emission technology solution.

"Healthy soils are high in economic and ecological value, acting as a vital carbon store that must be protected," he explains. "REFERTIL aims to close the nutrient loop by recycling compost and producing biochar safely."

BIOCHAR

Biochar is the product of carbonisation of plant and/or animal biomass. Unlike carbon, which is burnt for energy, biochar is a stable carbon-based carboniferous material that can be used for soil enhancement and carbon negative applications.

Plant based biochar is an effective soil improver with >90 per cent w/w of stable carbon content, a microporous structure, high levels of water and nutrient retention and carbon sequestration capacity, but no adequate soil fertilisation effects.

It provides highly efficient carbon sequestration to help offset global warming caused by climate change and the usual application rate is 2.5 t/ha (low dose) to 20 t/ha (high dose). The application of plant-based biochar should be judged on a case by case basis but above 5 t/ha the cost might be an economical challenge from the perspective of an end-user farmer.

Animal bone-based biochar is a full value NPK-C organic fertiliser with <20 per cent w/w low carbon and high calcium phosphate/apatite mineral content with trade name Animal Bone Charcoal 'ABC' product. ABC is made of food-grade bone meal, resulting in natural slow release fertilisation, plant growth promotion, improved retention of nutrients and water, improved cation exchange capacity, while decreasing and/or fully substituting the use of chemo-synthetic substances in low input and organic agriculture. ABC improves soil fertility, enhances soil microbiological life and biodiversity, and restores natural soil balance in different climatic conditions and soil types, especially in degraded soils. The usual and economical ABC application rate is 0.2 t/ha (low dose) to 1 t/ha (high dose).

Biochar production at an economical industrial scale is made by reductive thermal processing at a temperature of 450-650 °C under negative pressure. It comprises pyrolysis conversion of biomass into carbon/mineral-rich solids, with no air introduced during the process. Most known biochar production processes are conducted at research or laboratory scale with a few hundred tons per year production capacity. The 3R Agrocabon ABC biochar zero emission pyrolysis capacity is over 20,000 tons throughput per year.

REFERTIL

In 2008, the EU issued the 'End of Waste' (EoW) criteria within the Waste Framework Directive to reduce the use of untapped resources and recycle waste where possible. Phosphorus is an important case study for the need for resource efficiency. Europe has few phosphorus resources, but only 2-3 per cent of phosphorus applied in agricultural

INTELLIGENCE

REFERTIL

REDUCING MINERAL FERTILISERS AND CHEMICALS USE IN AGRICULTURE BY RECYCLING TREATED ORGANIC WASTE AS COMPOST AND BIOCHAR PRODUCTS

OBJECTIVES

To contribute to the transformation of urban organic waste, food industrial by-products and farm organic residues from a costly disposal process into an income generating activity.

PARTNERS

TERRA Humana Clean Technology Development, Engineering and Manufacturing Ltd, Sweden • **Stichting Dienst Landbouwkundig Onderzoek**, The Netherlands • **Aarhus University**, Denmark • **Knowledge Center for Agriculture**, Denmark • **University of Torino – Agroinnova**, Italy • **Gottfried Wilhelm Leibniz University**, Hannover, Germany • **BIOMASA del GUADALQUIVIR**, SA, Spain • **TWI Ltd**, UK • **WESSLING Hungary Kft**, Hungary • **Reginalna Wielkopolska Izba Rolno-Przemysłowa**, Poland • **KOTO**, Slovenia • **Comune di Grugliasco**, Torino, Italy • **Renetech Bioresources Ltd**, Ireland • **Profikomp Environmental Technology Plc**, Hungary

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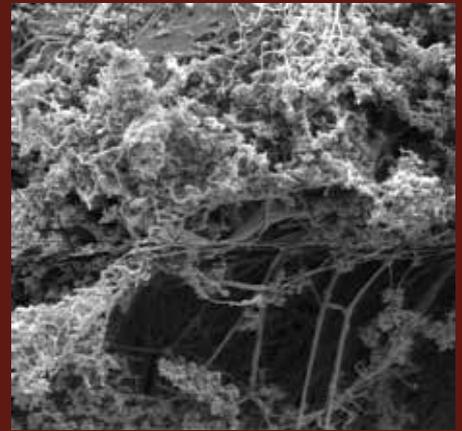
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EDWARD SOMÉUS is a Swedish environmental engineer with core competence in organic waste added value recycling and valorisation by pyrolysis, carbon processing and reuse applications. He graduated with an MSc in Natural and Environmental Sciences from the University of Lund in Sweden in 1978.

fertilisers and feeds finally reaches consumed human food. This inefficiency results in pollution (eutrophication) as phosphorus is lost to surface waters, and also in a long-term and irreversible problem of soil contamination by cadmium from mineral fertilisers. The EC considers that Europe needs to improve agricultural efficiency of phosphorus application, in particular, by improving soil quality and organic content to reduce soil erosion.

This objective fits perfectly with Soméus' science and technology development work in the EU and Australia in maximising the value and improve the safety of biomass through recycling technology: "Valorisation of organic waste and converting it into safe biochar/compost products is not only a profitable new industrial sector that creates new jobs, even in economically difficult times: it delivers sustainability by conserving natural resources long term," he states. New and advanced innovative technologies are critically important, as new technologies open novel technical, economical, environmental and climate protection opportunities, while supporting European bio-based economical developments.

The revised Waste Framework Directive (2008/98/EC) introduces the possibility that certain waste streams that have undergone a recovery operation can cease to be waste, if they fulfil certain criteria – called EoW. By meeting the criteria, REFERTIL is expanding the boundaries of science and technology for biochar/compost production and applications, from environmental risk and technical matters through legislative and quality issues to assessment and quantification of cost-effectiveness and benefits, with the ultimate aim



Electronic microscopic view of the biochar formulated with microorganism.

of establishing a workable strategy for re-fertilising Europe and Australia's depleted soils.

Extensive field trials of REFERTIL biochar have continued in Italy, The Netherlands, Germany, Spain, Hungary, Denmark and Slovenia and already show significantly better plant quality and fruit yields.

"REFERTIL animal bone-based biochar and bio-jet fuel production with 20,000 tonnes per year food-grade animal bone throughput is already targeted for 2014 in Europe and Australia," Soméus enthuses. "In improving the technical, economic and environmental efficiency of bio-waste recycling, REFERTIL is significantly increasing the competitiveness of the agricultural and bio-waste management sectors in the EU."

The project will now prepare compost and biochar scale-up scenarios and specimen business plans to demonstrate the technical viability and economic advantage of applying the approach to SMEs in the EU and Australia. The collaboration is already clearly reaping the benefits of their innovative approach, and if such success continues, the dawn of a new era in soil improvement may set into motion a much needed low carbon economy and advanced bioeconomy-based agricultural revolution for the 21st Century.

Healthy soils are high in economic and ecological value, acting as a vital carbon store that must be protected



3R zero emission biochar industrial production unit.

