Publishable Summary
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BioEcoSIM

Project Context and the Main Objectives

To ensure the sustainability and security of Europe's supplies of food and bio-based raw materials, there is a need to transform agriculture and reduce the adverse environmental impacts of current practices and fertiliser production methods. There have been a number of initiatives to improve the sustainability of intensified agricultural activities. However, suitable technological solutions have not yet been provided to make use of nitrogen (N) and phosphorous (P) in livestock manure to supply European fertiliser requirements.

Land application of animal manure supplies agricultural soil with valuable organic matter and essential nutrients, which help meet crop nutrient requirements and maintain soil fertility. Nevertheless, livestock intensification and regional conglomeration generates significant amounts of surplus manure in regions where it cannot be efficiently used as a resource. Manure is nowadays perceived in many regions as a waste to be treated and disposed of, losing the benefit of its fertiliser and soil conditioner value and consuming additional energy e.g. for transport and disposal.

Annually in EU27, over 10 million tonnes of N and 1.8 million tonnes of P are excreted by livestock. This quantity has the potential to fully meet the EU demands of mineral fertilisers. However, it is currently used wastefully to enrich crop growth in regions with high animal densities. Only 65% of livestock excretion is collected; over 50% of N is lost in storage and following application, resulting in harmful environmental effects:

- Eutrophication of surface and groundwater pollution caused by leaking earthen manure stores, direct run-off at outdoor storage and by N and P leaching resulted from excessive nutrient application in the fields.
- Air pollution through gaseous emissions (e.g. H_2S, CH_4, NH_3, and N_2O) during storage and land application.
- Soil pollution by land application of manure, creating imbalances of nutrients impairing plant growth
- Accumulation of heavy metals (e.g. cadmium, copper and zinc) and antibiotics in the soil after repeatedly manure applications.

Besides, due to the dramatically increasing interest in the production of bio-based products and bioenergy, soil degradation becomes a serious problem in Europe. The decline of soil fertility is masked by the overuse of synthetic fertilisers without the replacement of organic matter. This results in loss of soil fertility, carbon and biodiversity, lower water-retention capacity, and disruption of nutrient cycles.

BioEcoSIM addresses an important need for economically viable and environmentally benign practices to ensure sustainable European agriculture and supports the EU Bio-Economy Strategy and Action Plan to increase the use of bio-based raw materials. Livestock manure as an important example of valuable bio-waste will be converted into stable materials that can be easily handled, transported, and applied for agricultural and/or horticultural purposes. It targets to develop and demonstrate a resource and energy efficient pilot plant for the continuous conversion of wasted livestock manure to:

(i) valorise manure into pathogen-and antibiotic-free biochar and mineral fertilisers (ammonium sulphate, calcium phosphate and struvite) supporting the production of food and other bio-based raw materials;
(ii) reduce negative environmental impacts in intensive livestock regions;

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(iii) help to decrease ammonia (NH_3) produced by the energy-intensive Haber-Bosch process for manufacturing N-fertilisers;
(iv) mitigate EU's dependency on depleting mineral sources for P-fertilisers;
(v) increase water efficiency in agricultural use; and
(vi) generate economic benefits for farmers through the sales of electricity generated from syngas and fertiliser products.

Work Performed during the period and Main Results Achieved so far

With the quantified and qualified outputs from the integrated laboratory-scale unit of BioEcoSIM, the dependencies between operating variables and characteristics of the generated products could be determined. Control algorithms were developed and sensors suitable for the defined working conditions were selected as well as interface boundaries to ancillary systems to be controlled, monitored and powered had been established. Pilot-scale units for thermal processing of solid manure fraction and for recovery of phosphorus and ammonia from liquid manure fraction have been constructed, installed and commissioned at the facility of Agroenergie (Kupferzell, Germany). Performance of the integrated pilot-scale unit is currently being verified in accordance with the targeted operation ranges and quantities of outputs (biochar, pyrolysis gas, phosphate salts, and reclaimed water). Evaluation of the actual output stream against the theoretical mass-energy balance is in progress. The quality of the outputs has been assessed in pot and greenhouse experiments, providing evidence that biochar and mineral salts generated from the BioEcoSIM technology are of soil improver and fertiliser characteristics. Apart from the analyses on chemical compositions, water-soluble plant nutrients, heavy metals, antibiotics, and endocrine disruptors, biochar and mineral fertilisers have been validated through bioassays (seed germination, crop growth and earthworm mortality tests) as non-hazardous and non-eco-toxic products. The first field trials with BioEcoSIM outputs have also been carried out with maize. Evaluation of harvested maize is being conducted to determine the biomass yield, fresh and dry matter contents, macro- and micro-nutrient contents and the amount of heavy metals.

Expected Final Results and their Potential Impacts and Use (Including Socio-Economic Impact and the Wider Societal Implications of the Project so far)

ResResource efficiency means sustainable management and use of resources throughout their life cycle from extraction, transport, transformation and consumption to their disposal once they become waste. From this point of view, BioEcoSIM is in line with the concept of resource efficiency, as it aims for a resource-efficient valorisation of manure into a range of stable soil conditioners and fertilisers that can be applied on demand. This encompasses developing a cost-effective system combining three innovative technologies for prevention and mitigation of environmental pressures and risks associated with current manure management practices and by the state-of-the-art production methods of mineral fertilisers.

Part of the energy required in-process will be generated through combustion of pyrolysis gas, thus reducing the pressure on finite fossil fuel. Water reclaimed from manure will be utilised for livestock production and/or irrigation. The sustainability of BioEcoSIM's approach has been validated against standards ISO14040 and ISO14044 and will be updated with results from the demonstration activities.

BioEcoSIM will mitigate the current environmental and economic issues of nutrient surplus in regions with high livestock densities, which will not only benefit livestock farmers to generate income from the sales of soil improving products and electricity generated from pyrolysis gas instead of paying high costs for disposing of manure, but also crop farmers to consume less synthetic fertilisers to maintain or enhance the yields, thus reducing the dependency on non-renewable sources and fertiliser imports. Through the implementation of the results on a trans-regional basis by small agricultural entrepreneurs, new economic opportunities will be generated and the move towards a more resource-efficient and circular economy be facilitated. The project will guarantee full sustainability of the proposed approach by both economic and environmental measures that can be replicated across Europe in the medium-termource efficiency means sustainable management and use of resources throughout their life cycle from extraction, transport, transformation and consumption to their disposal once they become waste. From this point of view, BioEcoSIM

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BioEcoSIM's technological solution involves the advancement on the existing best available technologies (BAT) for the treatment of livestock manure. It will mitigate the current environmental and economic issues of nutrient surplus in regions with high livestock densities, which will not only benefit livestock farmers to generate income from the sales of soil improving products and electricity generated from pyrolysis gas instead of paying high costs for disposing of manure, but also crop farmers to consume less synthetic fertilisers to maintain or enhance the yields, thus reducing the dependency on non-renewable sources and fertiliser imports. Through the implementation of the results on a trans-regional basis by small agricultural entrepreneurs, new economic opportunities will be generated and the move towards a more resource-efficient and circular economy be facilitated. The project will guarantee full sustainability of the proposed approach by both economic and environmental measures that can be replicated across Europe in the medium-term.

For further information, please visit our website: http://www.bioecosim.eu/
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