ERA-MIN 2

RESEARCH & INNOVATION PROGRAMME
ON RAW MATERIALS
TO FOSTER CIRCULAR ECONOMY

Project DEASPHOR "Design of a product for SUBSTITUTION of phosphate rocks"

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Co-funded by the Horizon 2020 programme of the European Union

Consortium

- Main topic: Processing, Production and Remanufacturing

Sub-topic: Product design for critical materials substitution

- Project dates: 1st April 2018- 31st March 2022; Duration: 48 Months
- Project consortium, 10 partners: Porto University - Faculty of Sciences (FCT, Portugal); Università degli Studi di Brescia (MIUR, Italy); GIG - Central Mining Institute (NCBR, Poland); Ege University - Solar Energy Institute (TUBITAK, Turkey); Lorraine University (ADEME, France); University Politehnica of Bucharest (UEFISCDI, Romania); SWERIM (Vinnova, Sweden); Campoaves - Aves do Campo, SA (Portugal); PROGEO (Poland); Universidade Federal de Sergipe (Finep, Brazil; quit the project).
- 1 – 4 TRL
- Project budget 1,471,318 €/requested funding 1,533,318 €/ 100% (or close) project execution.

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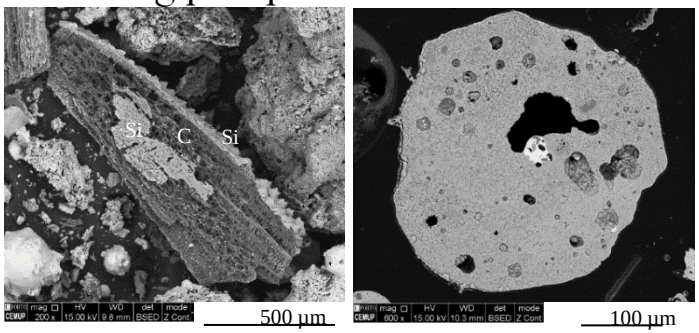
The main objective of this project is the recycling of phosphorus from aviary litter ash as a substituting material of phosphate rocks.

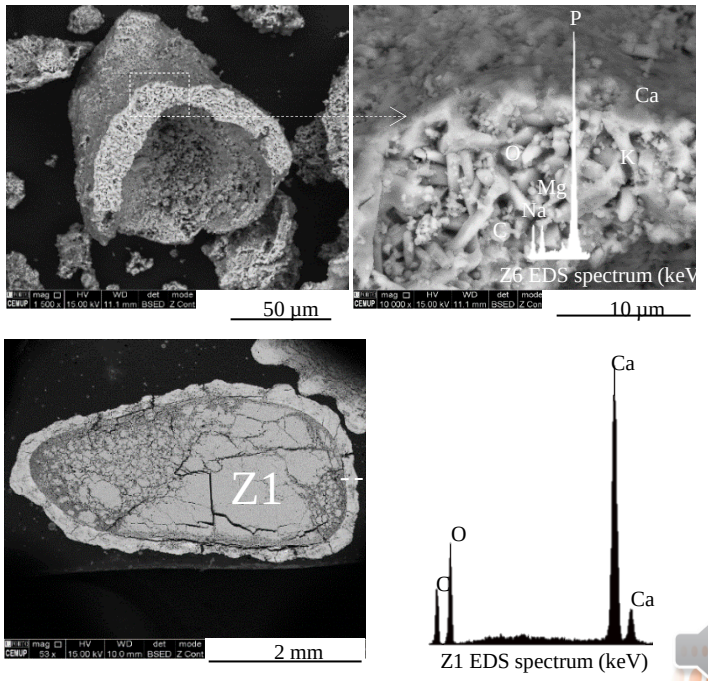
Final Results

- Aviary manure includes poultry litter mixed with different aviary bedding materials or laying hens manure. However, different incineration technologies generate different ashes:

Rice husk poultry litter in fixed bed:
Na-K-Mg phosphate, char and silica.



Laying hens manure in FBC:
hydroxyapatite, $CaCO_3$ and CaO.



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Final Results

- **Objective**: P-extraction from ash of an industrial chain grate incinerator of rice husk poultry litter (Campoaves, Portugal).
- **Final result**: P-extraction can be made simultaneously with recovery silica via a combined process to recover firstly P from an acid leachate and then amorphous silica in two subsequent steps:

1. Ash + HCl → P is leached, Si remains in the solid matrix.

2.1 $SiO_{2(s)} + 2\ NaOH_{(aq)} \rightarrow Na_2SiO_{3(aq)}$

2.2 $Na_2SiO_{3(aq)} + H_2SO_{4(aq)} \rightarrow SiO_{2(gel)} + Na_2SO_{4(aq)}$

Impact: instead of being just incinerators and landfilling ash, companies may operate to obtain three valuable products:

P, silica gel and char.

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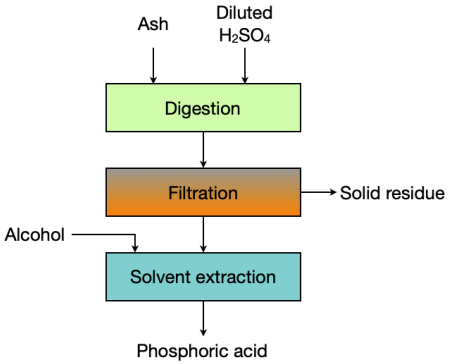
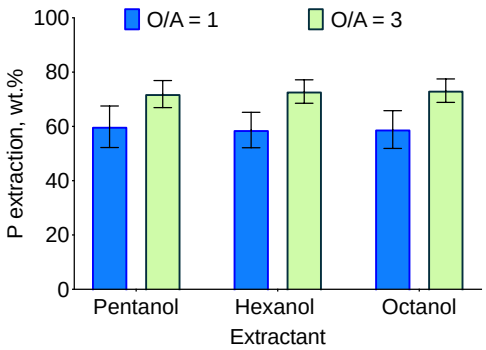
Final Results

- **Objective**: P-extraction from ash of an industrial FBC incinerator of laying hens manure (Güres Energy, Turkey): development of a hydrometallurgical route.
- **Final result**: The $CaCO_3$ fluidized bed sand is the main factor impeaching the separation of the ash by physical methods and the hydrometallurgical via acid leaching requires high H_2SO_4 concentration (102 g/L), but Solvent Extraction experiments with alcohols demonstrated a good extraction of P (~ 77 wt.%) independently of the alcohol used.





Impact: no impact, the Ca is an acid consumer and direct use of this ash would require high amounts of acid.

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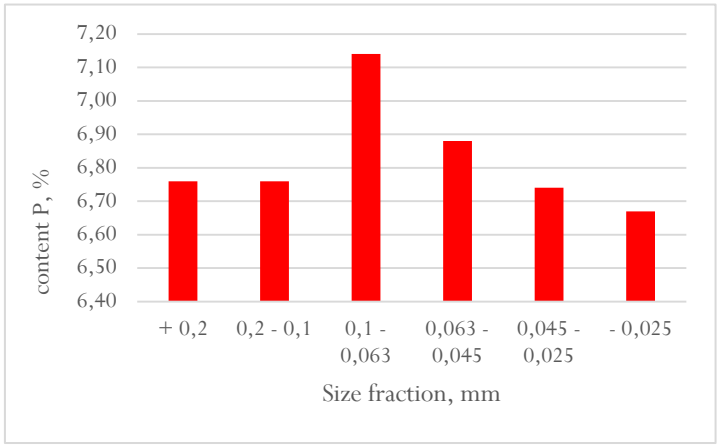
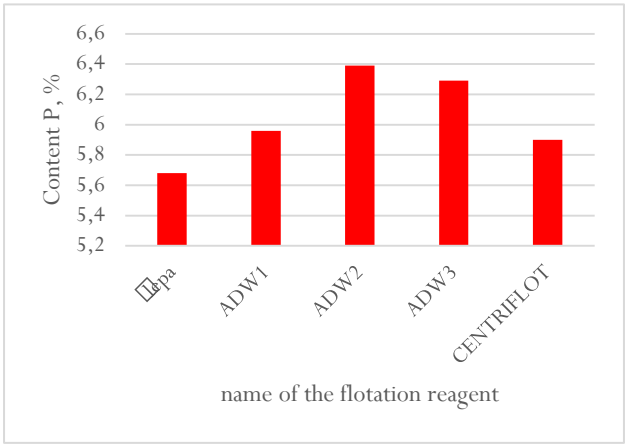
Final Results

- **Objective**: using physical methods to concentrate P in FBC laying hens manure ash.
- **Final result**: there is no differentiation in the content of P and Ca as a function of density, grain size and flotation.

At 2.4 g/cm^3 sinks,
At 2.5 g/cm^3 floats.





Impact: no impact.

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Final Results

- **Objective**: to study the effect of combustion conditions in poultry litter ashes using laboratory scale combustion reactors: pelletization and silica sand bed.

- **Final result**: Aviary manure pelletizing significantly improves the efficiency of a fluidized quartz sand bed combustion process in relation to a fixed bed, and the ash contains higher proportion of amorphous matter and three times more phosphorus content (about 29% wt.), which indicates a high potential for the bioavailability of phosphorus.

Impact: high impact is expected at industrial level regarding the best option for aviary manure incineration and further P-extraction.

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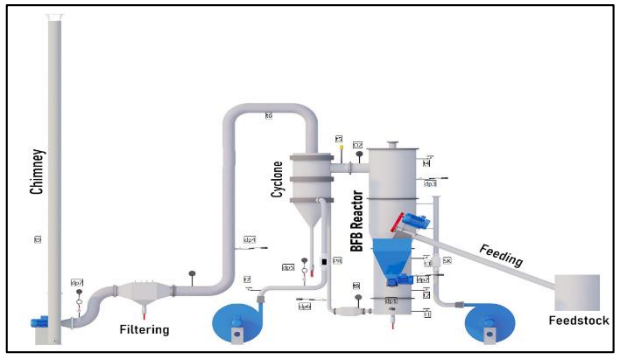
Final Results

- **Objective**: Conception and installation of a fluidized bed combustor specifically designed to burn laying hens manure and producing ashes for pilot-scale trials.
- **Final result**: The pilot-scale BFBC has been installed at Ege University - Solar Energy Institute (UEGE, Turkey), and in 2021 operated only for the DEASPHOR testing laying hens manure at different temperatures and bed materials.



Impact: the BFBC system will be used for investigating the optimum process conditions for maximizing energy yield and minimizing air emissions.

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Final Results

- **Objective**: to prove that P-recycling from poultry litter ash has derivative environmental benefits.

- **Final result**:

The rice husk poultry litter ash is suitable for heavy metal stabilization, namely to reduce leachable Pb and Zn in municipal solid waste fly ash.

The most sustainable method to manage rice husk poultry litter ash consists of P recovery by wet chemical extraction, and then address the SiO_2-rich solid residual as a building material.

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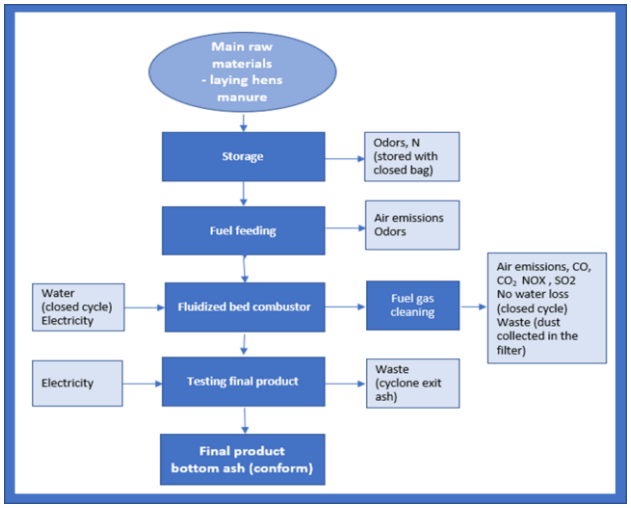
Final Results

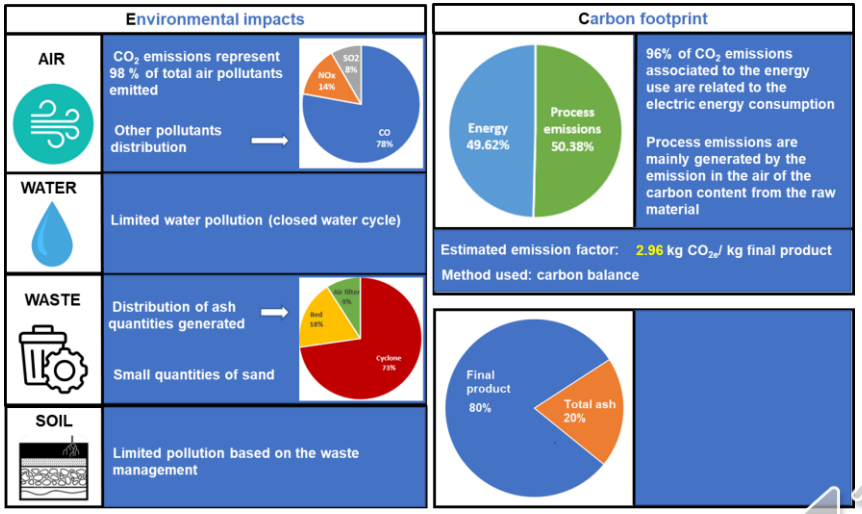
- **Objective**: Detailed carbon footprint evaluation of the BFBC applied to laying hens manure incineration.

- **Final result**: The technology proposed is at pilot level, the environmental impact of the technology is limited, and the preliminary results for carbon footprint indicate a high emission factor. This could be reduced by decreasing the carbon content of the energy used or capture part of the emitted carbon.

Technological and environmental diagram



Environmental impact assessment and Carbon footprint



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Follow-up

- The partner enterprises are following our results and the cooperation will continue after the end of this project in the search of new routes for P-extraction:

  1. By changing the combustion conditions followed by wet chemical extraction;

  2. Via pyrometallurgic methods to obtain P.

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Project publications so far:

Fiameni et al., 2021. Phosphorous and Silica Recovery from Rice Husk Poultry Litter Ash: A Sustainability Analysis Using a Zero-Waste Approach. https://doi.org/10.3390/ma14216297

Fahimi et al., 2021. Evaluation of the sustainability of technologies to recover phosphorus from sewage sludge ash based on embodied energy and CO2 footprint. https://doi.org/10.1016/j.jclepro.2020.125762.

Fiameni et al., 2021. Simultaneous amorphous silica and phosphorus recovery from rice husk poultry litter ash. https://doi.org/10.1039/d0ra10120f.

Kucharskiet al., 2021. Evaluation of specific capacity of poultry litter in heavy metal sorption. https://doi.org/10.1007/s11270-021-04984-w

Adamczyk et al., 2021. Phosphorus-rich ash from poultry manure combustion in a fluidized bed reactor. https://doi.org/10.3390/min11070785

Fahimi et al., 2020. Poultry litter ash characterisation and recovery. https://doi.org/10.1016/j.wasman.2020.05.010.

Kucharski, P., Bialecka, B., 2020. Methodology of environmental risk assessment of metal-contaminated soils. DOI: 10.15199/62.2020.11.17

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