Soil

Abstract 102

A LIMING AGENT BY RECYCLING MOLLUSC SHELLS

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The total EU fishery production amounted to around 4.5 million tonnes in 2022, of which 1.1 from aquaculture. This poses a challenge regarding the huge volume of wastes derived from seafood production and processing, in both economic and environmental terms. Anyway, these wastes contain valuable compounds that can be recovered in agriculture. The EU-funded SEA2LAND project, based on the circular economy model, explores the production of large-scale fertilisers in the EU from fishery and aquaculture wastes. In mollusc cultivation and fishery, the main waste is composed by shells, composed of CaCO3 and, at a lesser extent, of MgCO3, making them a promising source of liming agent for acidic soil correction. Several areas in Europe have low pH soils, due both to natural and anthropogenic processes, requiring lime distribution for agricultural production. Agricultural lime products are categorized as 'EC Fertiliser Liming Materials' in the EU Fertilizing Product Regulation (2022), the most used being ground limestone, dolomitic ground limestone, chalk, ground chalk, burnt lime and hydrated lime. However, although needed for soil quality and agricultural production, liming is often discarded due to its costs. The possibility to use waste products as liming agents allows to address both economic and environmental issues. The shellfish waste used in this work is a mixture of mussel, clam and murex shells discarded from a mollusc processing facility located in Ancona (Italy), whose production of discards accounts for about 1.4 ± 0.2 t·d-1. Waste was pre-treated by shredding the feedstock in the presence of water in a 1:3 (water: shellfish) ratio and the crushed shells (around 80% dry matter) were separated by gravity. The obtained shells were dried, milled and finally, sieved at 1 mm to obtain the liming agent with different particle sizes. These milled shells were first compared to reference liming agents (CaCO3 and CaO) in an incubation experiment to determine their effect on soil pH (UNI EN 14984:2006 method). Then the recycled liming agent was applied in two sites in northern Norway that needed liming, one with oceanic climate and one with more continental climate. The recycled liming agent was compared to conventional liming agent and no liming. Grass was sown at both sites. Results from the incubation trial suggest that the recycled liming agent has a high pH corrective power, similar to CaO and CaCO3. The results on soil pH and yield from the field trials will also be presented.

A liming agent by recycling mollusc shells

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- The EU-funded SEA2LAND project explores the production of large-scale fertilisers in the EU from fishery and aquaculture wastes
- Total EU fishery production: around 4.5 million tonnes in 2022.

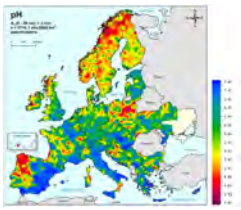
→ Economic and environmental challenge: huge amount of wastes → Possible recovery in agriculture

- In mollusc cultivation and fishery, the main waste is made up by shells, composed of $CaCO_3$ and, at a lesser extent, of $MgCO_3$

→ Promising source of liming agent for acidic soil correction

- Several areas in Europe have low pH soils, due both to natural and anthropogenic processes, requiring lime distribution for agricultural production

Figure 1. Maps of pH ($CaCl_2$) in GEMAS soil samples from agricultural (Ap)



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Shellfish waste treatment and characterization

- The shell waste, a mix of clam, mussel and murex shells, discarded by a mollusc processing facility (Co.Pe.Mo., Ancona, Italy) was pretreated as follows:
- shredding in presence of water (1:3 water:shellfish)
- Crushed shells were separated by gravity, dried, milled and sieved **<1 mm**
- Chemical composition in Table 1

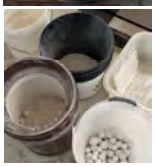


Table 1. Shell waste chemical composition

Sample	% CaO	% MgO
mix of clam, mussel and murex	49.77 ± 0.91	0.41 ± 0.03
Commercial CaO	82 ± 0.66	1.9 ± 0.02
Commercial CaCO3	51 ± 0.33	0.9 ± 0

Liming efficiency test in pots

- The shell waste and two commercial corrective agents (used in field tests) were compared with $CaCO_3$ and CaO, for their liming efficiency.
- Procedure: UNI EN 14984: 2006 – *Liming materials – Determination of product effect on soil pH – Soil incubation method*
  - 3 replicate pots for each treatment; in each pot:
    - 500 g dried soil
    - 0.5 g corrective ($CaCO_3$, or CaO, or LA1 (Liming agent 1), or LA2 (liming agent 2), or shell mix)
    - water (up to 60% of water holding capacity)
  - pH measurement (ISO 10390: 2005 standard method) at day 3, day 10, day 20, day 30
  - E1 (index of efficiency)=(pHp-pH0)/(pHr-pH0)
    pHp : product tested
    pH0 : control (no addition)
    pHr : reference material (CaO or $CaCO_3$)

Table 2. Index of liming efficiency E_1

	E_1 $CaCO_3$	E_1 CaO
LA1	0.245	0.165
LA2	0.431	0.291
Shells < 1mm	0.822	0.554
Shells >1mm	0.478	0.322

E1<1 : corrective power lower than reference
E1>1 : corrective power higher than reference

Field tests to verify the liming efficiency of shell waste

Two sites in Norway:

- 1st site: Tjøtta: Salt watery coast climate, organic soil, pH 5.7
  - Sowing: 23.05.2023
- 2nd site: Trofors: : fresh watered valley climate (inland), organic soil, pH 5.7
  - Sowing: 14.06.2023

In both sites a mix of *Phleum pratense* (80%) and *Festuca pratensis* (20%) was sown

Experimental plan:

- 3 treatments: Control (no addition)
  LA1 (Tjøtta) or LA2 (Trofors)
  Shell waste <1 mm
- 3 parcels (10.5 m^2) for each treatment, randomised
- Each parcel recieved 4.2 kg of liming agent (around 4 t ha^{-2}) one week before sowing
- Measurement of parcels' pH in summer 2024 (Table 3)
- Mesurement of yield for 2 harvests in 2024 (Figure 3)

Table 3. pH values in summer 2024

	Control	Shell waste	LA
Tjøtta	5.7 ± 0.1	5.9 ± 0.0	5.9 ± 0.1
Trofors	5.7 ± 0.1	5.9 ± 0.1	5.9 ± 0.1

LA: Liming agent

Figure 2. Tjøtta yield

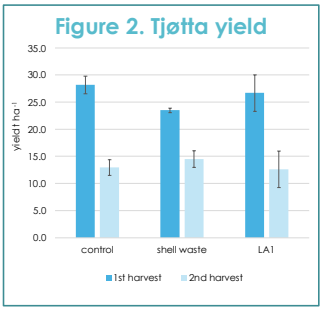
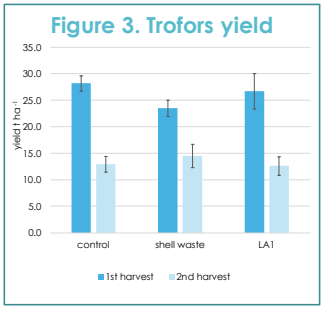


Figure 3. Trofors yield



Conclusion

The possibility to use waste products as liming agents allows to address both economic and environmental issues. In this work, the feasibility of using a mixed shell waste produced in Ancona as a correcting agent for acidic soils was explored both by pot experiment and by field trials conducted in Norway.
In the pot experiment shell waste showed a liming efficiency comparable to that of $CaCO_3$ and higher than that of two commercial liming agents.
In the filed trials the pH resulted increased by treatments with commercial liming agents (LA1 and LA2) and with shell waste. The yield in the treated parcels was not different from the control yield, suggesting that reiterated applications of liming agent/shell waste would be useful.
Further investigation is needed to assess the optimal shell waste dose and particle size in order to optimize efficiency in differently acidic solis (mineral vs. organic soils), taking into account environmental and economic factors (i.e. milling requires energy).