INSTITUTO DE CIENCIAS AGRONÓMICAS Y VETERINARIAS

# Nanominerals and biochar as additives in the composting of agricultural waste: effects on GHG emissions, composition and biodegradability of end-products on grassland soils.

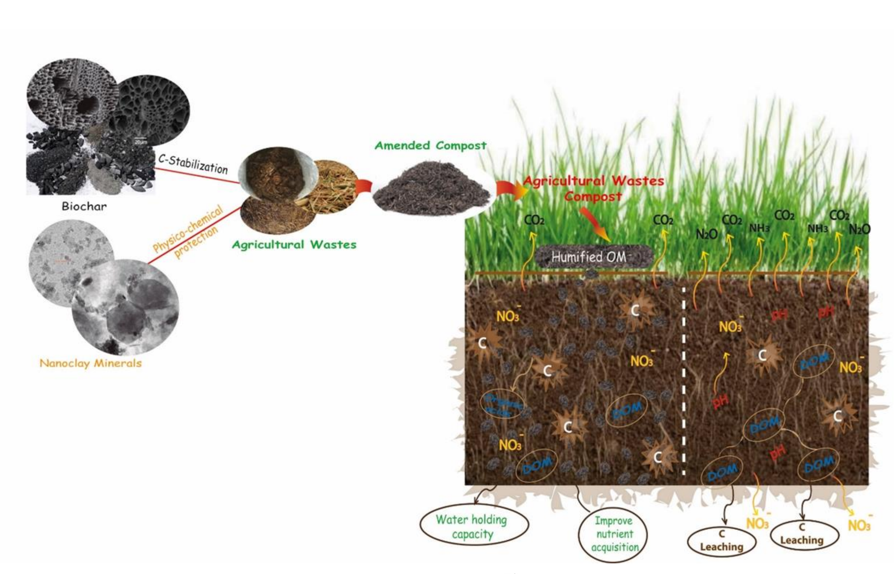
**Medina, J.[ab], Calabi-Floody, M.[c], Panettieri, M.[d], Cornejo, P.[a], Borie, F.[af], Knicker, H[d].**

[a] Centro de Investigación en Micorrizas y Sustentabilidad Agroambiental (CIMYSA), Scientific and Technological Bioresources Nucleus-BIOREN, Universidad de La Frontera, Temuco, Chile.
[b] Instituto de Ciencias Agronómicas y Veterinarias, Universidad de O'Higgins, San Fernando, Chile.
[c] Center of Plant, Soil Interaction and Natural Resources Biotechnology, Scientific and Biotechnological Bioresource Nucleus, BIOREN-UFRO, Universidad de La Frontera, Temuco, Chile.
[d] Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC), Seville, Spain.
[e] Instituto de Investigaciones Agropecuarias. INIA Carillanca, Casilla Postal 58-D Temuco, Chile.
[f] Facultad de Recursos Naturales. Universidad Católica de Temuco, Campus Juan Pablo II, Temuco, Chile.
*corresponding author: jorge.medina@ufrontera.cl; jorge.medina@uoh.cl

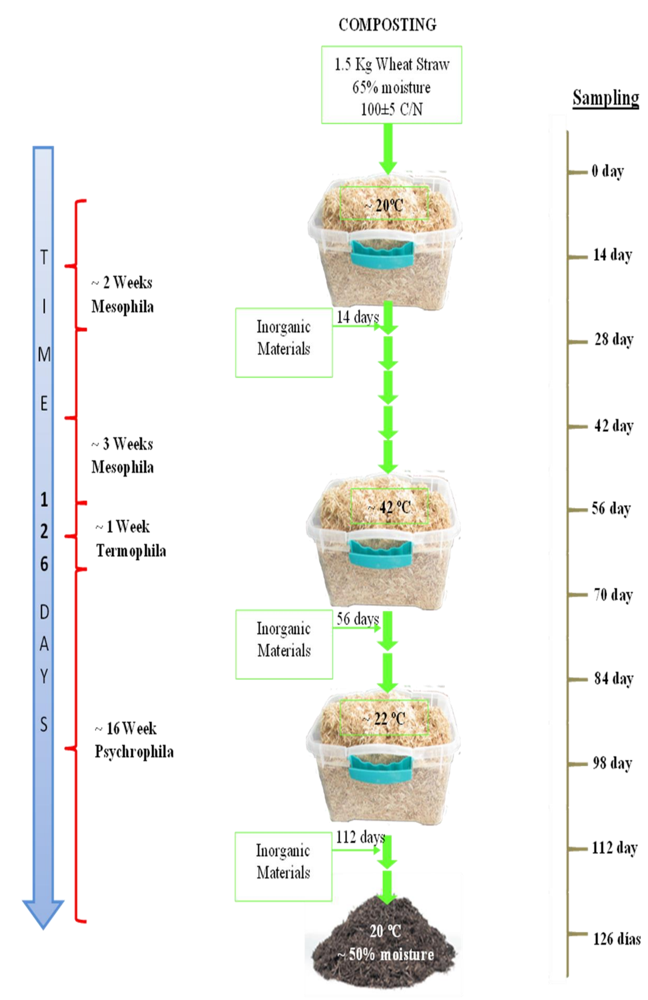
## Introduction

The utilization of additives is a strategy commonly used in composting operations to enhance the physicochemical properties and optimize the process. However, little is known about the impact of nanominerals, biochar and their combination during composting. The objective of this research was to evaluate the effects of iron oxide/halloysite nanominerals and oat hull-biochar as additives in the physicochemical properties of an aerobic composting process, the emission of greenhouse gases (GHG) and the composition of end-products.

a)



b)




c)

d)

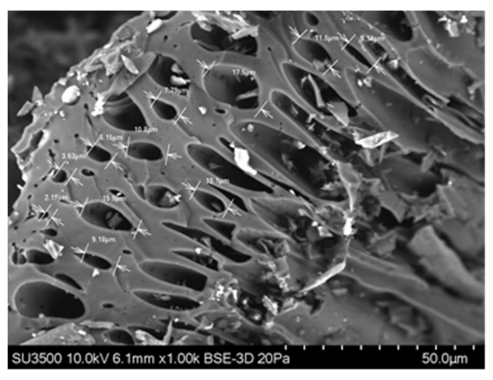


**Figure 1.** a) Graphical abstract; b) schematic representation of composting process; c) GHG analysis and d) biochar.

## Materials and Methods

- Wheat straw, lupine and beef manure composting mixture (C/N: ~25).
- Iron oxide (Fe) or halloysite (Ha) nanoparticles (2% w/w), oat-biochar (B) (7% w/w) and their combination (BFe, BHa) were applied as additives.
- Physicochemical properties, the emissions of $CO_2$-$CH_4$ were determined during the process (128 days) (Sánchez-Monedero et al., 2010).
- The end-products characterized by nuclear magnetic resonance ($^{13}$CNMR).
- Respiration experiment (Respicond) combined with $\delta^{13}C$ isotopic analysis was conducted.

## Conclusion

These results suggest that the addition of halloysite and biochar to composting operations have significant effects on C stabilization and biodegradability of compost in grassland soils, that is relevant in the production of C sequestrant amendments.

## Acknowledgements

FONDECYT N°3170677

## References

Sánchez-Monedero, M., Serramiá, N., García-Ortiz Civantos, C., Fernandez, A Roig, A. 2010. Greenhouse gas emissions during composting of two-phase olive mill wastes with different agroindustrial by-products. Chemosphere 81, 18-25

## Result and Discussion

A decrease of final C/N ratio was observed in all treatments that was lower in B treated compost. Nitrate concentration increased as composting progressed, and compost supplied with Ha showed the higher final content of $NO_3$ (5800 mg kg$^{-1}$) and $NH_4$ (220 mg kg$^{-1}$). The addition of B significantly decreased the mean emission of both $CO_2$ (~400 g $CO_2$ m$^2$ d$^{-1}$) and $CH_4$ (~4.5 g $CH_4$ m$^2$ d$^{-1}$). Nanominerals significantly decreased the final E4/E6 ratio (<6) and the addition of B increased the aromaticity (twice), the alkyl-C/O alkyl-C ratio and the hydrophobicity which are parameters associated to stabilized end-products. In soil, the incorporation of additives reduced the loss of C (<5% after 60 days of incubation). Treatments supplied with B and Ha showed a higher mean residence time (8 and 5 years respectively) than compost without additives.

**Table 1.** Chemical properties of the end-products after 128 days of composting process.

| Treatment | pH | EC | TOC (mg g$^{-1}$) | Nt (mg g$^{-1}$) | C:N | $NH_4$ (mg kg$^{-1}$) | $NO_3$ (mg kg$^{-1}$) | Mean FDA act. | elemental C relative reduction % |
|---|---|---|---|---|---|---|---|---|---|
| *NA* | 7.5 | 4.9 | 249[c] | 24.4[b] | 10[b] | 226.7[a] | 4066.7[a] | 401[ab] | 29.2 |
| *Nanoparticles* | | | | | | | | | |
| *Fe* | 7.7 | 3.3 | 285[c] | 26.2[ab] | 11[b] | 133.3[c] | 2933.3[c] | 399[ab] | 19.2 |
| *Ha* | 7.1 | 4.9 | 339[b] | 28[a] | 12[b] | 219.3[a] | 5750[a] | 389[ab] | 2.58 |
| *Biochar and nanoparticles* | | | | | | | | | |
| *B* | 7.6 | 2.6 | 386[a] | 24[bc] | 16[a] | 204.3[b] | 3903.3[ab] | 445[a] | 5.31 |
| *BFe* | 7.6 | 2.5 | 374[ab] | 21.5[c] | 17[a] | 85.9[d] | 1501[d] | -- | 11.5 |
| *BHa* | 8.1 | 1.6 | 337[b] | 19.6[d] | 17[a] | 24.3[e] | 775[c] | -- | 17.8 |
| ANOVA | *** | *** | *** | *** | *** | *** | *** | ** | |

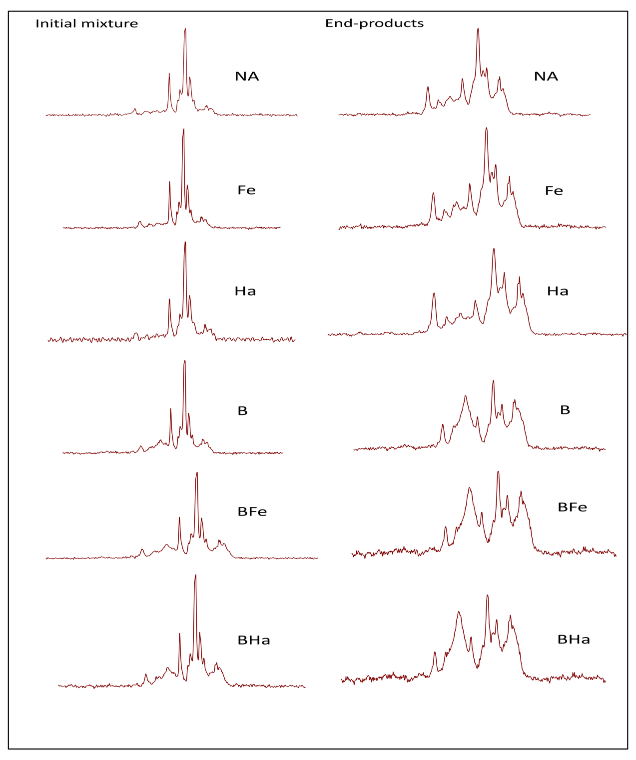
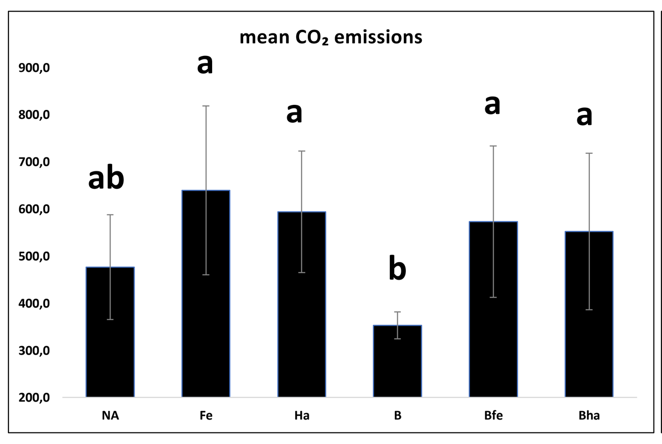



**Figure 2** Solid state NMR spectra of compost at day 0 and 128

a)




b)

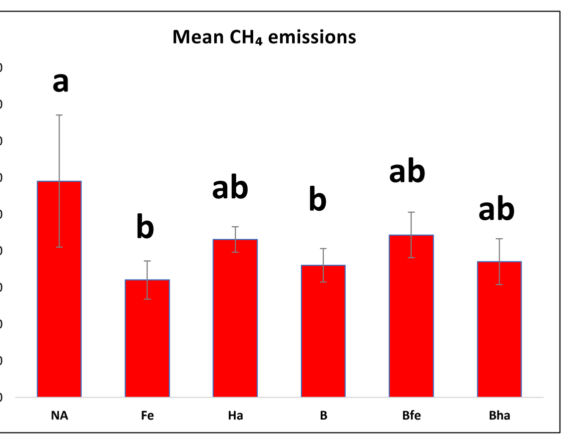


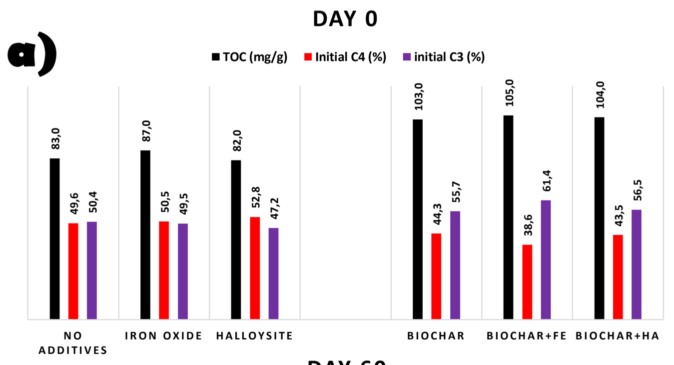

**Figure 3.** Mean a) $CO_2$ and b) $CH_4$ emissions from composting treatments

**Figure 4.** Respicond experiment

**Table 2.** Degradation constants, C losses and MRT of compost in grassland soil.

| Treatment | Total C loss (% of $C_{org}$) | $A_1$ (% of $C_{org}$) | $K_1$ (year$^{-1}$) | $MRT_1$ (years) | $A_2$ (% of $C_{org}$) | $K_2$ (year$^{-1}$) | $MRT_2$ (years) | $t_{1/2}$ (years) |
|---|---|---|---|---|---|---|---|---|
| **Soil** | **2.8±0.3** | 1.25±0.3 | 64.2±2.7 | 0.0156±0.00 | 98.7±0.3 | **0.104±0.004** | **9.2±0.4** | 6.4±0.3 |
| **No additives** | **4.7±0.6** | 1.7±0.3 | 82.9±11.0 | 0.0122±0.00 | 98.1±0.4 | **0.225±0.025** | **4.5±0.5** | 3.1±0.4 |
| **Iron oxide** | **4.6±0.3** | 1.9±0.2 | 124.9±30 | 0.0084±0.00 | 98.0±0.4 | **0.205±0.034** | **5.0±0.8** | 3.4±0.6 |
| **Halloysite** | **3.3±0.3** | 1.0±0.5 | 148.8±5.1 | 0.0172±0.00 | 99.0±0.5 | **0.185±0.010** | **5.4±0.1** | 3.7±0.1 |
| **Biochar** | **3.8±0.6** | 2.1±0.5 | 36.2±6.0 | 0.0281±0.00 | 97.8±0.6 | **0.132±0.012** | **7.6±0.7** | 5.3±0.5 |
| **Biochar +Fe** | **5.0±0.2** | 0.8±0.1 | 137.5±32.7 | 0.0070±0.001 | 99.2±0.1 | **0.300±0.03** | **3.2±0.3** | 2.2±0.2 |
| **Biochar+Ha** | **5.2±0.4** | 1.0±0.1 | 154.47±4.8 | 0.0065±0.00 | 99.0±0.1 | **0.319±0.00** | **3.2±0.4** | 2.2±0.3 |

a)




b)

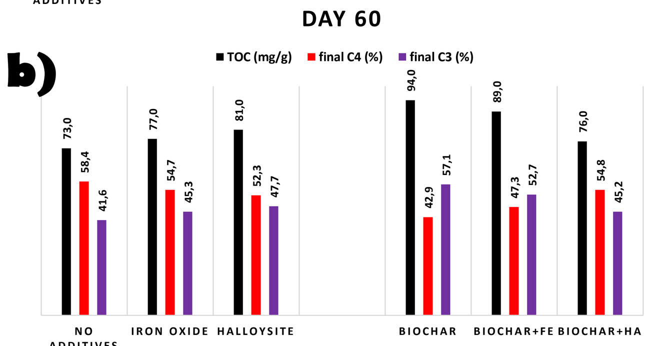



**Figure 5.** Fraction of OC derived from amendments ($\delta^{13}$) a) at day 0 and b) day 60 of soil-compost incubations

CONICYT Ministerio de Educación
Gobierno de Chile
FONDECYT
Fondo Nacional de Desarrollo Científico y Tecnológico
BIOREN - UFRO
Scientific and Technological Bioresource Nucleus
CENTRO DE INVESTIGACIÓN EN MICORRIZAS Y SUSTENTABILIDAD AGROAMBIENTAL
CIMYSA