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Hydrothermal carbonization (HTC) of digestate and the potential of its by-products to be used in soilless culture systems

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The anaerobic digestion (AD):

is a biochemical process, where bacteria, in the absence of oxygen, gradually transform the organic matter producing biogas, mainly composed of methane and carbon dioxide. A by-product of the AD process is the digestate, which is used as a fertilizer in agriculture or is dried and burned in incinerators or disposed in landfills. These uses of digestate cause a negative impact on the environment due to nutrient leaching and ammonia volatilization

The hydrothermal carbonization (HTC):

is a thermal post-treatment of manure-based digestate and it could represent a sustainable alternative to its common treatments and could be of considerable importance to limit the problems related to land spreading

The AD-HTC process leads to two nutrient-rich by-products : one solid = hydrochar and one liquid = aqueous HTC liquid (AHL)

AIM :

to evaluate the potential of both HTC by-products to be used in soilless culture systems as either growing medium and fertigation solution

The HTC process was performed in a batch reactor, by varying the operating temperature (180, 220 and 250°C) and residence time (1 and 3 h), to assess the influence of these parameters on the physical-chemical characteristics of the hydrochars and AHLs

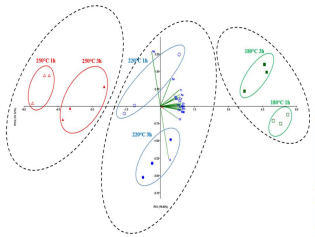
MINERAL ELEMENT CONCENTRATION

HYDROCHAR

Feedstock highly influences the physical-chemical characteristics of by-products

The mineral element content of hydrochars, deriving from manure-based digestate, is higher compared to that of hydrochars from other feedstocks.

Effect of process temperature is higher than that of the residence time → the element content increases with increasing temperature.



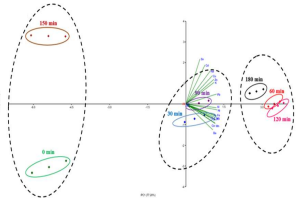
AHLs

Comparison of mineral composition of AHLs with that of a conventional nutrient solution

The concentrations of Mg, Ca and P in the AHLs are of the same order of magnitude of those in the nutrient solution, whereas the content of S and Na in the AHLs is higher than that in the nutrient solution.

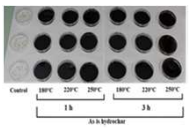
P, Mg, K, Cu, Mn, Fe, Zn, Pb, Cr, and Cd show a time-dependant concentration.

The mineral element concentration decrease with increasing process temperature, except for Zn and Pb.



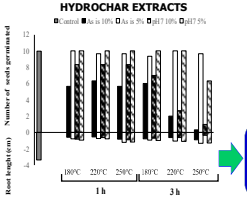
GERMINATION TESTS using cress seeds

AS-IS HYDROCHAR



Only control germinated

HYDROCHAR EXTRACTS



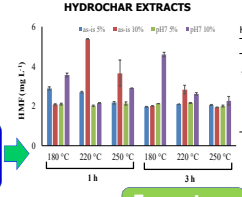
No negative effect on 5% (m/v) hydrochar extracts.

With 10% (m/v) hydrochar extracts only 60% of seeds germinated and even less with increasing process severity.

Root inhibition: toxic compounds

CHROMATOGRAPHIC DETERMINATIONS

HYDROCHAR EXTRACTS



Furan-type compounds

AHLs

Hydroxymethylfurfural (HMF), LD = 2500 mg/kg

HMF

Value ± SEM (mg/L)

Temperature (°C)	0 min	30 min	60 min	90 min	120 min	150 min	180 min
180	5.2 ± 2.1	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD
220	5.2 ± 0.1	2.1 ± 0.0	2.1 ± 0.1	2.1 ± 0.1	< LOD	< LOD	< LOD
250	< LOD	< LOD	2.0 ± 0.0	2.0 ± 0.0	2.0 ± 0.0	2.0 ± 0.0	2.0 ± 0.0

Furfural

HMF

Furfural, LD50 = 90-204 mg/kg

Furfural

Value ± SEM (mg/L)

Temperature (°C)	0 min	30 min	60 min	90 min	120 min	150 min	180 min
180	4.6 ± 0.1	< LOD	< LOD	< LOD	< LOD	< LOD	4.4 ± 0.1
220	405.8 ± 5.1	342 ± 0.2	5.9 ± 0.1	5.0 ± 0.0	5.9 ± 0.1	5.3 ± 0.0	6.1 ± 0.0
250	4.2 ± 0.0	4.2 ± 0.2	< LOD	< LOD	< LOD	< LOD	< LOD

Conclusions : the AD-HTC coupling could represent a sustainable practice in the field of biomass and waste conversion, since a management strategy, aimed at reducing and recycling the amount of waste, is needed.

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