# *Unveiling The Potential of Cow Manure Hydrothermal Processing: Safer Land Application And Energy Recovery Opportunities*

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## Background

Cow manure is a valuable source of nutrients, but its direct application to agricultural land poses risks to the environment and public health. Anaerobic digestion (AD) in combination with the land application of digestate is a typical alternative. However, due to the high concentrations of nutrients and pathogens in the digestate, AD is not sufficient to mitigate the risks associated with manure management. These challenges require environmentally sound solutions that advance the principles of organic agriculture and the circular bio-economy.

Considering the manure's high moisture content, hydrothermal processing is a promising approach for its sustainable valorisation to produce biochar, referred to as hydrochar, which can be utilized as a solid fuel and soil amendment. In addition, the process water obtained after dewatering the hydrochar can be valorised to recover bioenergy through anaerobic digestion.

## Research Gap & Objectives

There are existing studies on the hydrothermal processing of cow manure, yet there is still a knowledge gap in understanding the fate of primary (N, P and K), secondary (Ca, Mg, S and Na) and micro-nutrients (Bo, Co, Cu, Fe, Mn, Mo and Zn) in the resulting hydrochar and process water. Accordingly, the research objectives of the study are to:

1. Understand the hydrothermal processing temperatures impact on nutrients' fate.
2. Assess the suitability of the hydrothermal processing products for land application and bioenergy recovery.

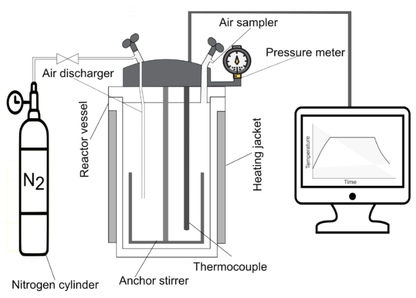
## Materials & Methods

***Raw Cow Manure***

***Hydrothermal treatments: 100 - 260°C for 1 hour***

***Hydrochar & Process water***

***Comprehensive characterization & Application assessment***

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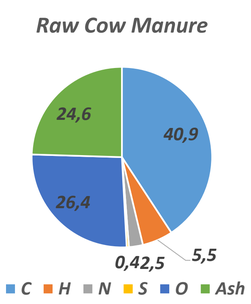
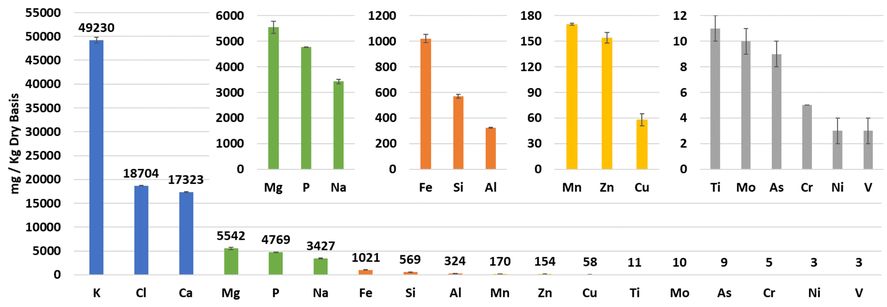
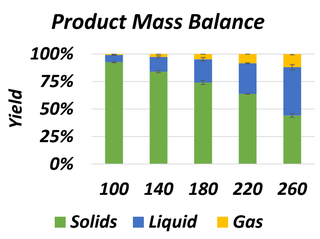
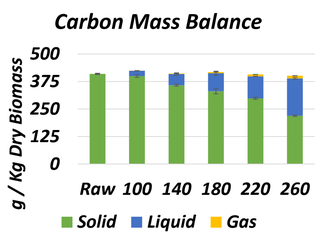
## Results & Discussion

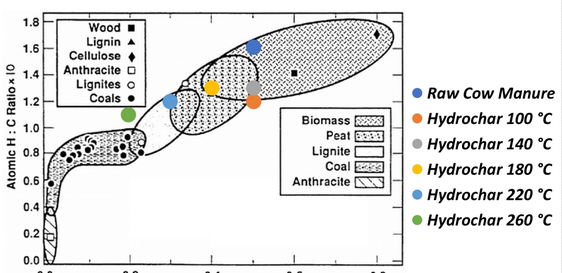
- The collected manure had a solids content of 8.1±0.2% and was hydrothermally processed as received.



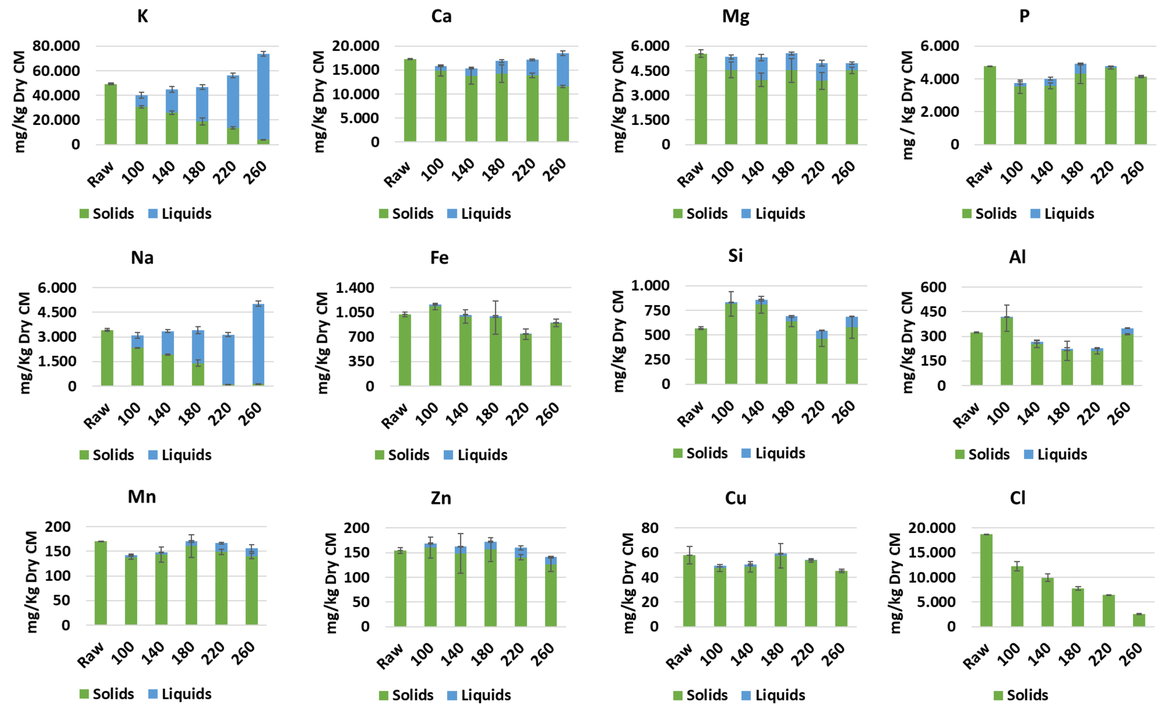

***Hydrochar produced at 220°C and 260 °C has the potential for solid fuel applications, but its ash composition can be problematic during combustion.***

- Process water had a higher stochiometric methane yield (666±36 ml $CH_4$/g VS) than cow manure (581 ml $CH_4$/g VS) at all temperatures.
- Considering the characteristics of biodegradability, namely COD and TOC, the methane yields for process water were 52%, 47%, 50%, 42% and 37% at 100°C, 140°C, 180°C, 220°C and 260°C, respectively.
- The ammonium-nitrogen contents in the process waters were suitable for anaerobic digestion at all temperatures without inhibiting methanogenesis.

***The potential for energy recovery lies in the anaerobic digestion of the process water, from which higher methane yields can be obtained than from raw cow manure.***

## Results & Discussion (continued)

- Satisfactory elemental balances were obtained for the organic elements, ranging between 90 and 110%, and for most inorganic elements between 75% and 110%.




- Most of the inorganic elements were incorporated into the solid phases.
- Potassium and sodium were mostly solubilized in the process water.
- Calcium and chlorine were solubilized in the process water to a lesser extent.
- Based on the oxygen to carbon atomic ratio, the dewaterability of cow manure was only enhanced within the HTC temperature range.

***According to EU Regulation 2019/1009 on fertilizing products, Hydrochar produced within the HTC temperature range (180 – 260 °C) meets the criteria for solid organic fertilizers.***

## Conclusions

- HTC temperatures are favoured due to the lower chlorine content, enhanced dewaterability and the abundance of aromatic functional groups in the hydrochar, which promote stability as a soil amendment.
- Considering the potential energy recovery from process water through anaerobic digestion, lower HTC temperatures could be a trade-off for improved methane yields and suitability of the hydrochar for agricultural land applications.
- Further studies are needed to evaluate the dewaterability, phytotoxicity and application of cow manure-hydrochar on agricultural land as well as experimental anaerobic digestion of process water.

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