

The Fate of Nitrogen and Phosphorous in Hydrothermal Carbonisation

Hydrothermal carbonisation of biowaste has two main outputs: hydrochar and process water. Fate analysis showed that most of the nitrogen is in the hydrochar, while the phosphorus is mainly in the process water. Amounts of both elements in the hydrochar were ready for plant uptake. Imanol Zabaleta¹, Hala Jamhoury², Chris Zurbrugg¹

Introduction

Hydrothermal carbonisation (HTC) or wet pyrolysis, is gaining increased attention as a potentially sustainable biowaste treatment technology. End products from HTC treatment are hydrochar, a sterile and carbon-rich solid material, and process water (PW), an acidic liquid with dissolved organic compounds. The majority of HTC studies focus on energy recovery from hydrochar due to its high heating values, which range between 13.8 and 36 MJ/kg depending on feedstock and process conditions [1]. Other uses for hydrochar, i.e. soil conditioning and carbon storage, have also been suggested due to its carbon content and chemical and physical characteristics [2]. Process water is considered mainly as a waste product. It needs to be treated before discharge given its low pH and high COD values, similar to landfill leachate [1]. Although HTC treatment is known to preserve the nutrients contained in the original feedstocks [3], little is known about their fate. This research assessed the fate and plant-availability of nitrogen (N) and phosphorus (P) after HTC treatment of biowaste.

Methodology

HTC experiments were conducted at different temperatures and with a total solid content (TS) of 25%. The feedstock consisted of a mix of banana peels, potato, cabbage, rice and dried maize stem pellets, all mixed in water. Total nitrogen (TN) and total phosphorus (TP) were measured in the feedstock, hydro-

char and process water. To determine the plant-availability of N and P, Ammonium (NH_4^+) and Nitrate (NO_3^-) were measured in the hydrochar and the process water and water-dissolvable TP was measured in the hydrochar.

Results

The feedstock's TN content was approximately 62 g for all experiments. Figure 1 shows the amounts (g) of N recovered in the hydrochar and process water. 65–68% of the output TN was in the hydrochar, while 32–35% was in the process water. 30–35% of the total output-N was readily plant-available, most of it contained in the process water. On average, only 11% and 1.3% of the output-N in the hydrochar were plant-available, as NO_3^- and NH_4^+ , respectively. The remaining 88% was bound to the organic matrix as organic-N, most likely due to the relative low temperatures in the experiments which were not high enough to break down cellulose, hemicellulose and lignin [4]. As for the output-N in the process water, on average 28% consisted of organic-N, while the plant-available fractions comprised most of the output-N, 70% was NO_3^- and 1.6% NH_4^+ . The low amounts of NH_4^+ were unexpected as the hydrolysis of the proteins at high temperatures should yield organic acids, NH_4^+ and CO_2 [5] and, therefore, result in higher NH_4^+ concentrations. We assume that NH_4^+ molecules reacted with the solid matrix during polymerization, or that they were precipitated as salts [3].

The feedstock's TP content was on average 9 g. Figure 2 shows the amounts (g) of P recovered in the hydrochar and process water. Around 70% of the TP was in the process water for which a TP characterisation into organic-P and non-organic-P was not done. The hydrochar contained 30% of the total output-P, from which 50–90% consisted of plant-available P. This percentage decreased in higher temperature experiments (Figure 2).

Conclusion

Nutrient analysis revealed that most N was in the form of organic-N and was contained in the hydrochar, whereas most P was measured in the process water. One third of the output-N and more than half of the P contained in the hydrochar were readily plant-available, indicating that the output materials from HTC have good short-term plant fertilising properties. Further research is needed to assess the long term release of the nutrients embedded in the organic matrix.

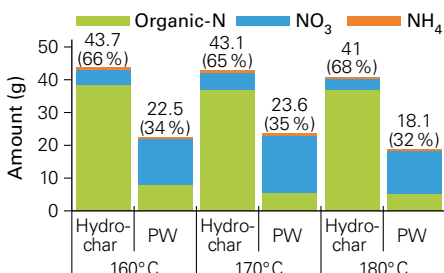


Figure 1: N amounts (g) & fractionation. Upper figure: absolute amount measured. In parentheses: % of total output-N contained in output materials.

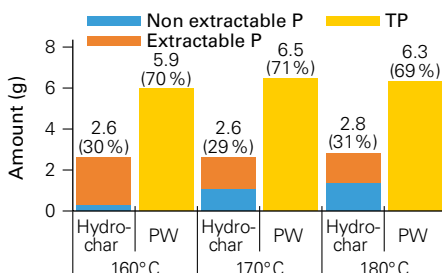


Figure 2: P amounts (g) & fractionation. Upper figure: absolute amount measured. In parentheses: % of total output-P contained in output materials.

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