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Production of Fertilizer from Process Water Generated by Hydrothermal Carbonization of Food Waste

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Abstract

Hydrothermal Carbonization (HTC) is a promising thermochemical technique that could be practiced as a method of energy and material recovery. As food waste is a wet, inhomogeneous biomass, it shows desirable potential to undergo HTC, other than other thermal conversion technologies. According to the physiochemical characterization of process water, it contains nutrients such as, Magnesium (Mg^{2+}), Ammonium (NH^{4+}) and Phosphate (PO_4^{3-}). Therefore, struvite precipitation was tested as the potential solution. Struvite yield was calculated in order to find out the efficiency and the feasibility of the precipitation method. Since struvite can be used as a fertilizer, building material or adsorbent, this will be a commercially viable application to produce value added product from HTC process water. According to analysed results, process water should have either a proper treatment mechanism or a properly designed water purification plant.

Keywords: Hydrothermal carbonization; Process water; Material recovery; Struvite

Introduction

Food waste is a large and currently underutilized source that represents higher potential in chemical and energy recovery [1]. Over 1/3rd of all food produced globally goes to waste while, in most developed countries, over half of all food waste generates in the home [2]. Food waste management has given a larger scale priority in the current world. "Waste to Energy" is one of the projects carried out at John Keells Research (JKR) in Sri Lanka, to generate power in a renewable and sustainable way. Hydrothermal Carbonization (HTC) is a method of energy and material recovery from wet inhomogeneous biomass. This research is focused to find potential solutions for HTC process water from hydrothermal carbonization of food waste by developing new product which can use as a new fertilizer [3].

Methods

The Process water sample was subjected to both physical and chemical analysis according to the standard guidelines under the American Public Health Association. pH, EC, Dissolve Oxygen (DO), BOD, COD, total hardness, alkalinity, total solids, total suspended solids, total dissolve solids, nutrients (ammonical nitrigen & phosphate), proteins, carbohydrates and major and trace metals were determined using standard methods. Struvite was precipitated by recovering phosphorous in process water. X-Ray Fluorescence Diffraction test (XRD) was performed to synthetic struvite precipitates in order to confirm that formed precipitates are struvite [4,5].

Results and Discussion

The pH measurements of two HTC process water samples are in acidic range where pH is ranging from 4.41 to 4.55. During HTC process, a variety of organic acids produce like carboxylic acid, phenols etc. in higher concentrations. It has been found that furans are degraded under these conditions (Smith et al., 2016) which will impact pH value to be drop below 7.0 to the acidic range as seen elsewhere. Other than the organic acids, some protein may degrade to amino acids and contribute to the acidic nature of the HTC process liquid. EC is linked to the total ions in water, treatment should be conducted either by neutralization, by precipitation, filtration or by extraction of metals. According to the analysis, the average BOD of HTC process water Sample is 4169 mg/L. The average COD value of HTC process water sample showed 33,637 mg/L. However, according to the calculated values, for HTC process water BOD/COD ratio is, 0.12 which implies that, either the process water may have some toxic compounds or acclimated microorganisms may be required in stabilization. It is clear that the HTC processed water is highly acidic and the average acidity is 7233 ± 71 mg/L. Acidity of this process water may due to reactions such as hydrolysis, dehydration and decarboxylation, decomposition which results in the formation of organic acids and due to formation of acidic molecules in biological degradation of organic matter. TDS includes material such as, carbonates, bicarbonates, chloride, phosphate, nitrate, calcium, magnesium, sodium, organic ions and other ions. Nutrients, especially nitrogen and phosphorus are key water quality parameters and depending on their chemical forms. As this process water is resulted from food waste, it is comprised of adequate quantities of nutrients and the applicability of the process water in applications are much viable since it does not contain any or no harmful constituents in food waste. However, in this study priority has been given to major nutrients such as, nitrogen, phosphorus, carbohydrates and proteins that could be

available in the process water. Therefore, the results obtained in this study will be beneficial for proper management of HTC process water [6-8].

Struvite precipitation is a method of recovering Phosphorus from wastewater sources. Therefore, the suggested solution is mainly focused on the Phosphorus recovery from HTC process water. Struvite is a white crystalline substance that consists of Magnesium, Ammonium Nitrogen, and Phosphate in equal molar concentrations. X-ray Diffraction analysis (XRD) was tested to confirm the 89% of crystal structure of actually synthetic struvite (Figure 1). Based on above results, phosphate was recovered as struvite ($MgNH_4PO_4.6H_2O$). Since struvite can be used as a fertilizer, building material or adsorbent, this will be a commercially viable application to produce value added product from HTC process water [9-11].

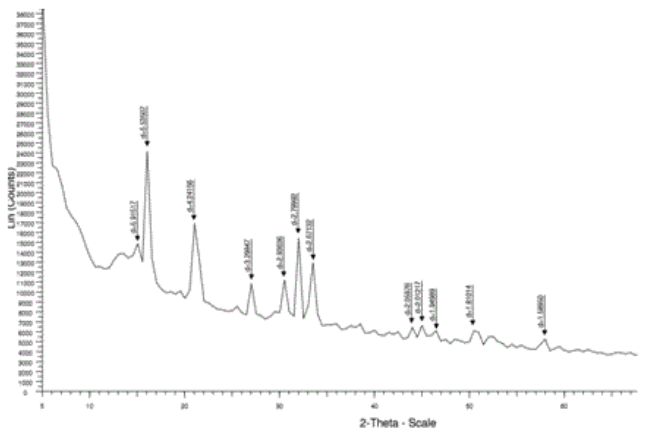

Figure 1: Peak pattern of synthetic struvite.

Conclusion

According to the physiochemical characterization of process water, it contains nutrients such as, Magnesium (Mg^{2+}), Ammonium (NH^{4+}) and Phosphate (PO_4^{3-}). Therefore, struvite precipitation was tested as the potential solution. Struvite yield was calculated in order to find out the efficiency and the feasibility of the precipitation method. Since struvite can be used as a fertilizer, building material or adsorbent, this will be a commercially viable application to produce value added product from HTC process water.

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