Thermal depolymerisation of digestate for biofuel and biomaterial production

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Contents

- A review of the background and motivation of this study.
- Value extraction from digestate: methodology employed.
- Research results we have obtained.
- Conclusion.

Motivation for utilising meat processing waste as a feedstock biochemicals and biofuel production

- Significant masses of dissolved air flotation (DAF) sludge, (~2.8×10^6 tonnes) and stockyard (SY) waste generated (>15×10^6 tonnes) annually by New Zealand meat processing plants.

- DAF and the SY waste streams constitute a waste management issue (Richard Stapel, personal communication, 2015).

- Limitations of current waste management approaches such as the generation of unpleasant smells from direct land disposal and sludge composting and the high energy drying operations prior to waste incineration.

- Sustainable biomass supply for biochemical and biofuel production in the absence of associated costs of cultivation, harvesting or agricultural land for biomass production.

New paradigm – integrated biofuel and biochemical production using meat processing waste biomass

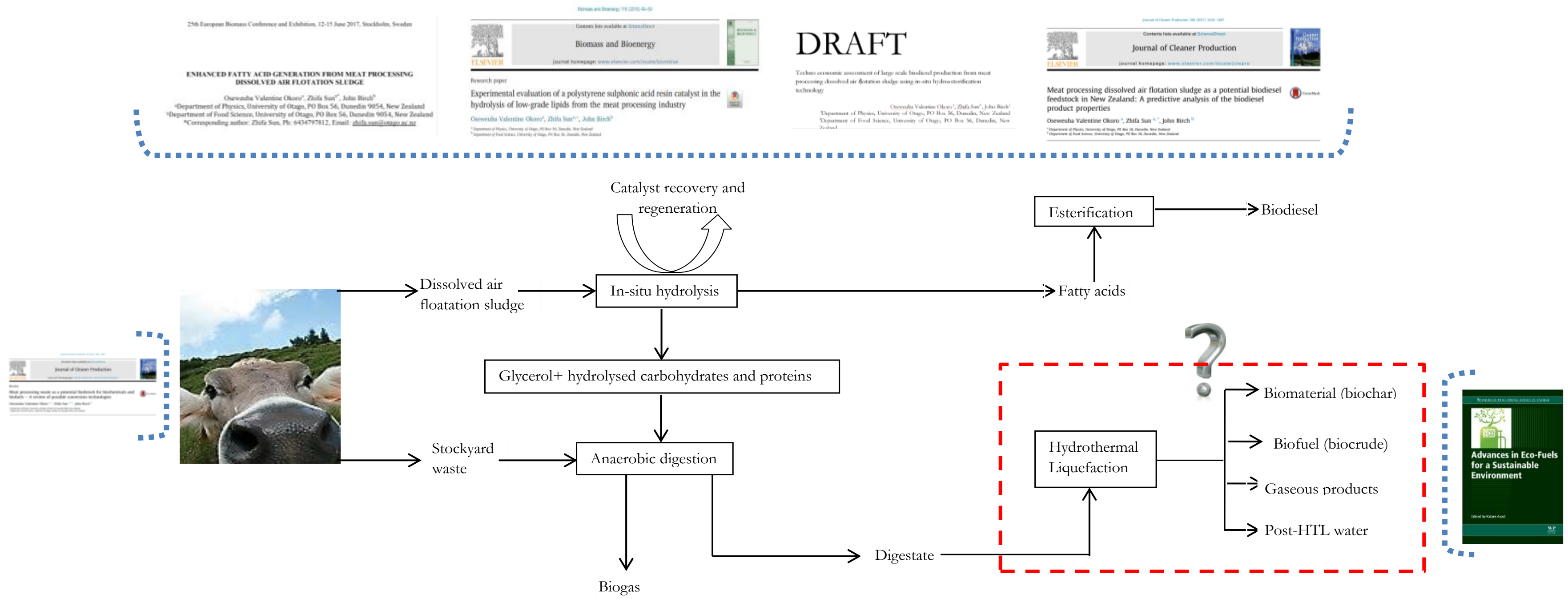


Fig. 1: Biorefinery design for meat processing waste conversion to biofuels and biochemicals.

Previous studies undertaken for processes in Figure 1.

- We have explored the utilisation of DAF sludge as a sustainable biodiesel feedstock via an integrated hydrolysis and esterification process.

- The viability of an DAF sludge lipid hydrolysis via a microporous resin aided catalysed in-situ pathway has been demonstrated.

- The viability of enhanced biomethane generation via the introduction of synergising effects during the AD of substrate mixture of stockyard waste and the wet hydrolysed DAF sludge residue (after in-situ hydrolysis) has been demonstrated.

- The possible challenges associated with the management of digestate i.e possible retention of harmful pathogens, have been identified.

- The HTL processing of the digestate has been identified as a possible resource recovery approach.

Value extraction from digestate: methodology employed

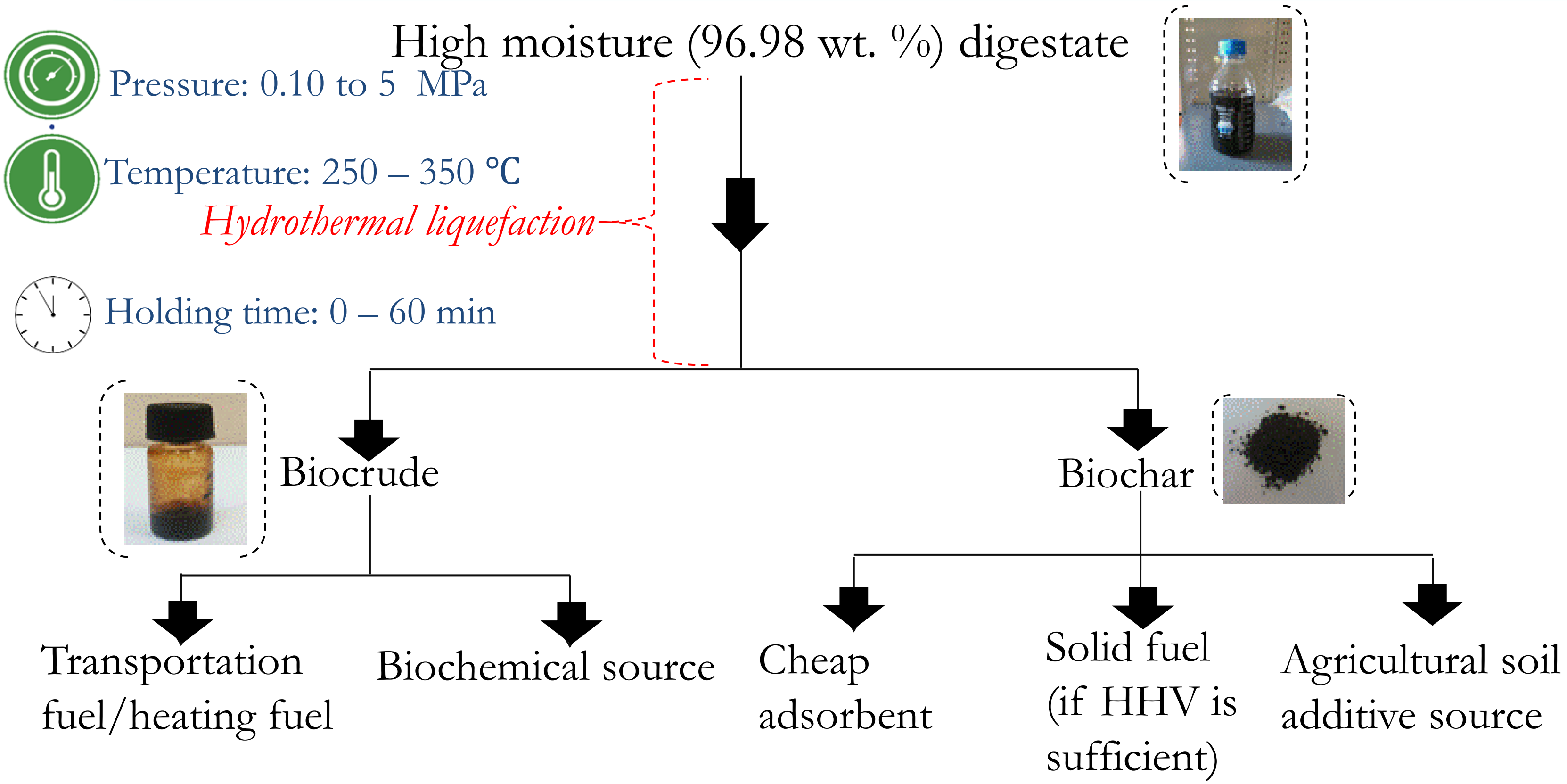
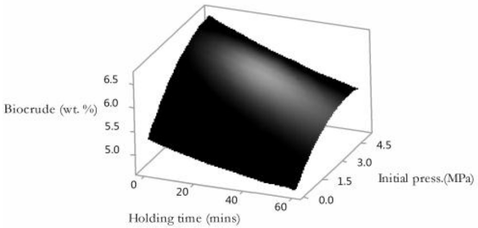
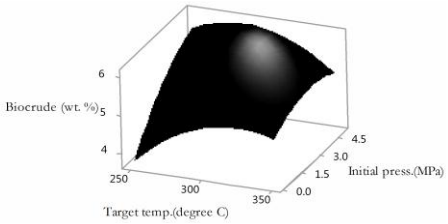


Fig. 2: Typical applications of HTL products of biocrude and biochar.

Results: effects of processing variables on the biocrude yield



[A]



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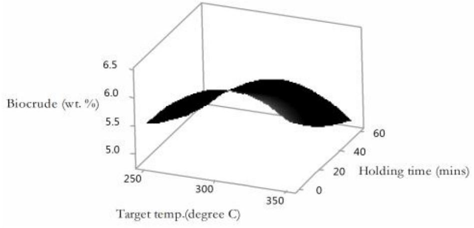
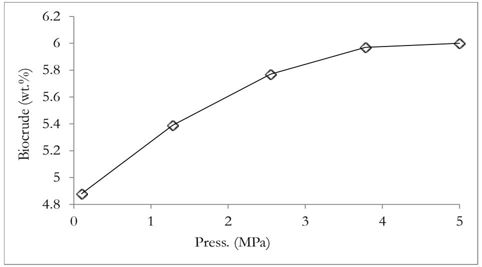
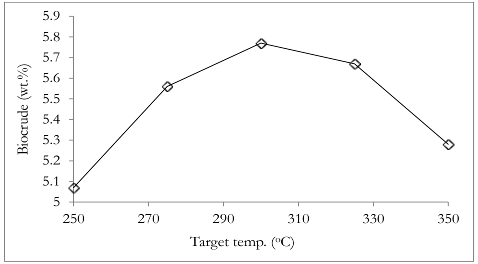


[C]

Fig.3: The combined effects of process variables on biocrude yield. (A): T=300 °C, (B): t=30 min, (C): p=2.55MPa.



[A]



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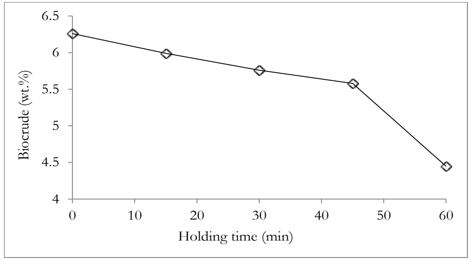
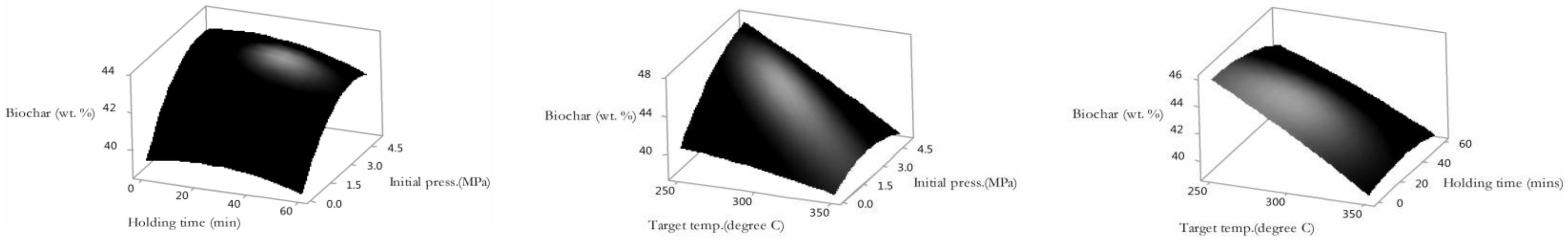


[C]

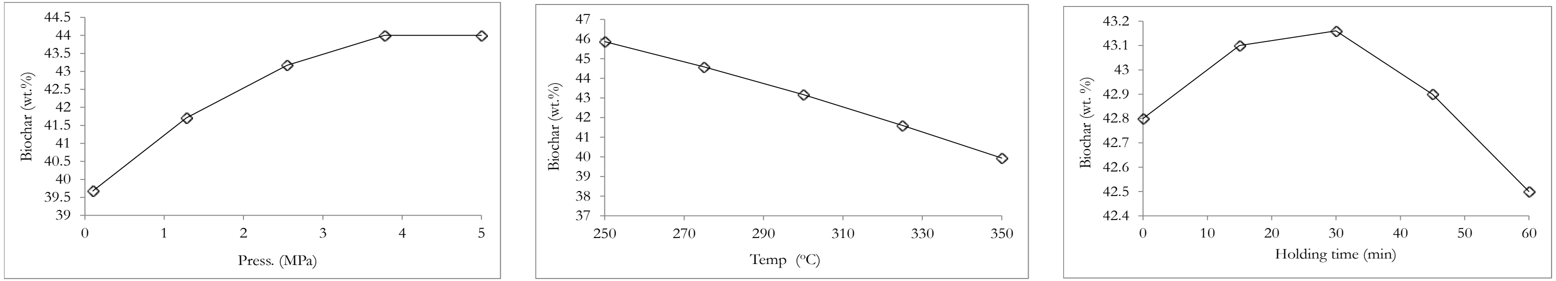
Fig. 4: The individual effect of process variables on biocrude yield. (A): t =30 min , T =300 °C, (B): t= 30 min, p= 2.55 MPa, (C): T=300 °C, p=2.55 MPa.

Results: effects of processing variables on the biochar yield



[A] [B] [C]

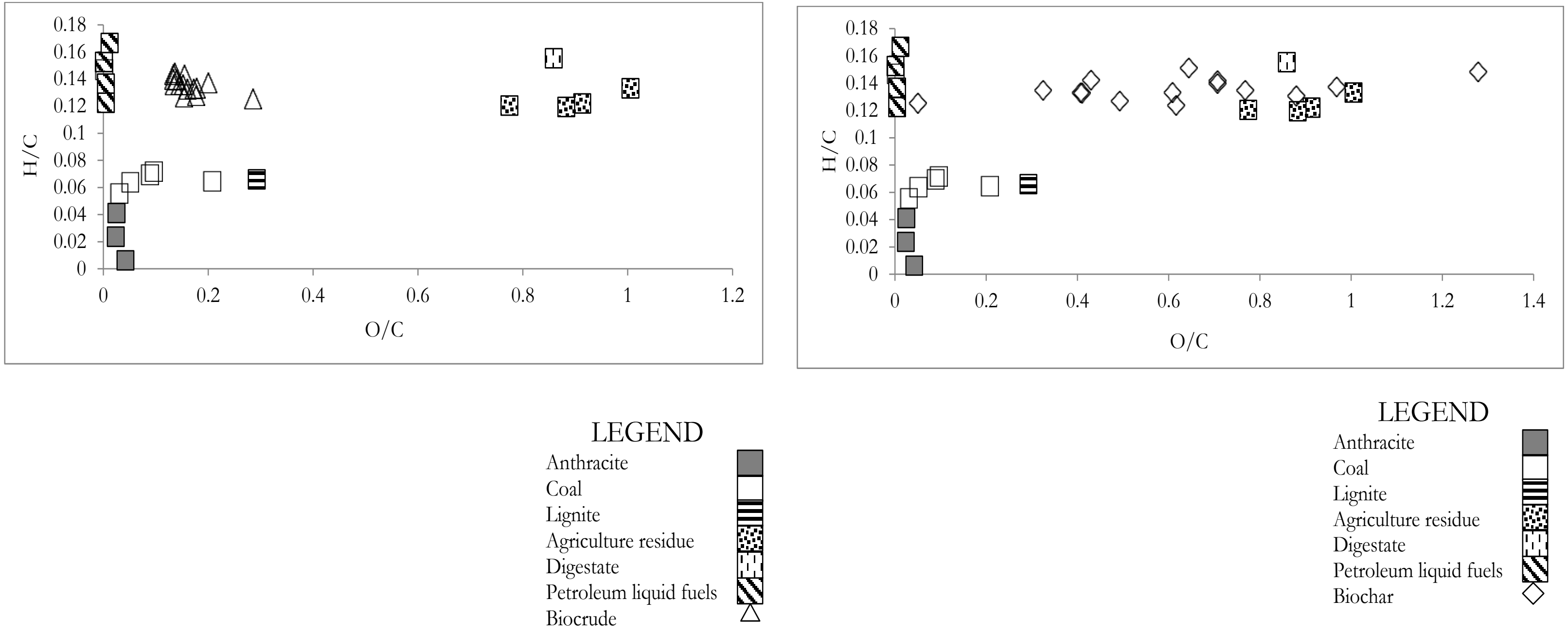
Fig. 5: The combined effects of process variables on biochar yield. (A): T=300 °C, (B): t=30 min, (C): p=2.55MPa.



[A] [B] [C]

Fig. 6: The individual effect of process variables on biochar yield. (A): t =30 min , T =300 °C, (B): t= 30 min, p= 2.55 MPa, (C): T=300 °C, p=2.55 MPa.

Results: compositional characteristics using Van Krevelen diagram



[A]

[B]

Fig. 7: Van Krevelen diagram (VKD) for compositional assessment relative to fossil fuels and biomass. [A]: biocrude and [B]: biochar.

Biocrude as a biofuel and a source of biochemicals

- The Van Krevelen diagram shows that the biocrude product of the HTL of digestate is similar to liquid fossil fuels with respect to H/C and O/C elemental ratios.

- Its similarity to liquid fossil fuels is further reinforced by the favorable higher heating values (HHVs) of the biocrude products ranging from 31.9 to 39.8 MJ/kg which is comparable to the HHV of heavy petroleum fraction of ~43 MJ/kg.

- Employing proton nuclear magnetic resonance, Fourier Transform infrared and Gas Chromatograph–Mass Spectrometry it was established that biocrude from digestate would contain compounds with carboxylic acid, aromatics and heterocyclic functional groups.

- The poor yields of biocrude ranging from 3.7 wt. % to 6.8 wt. % (dry basis of digestate) may not justify employing secondary biochemical recovery or biocrude upgrading.

Biochar as a biomaterial for improving the agricultural properties of soil

- Biochar from the HTL processing of digestate is characterised with very low HHVs ranging from 2.49 to 8.78 MJ/kg.

- It however has several properties that may enhance soil property such as soil's alkalinity (pH = 7.54) for neutralising acidic soils, high electrical conductivity (0.06 S/m), enhanced porosity (Fig. 8).

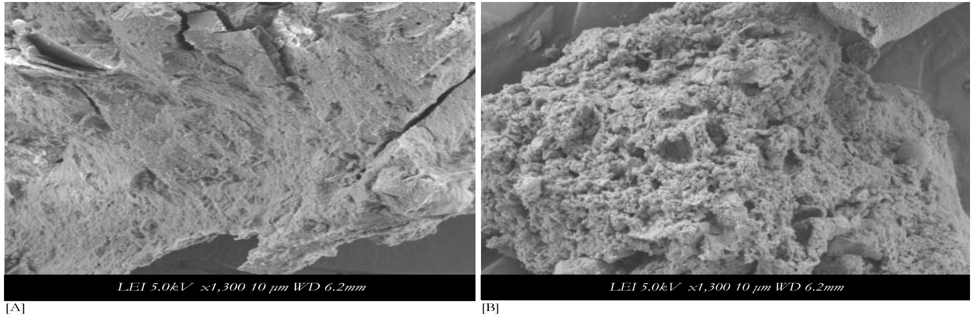


Fig. 8: Morphological structures of dried digestate feedstock [A] and the optimally produced biochar product [B].

Biochar as a biomaterial for improving the agricultural properties of soil

Nutrient measurement using an inductively coupled plasma mass spectrometry system also showed that biochar produced from digestate had a high nutrient concentration (Fig. 9).

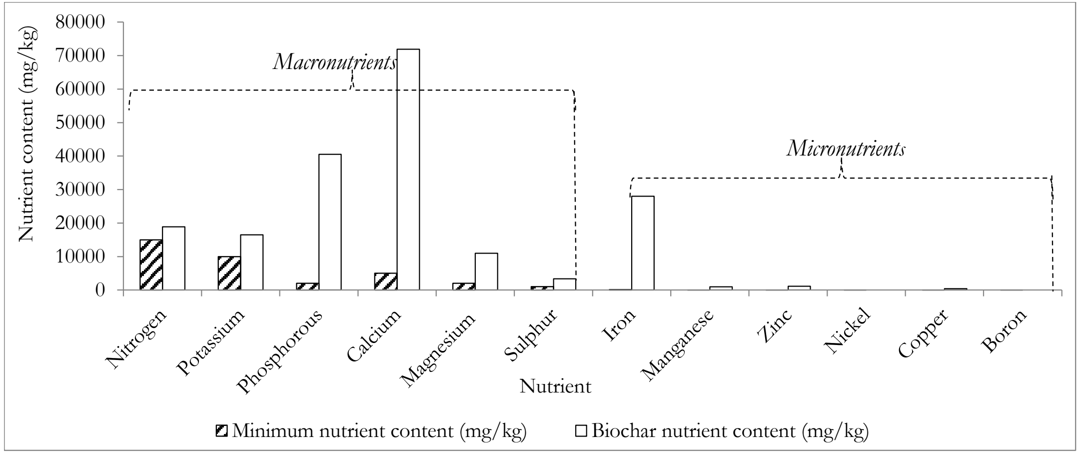


Fig.9: Comparative assessment of nutrient content concentration of generated biochar with the minimum nutrient concentration required for plant growth.

Conclusions

- Possible unfavourable impacts of the digestate on the health of humans and livestock are avoided since the HTL process sterilises the digestate.
- Digestate valorisation will present opportunities for the recovery of valuable product with the production of energy dense biocrude and soil friendly biochar demonstrated.

Some issues may however limit the practical employment of the proposed biorefinery system (Fig. 1):

- Technical risks associated with upscaling the complex biorefinery system proposed investors may limit their participation in such long term strategic projects.
- Also, current energy prices may limit motivation for investing in a biorefinery system.

Thank you

Questions