A feasibility study on Bio-coal with Hydrothermal carbonization by Organic Waste as a Solid Fuel

Hye-Won Park* and Jai-Young Lee[1]

****,1 Department of Environmental Engineering, University of Seoul**, Seoul 02504, South Korea*
(E-mail: hwonpark@uos.ac.kr; leejy@uos.ac.kr)

Introduction

Sewage and Paper sludge

- The quantity of sludge is continuously increasing due to the construction and expansion of sewage facilities every year.
- Difficult to remove its high moisture content, and its necessary to improve mechanical properties for recycling.

Food waste

- High moisture (>80%) and chlorine(Cl) content, so requires an energy-intense drying process to make it suitable for recycling.
- Hydrothermal Carbonization(HTC) technology is special due to its high adaptability to wet biomass like food waste. Based on these, Hydro-char, generally had improved calorific value, homogeneous properties during HTC.

Carbonization problems

- Food waste : High calorific value, but contains a high concentration of chlorine
- Sewage sludge : Low calorific value and high ash content

Research objectives

❖ Mixing food waste, sewage and paper sludge, to produce Bio-coal using Hydrothermal Carbonization(HTC).
❖ Comparative analysis of biocoal properties and evaluate the value as a solid fuel.

Materials

S.S : Sewage sludge
F.W : Food Waste
P.S : Paper sludge
S-F : Mixing Sewage sludge and Food waste
P-F : Mixing Paper sludge and Food waste

Mixing ratio of food waste and sewage or paper sludge

Sample name	Sewage Sludge	Food Waste	Paper Sludge
S.S 100	100	-	-
F.W 100	-	100	-
P.S 100	-	-	100
S-F 7:3	70	30	-
S-F 5:5	50	50	-
S-F 3:7	30	70	-
P-F 7:3	-	30	70
P-F 5:5	-	50	50
P-F 3:7	-	70	30

Experimental methods

▪ Hydrothermal Carbonization(HTC) is a pyrolysis technology to produce hydro-char, under low temperature. Able to use **without** dehydration and drying process.
▪ The reaction conditions in this study were selected as 220°C for 2 hours, specified in Table 2.

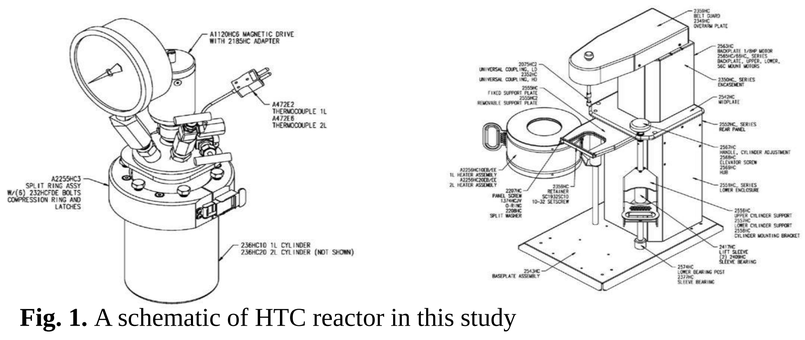

Fig. 1. A schematic of HTC reactor in this study

Results

Proximately analysis

▪ As the proportion of food waste increased, the ash content decreased, also derived the volatile matter and fixed carbon content increased.
▪ The ash content significantly decreased when the ratio of food waste increased.

<Ash content> **S-F 3:7** = 18.39%, **P-S 3:7** = 23.05%
<Volatile content> **S-F 3:7** = 57.17%, **P-S 3:7** = 57.34%
<Fixed carbon content> **S-F 3:7** = 27.44%, **P-S 3:7** = 19.61%

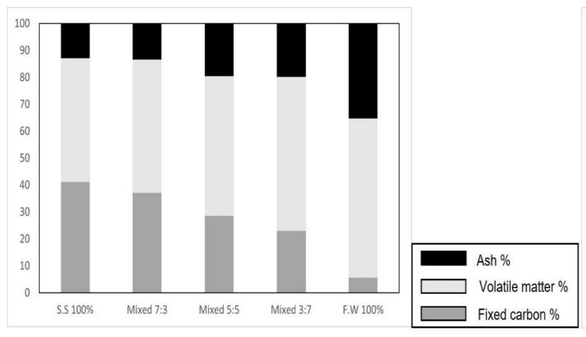

Fig. 2. Results of bio-coal (Sewage sludge and food waste)

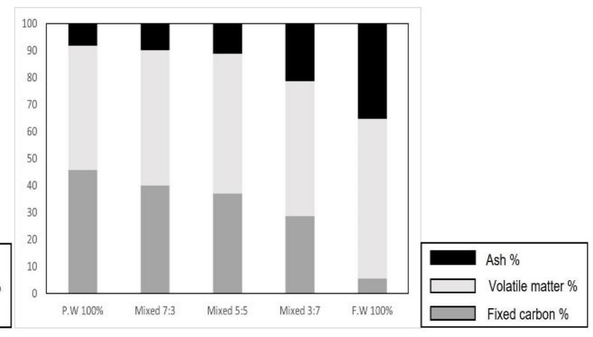

Fig. 3. Results of bio-coal (Paper sludge and food waste)

LHV (Lower Heating Value)

- Bio-coal produced from 100% of food waste exhibited the highest fixed carbon and Lower Heating Value (LHV). As the increased of F.W, the fixed carbon and carbon content of bio-coal increased, as resulting in increase of calorific value.
- S-F bio-coal, all mixing ratios satisfied the Solid Refuse Fuel (SRF) standard in South Korea.
- P-F bio-coal, derived the LHV of 3,000 kcal/kg when mixing ratios below 70% of food waste.

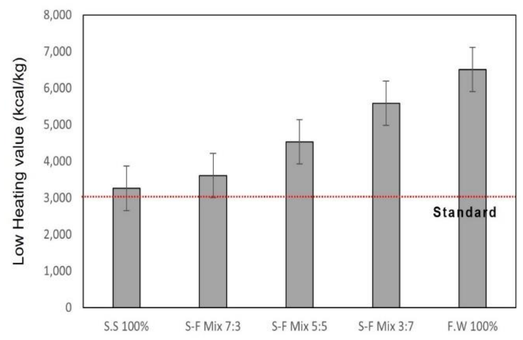

Fig. 4. LHV results of bio-coal (Sewage sludge and food waste)

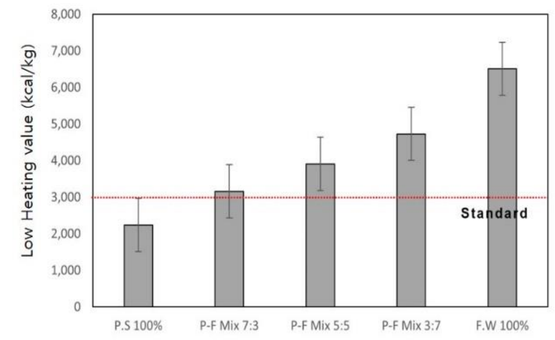

Fig. 5. LHV results of bio-coal (Paper sludge and food waste)

TGA

- **Fig.6.**, showed mixing ratio of F.W increased, the weight loss increased during 180-500°C.
  ~180 °C : Weight reduction due to water content
  180~300 °C : Weight reduction due to volatile content
  300~500 °C : Weight reduction due to fixed carbon
- Food waste increased, ash content ↓, fixed carbon ↑ improve LHV, and combustion characteristic

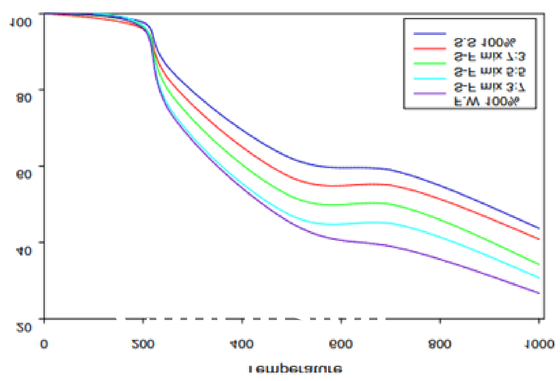

Fig. 6. Results of bio-coal (Sewage sludge and food waste)

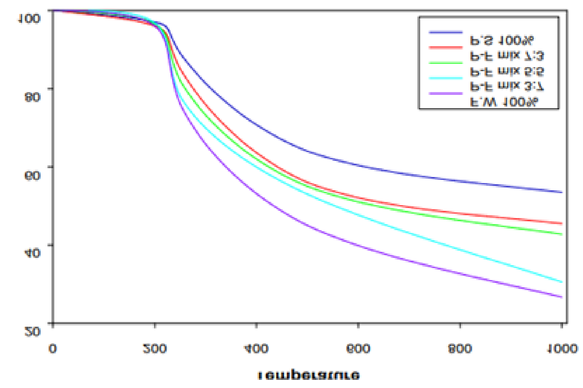

Fig. 7. Results of bio-coal (Paper sludge and food waste)

Conclusion

▪ Mixing food waste with sewage sludge showed an increase in LHV by increasing the fixed carbon, which in turn reduced fuel ratio costs.

▪ In this study, it was confirmed that using *paper sludge* as a solid fuel is *not feasible* due to its very low heating value(LHV) and high fuel ratio. However, the **sewage sludge**, *LHV increased due to an increase in fixed carbon*, and the fuel ratio was derived the low-grade coal.

▪ As the results, the sewage sludge can be alternative material as a solid fuel. So, it was confirmed that Bio-coal can be as an alternative fuel.

Reference

▪ Jin, F., 2014, Application of Hydrothermal Reactions to Biomass Conversion, Green Chemistry and Sustainable Technology.
▪ Joseph, S., 2010, Sustainable Bio-char to Mitigate Global Climate Change, Nature Communication, 1(5), pp.1-9.
▪ Biller Patrick., 2013, Hydrothermal processing of microalgae, University of Leeds
▪ Federal Remediation Technologies Roundtable, Schematic of Technology Screening Matrix
▪ Environment-friendly Rainwater Management LID Technique, Water-permeable Package(Porous Pavement), 2019

This work was supported by the Korea Ministry of Environment as Waste to Energy-Recycling Human Resource Development Project.(YL-WE-22-001)