Physicochemical Properties of Biochar Derived from Anaerobic Digestion Effluent from Cheese Factory Drainage

Yoshiyuki Hirata (email: e14m5711@soka-u.jp) and Shinjiro Sato
Graduate School of Engineering, Soka University, Tokyo, Japan

Objectives

Anaerobic digestion technology is one of efficient waste treatment processes. It can successfully treat the organic wastes from many industries such as municipal sludge, industrial wastewater, agricultural waste. Anaerobic digestion effluent (ADE) which is residue of anaerobic digestion process contains sufficient amounts of plant nutrition such as nitrogen (N), phosphorus (P) and potassium (K). Fertilizer effects of liquid part of ADE have been shown in previous studies. However, usage of solid part of ADE has not been established. Generally, residues obtained from anaerobic digestion are applied as compost to soils directly. But increasing concerns regarding the contamination potential of toxic substances have necessitated alternative methods[1]. Pyrolysis of the solid part of ADE to produce biochar has been proposed as a beneficial product. Therefore, the objective of this study was to investigate the physicochemical properties of biochars derived from ADE from cheese factory drainage.

Materials and Methods

Liquid and Solid parts of Anaerobic Digestion Effluent

The ADE used in this study was separated for liquid and solid parts. The solid part was pyrolysed at 350, 550, and 800ºC (ADE350, ADE550, and ADE800, respectively).

Pyrolysis

Solid parts of ADE were placed in ceramic crucibles, each of them covered with a fitting lid, and pyrolysed under oxygen-limited conditions in an electric muffle furnace to produce biochars[2]. The pyrolysis temperature was raised to 350, 550 or 800ºC at a rate of approximately 25ºC per minute and held for 2 h. The biochars were referred to as ADE350, ADE550, and ADE800. Biochar samples were sieved <2.0 mm and stored in plastic sample bags for analysis[3].

Chemical and Physical Properties of Biochar

Biochars was used for proximate analysis for water content, ash content and volatile matter content. Samples were analyzed for total carbon (TC), total N (TN)[2].

Biochar pH were measured in water solution. In this method, 1 g of biochar was put in 100 cm^3 deionized water and stirred[3].

The fertilizer value of the biochar will be investigated by determining the concentrations of P and K. The amount of P available to plants is determined by citric acid-extractable P concentration. Total P and K will be analyzed according to dry ash method.

Brunauer-Emmet-Teller (BET) surface area of the biochars will be measured by nitrogen gas sorption analysis at 770K using a surface area analyzer. Samples will be pretreated by degassing at 300ºC for 4 h in N gas[4].

Thermogravitmeric analysis

The biochars were used for thermogravimetric analysis by using a TGA analyzer. Samples were placed in alumina crucibles and were pyrolysed with N as a carrier gas at a flow rate of 100 cm^3 per minute. A temperature rate rising up to 950ºC of 10K per minute was used to research a characteristics based on temperature[3].

References

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Results and Discussion

Production Rate of Biochar

Table1. Production rate of biochars derived from ADE

Produced Biochar	Amount of solid (g)	Amount of biochar (g)	Efficiency (%)
ADE BC 350	80.0	36.0	45.0
ADE BC 550	80.0	20.3	27.5
ADE BC 800	80.0	22.0	25.4

- As the pyrolysis temperature increased from 350 to 800ºC, biochar yields decreased from 45.0% to 25.4% for ADE studied. This was due to significant loss of volatile matter in the proximate analysis.

Chemical Properties of Biochar

Table2. Chemical properties of ADE and other feedstock biochars [6]

Produced biochar/ Feedstocks	pH	TC (wt%)	TN (wt%)
ADE BC 350	7.01	25.12	1.51
ADE BC 550	8.55	25.14	2.71
ADE BC 800	9.31	34.28	4.58
Switchgrass 450	9.1	66.54	1.28
Switchgrass 600	10.6	71.52	1.13
Switchgrass 800	11.2	71.62	0.86
Pine wood 450	5.1	71.8	0.23
Pine wood 600	6.5	84.7	0.23
Pine wood 800	10.4	89.7	0.26

ADE: TC Low (wt%), TN High (wt%); Switchgrass: TC High (wt%), TN Low (wt%); Pine wood: TC High (wt%), TN Low (wt%)

Thermogravitric analysis

Table3. Proximate analysis of ADE and other feedstocks biochars [6]

Produced biochar/ Feedstocks	Water content (wt%)	Volatile matter (wt%)	Fixed carbon (wt%)	Ash (wt%)
ADE BC 350	4.6	46.9	13.2	40.2
ADE BC 550	4.7	37.2	15.4	42.8
ADE BC 800	3.6	16.4	15.9	64.0
Switchgrass 450	1.84	26.3	58.4	13.4
Switchgrass 600	0.9	11.2	68.5	19.4
Switchgrass 800	0.5	3.3	74.7	21.5
Pine wood 450	1.8	44.7	52.2	1.4
Pine wood 600	1.0	19.7	77.3	2.1
Pine wood 800	0.6	2.6	91.6	5.2

ADE: Fixed carbon Low (wt%), Ash High (wt%); Switchgrass: Fixed carbon High (wt%), Ash Low (wt%); Pine wood: Fixed carbon High (wt%), Ash Low (wt%)

- The pH of ADE biochars increased from 7.01 to 9.31 with increasing pyrolysis temperature.
- The chemical analysis of ADE biochars showed higher TN contents, while lower TC contents of ADE biochars with increasing pyrolysis temperature.
- Fixed C of ADE biochars are lower, while ash contents of ADE biochars are higher with increasing pyrolysis temperature.

Conclusion

ADE derived from cheese factory drainage were converted to biochars by the pyrolysis process under conditions of 350, 600, and 800ºC.

ADE Biochars were recognized to provide insight with respect to how they may behave as a soil amendment and organic fertilizer in soil.

ADE biochars containing higher ash content and plant nutrients, especially N, can play a role as a liming agent and organic fertilizer in soil.