Converting Agricultural Wastes to Biochar: From Good Agricultural Waste Management Practice to High-Potential Use of Biochar as Heterogeneous Catalyst

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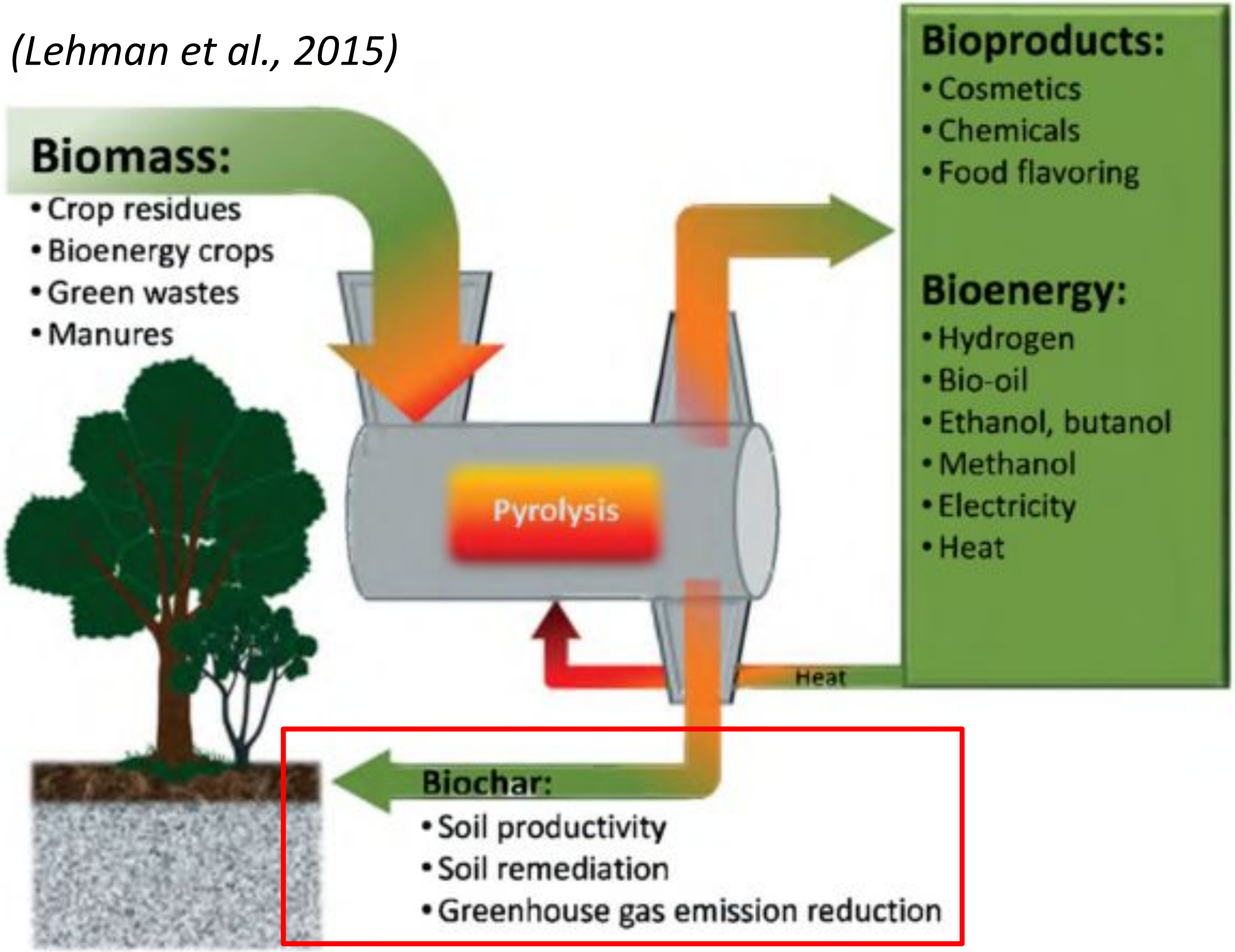
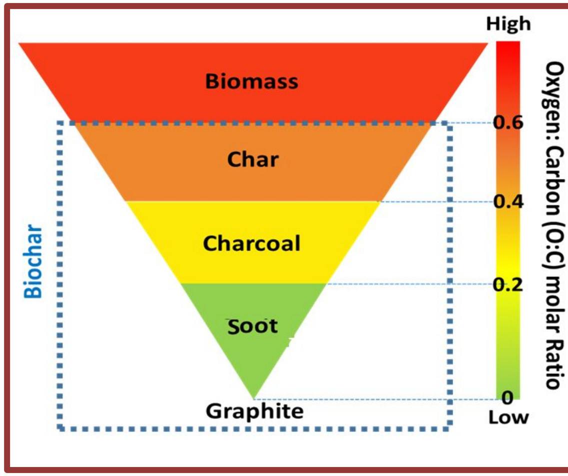
OUTLINE

- Introduction
- Material & Method
- Results and Discussions
- Conclusions

Biochars – Generation and Applications

(Lehman et al., 2015)





Biochar criteria:
$H/C_{org} < 0.7$ (EBC and IBI)
$O/C < 0.4$

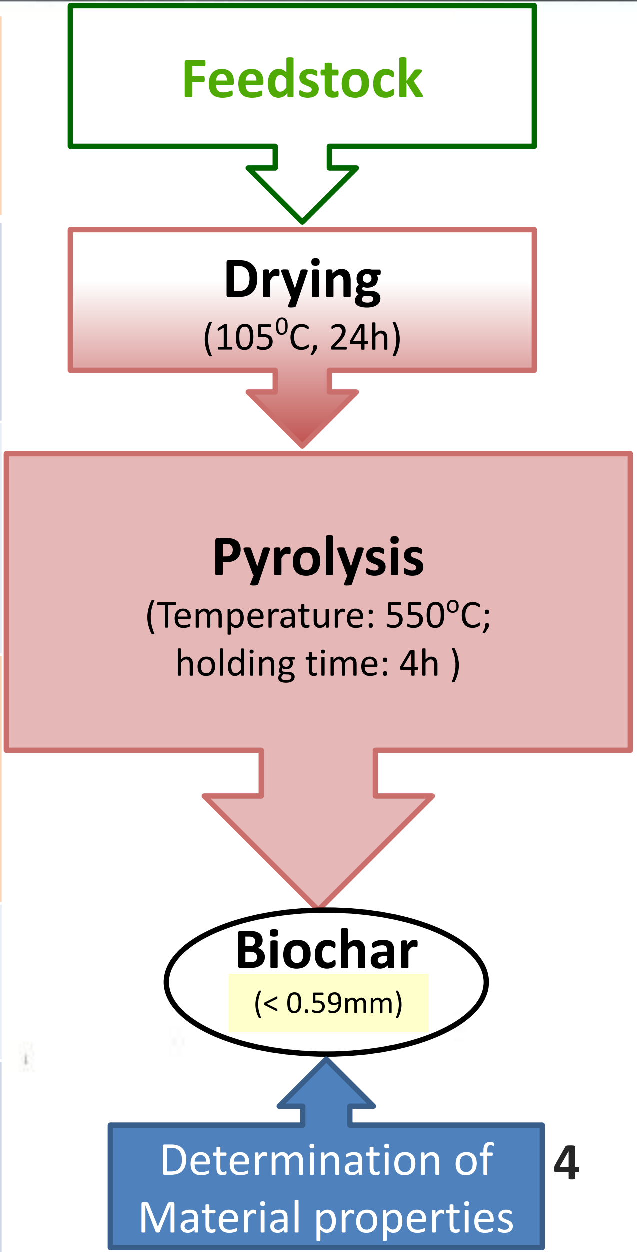
Objective:

- *Recycle agricultural waste by converting to biochar*
- *Determine surface acidity of biochar as an important factor of catalyst*

MATERIALS & METHODS

Biochar Preparation

Wood biochar (Wood)	Coconut fiber biochar (Coconut)	Rice husk biochar (Rice husk)	Pinecone biochar (Pinecone)	Sugar bagasse biochar (Bagasse)
Corncob biochar (Corncob)	Bamboo biochar (Bamboo)	Water caltrop shell biochar (Water caltrop)	Long-an shell biochar (Longan)	White popinac biochar (White popinac)



Results and Discussions

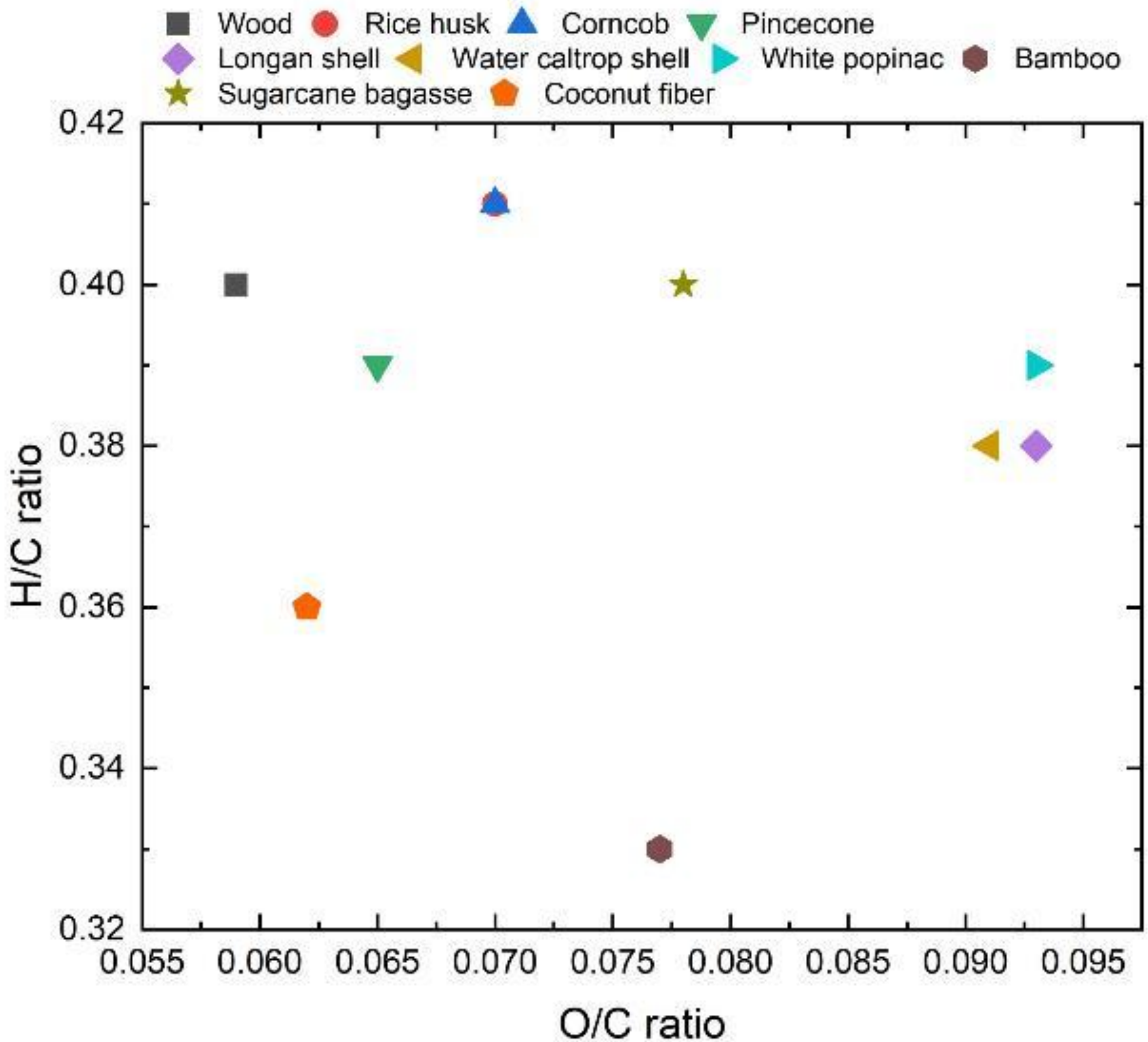
Characteristics of Biochars

- O/C < 0.4 and H/C<0.6
- Biochar mass yield: from 26.66 ± 4.21 to 37.35 ± 1.90 %
- S_{BET}: 142 – 371 m^2/g
- Pore size: 19.1 – 23.6 nm
- Pore volume: 0.070 – 0.163 $cm^3.g^{-1}$
- High content of phosphorus, alkali and alkaline earth metal content

 Good for soil amendment

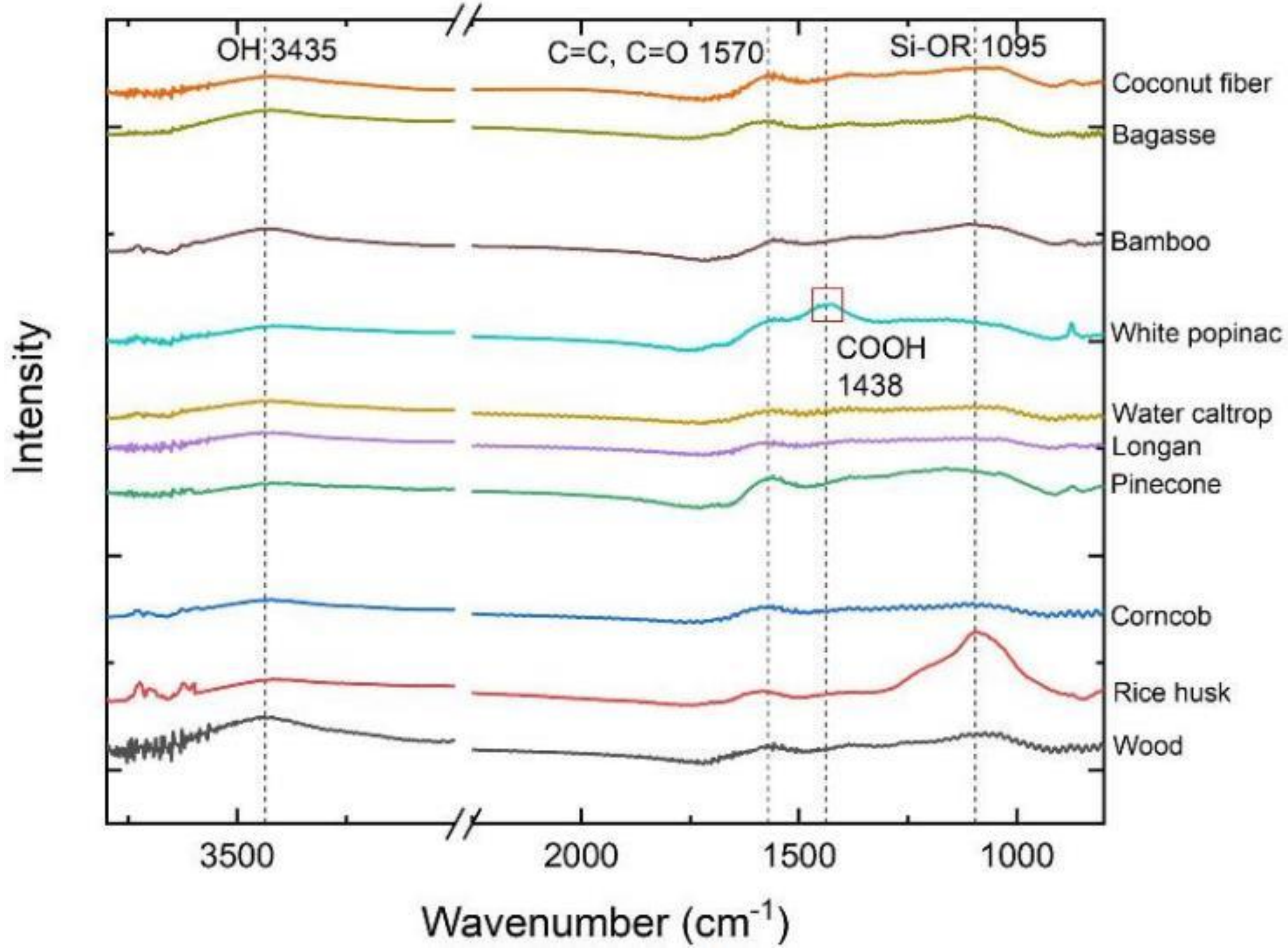
- The higher heating value (HHV): 18.14 – 31.63 $MJ.kg^{-1}$

 high energy potential



Characteristics of Biochars

FTIR spectra of the functional groups on biochars at 550^{o}C



Characteristics of Biochars

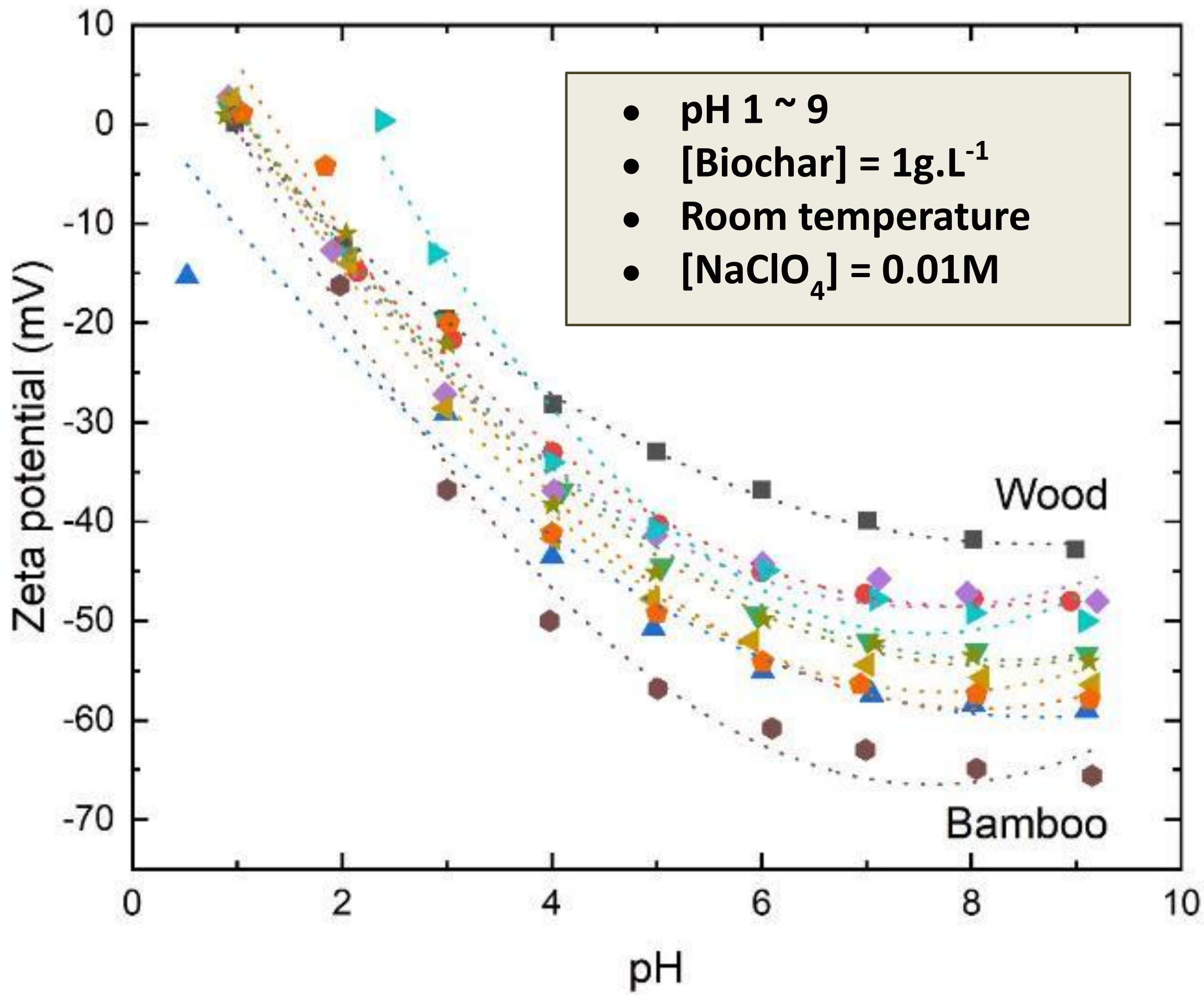
- XRD patterns:
  - The peaks at $2\theta = 20^\circ – 30^\circ$ refer to the stacking structure of aromatic layers (graphite 002)
  - Sharp, non-labeled peaks in bio-char indicate miscellaneous inorganic components. (the high content of SiO_2, CaO, and MgO)
- TGA results:
  - Volatile matters: 15.11% - 25.34%
  - Fixed carbon: 45.11% - 76.58%

Characteristics of Biochars

- Based on Gouy – Chapman theory of electrical double layer:

Zeta potential
↓
Surface potential
↓
Surface charge

- Negative zeta potential in a wide range of pH negative surface charge



Surface acidity

- An important factor of catalysts
- Including: acid strength, density, and the nature (Bronsted or Lewis type)
- Biochar is submersed in aqueous medium:

$$\underline{S}OH_2^+ \rightleftharpoons \underline{S}OH + H^+, K_{a_1}^{int} \qquad (1)$$

$$\underline{S}OH \rightleftharpoons \underline{S}O^- + H^+, K_{a_2}^{int} \qquad (2)$$

The total surface Bronsted site, S_T, is the sum of positive, neutral, and negative charge species:

$$S_T = \{\underline{S}OH_2^+\} + \{\underline{S}OH\} + \{\underline{S}O^-\} \qquad (3)$$

Surface acidity

Biochar	pKa_2^{int}	pH_{zpc}	pKa_1^{int}	S_T, $C.m^{-2}$
Wood	2.71	0.91	- 0.89	4.81×10^{-2}
Rice husk	3.01	1.01	- 0.99	7.06×10^{-2}
Corncob	2.21	0.98	- 0.25	1.25×10^{-1}
Pinecone	2.75	1.05	- 0.65	9.38×10^{-2}
Longan shell	2.13	0.92	- 0.29	6.64×10^{-2}
Water caltrop shell	2.24	1.01	- 0.22	1.07×10^{-1}
White popinac	2.83	1.64	0.45	7.61×10^{-2}
Bamboo	1.84	0.91	- 0.02	1.70×10^{-1}
Sugarcane bagasse	2.52	1.02	- 0.48	9.55×10^{-2}
Coconut fiber	2.54	1.24	- 0.06	1.02×10^{-1}

Conclusions

- Agricultural waste mass reduction ~ 60%: good for waste management
- Biochar:
  - Good for soil amendment
  - Negative surface charge: cation adsorption dominant
  - Promising heterogeneous catalyst or catalyst precursor substance

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Thank you for your attention

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