Enhanced Adsorption Capacity of Biochars Derived from Water Hyacinth for Ammonium-nitrogen by Different Pre- and Post-treatments

Yudai Kohira*, Shinjiro Sato**
*Graduate school of engineering, Soka University, Tokyo, Japan, E-mail: e21m5809@soka-u.jp
**Corresponding author. Tel: +81 42 691 9490, E-mail: ssato@soka.ac.jp

We support the Sustainable Development Goals

WLC18- 0037

Introduction

- Lake Tana, the largest lake in Ethiopia, has been invaded since 2011 by a notorious invasive water hyacinth (*Eichhornia crassipes*)[1].
- In efforts to utilize this hyacinth, we propose to harvest it, then carbonize it (pyrolysis) to make biochar with high adsorption capacity.
- Biochar has shown good adsorption capacity for ammonium-nitrogen (NH_4^+-N), which can be improved by pre-treatment of hyacinth (feedstock)[2] or post-treatment of biochar[3].

Objective

To increase NH_4^+-N adsorption capacity of water hyacinth biochars by pre- and post-treatments.

Materials

Water Hyacinth

Untreated biochar (BC)
- **Feedstock**: water hyacinth (WH)
- **Temperature**: 350°C
- **Retention time**: 2 h
- Washed with DIW
- Sieved < 500 μm

KOH pre-treated biochar (KBC)
- WH was stirred into 0.5 M KOH for 6 h at 25°C

H_2O_2 post-treated biochar (HBC)
- BC was stirred into 30% H_2O_2 for 12 h at 25°C
- The biochar pH was adjusted to 12 by adding 0.1 M NaOH

Table.1 Basic properties of biochar

Biochar	pH	pHpzc	EC ($\mu S\ cm^{-1}$)	CEC ($cmol^+\ kg^{-1}$)
BC	6.4	6.5	824	**77**
KBC	10.1	9.4	9.27	**107**
HBC	3.4 (➔ 12)	9.2	897	**76**

Methodology

Adsorption kinetics

- **Biochar dosage**: 50 mg
- **NH_4^+-N solution**: 25 ml
- **Experimental conditions**: 25°C
- **Contact time**: 15-1440 min (8 series)
- **Initial pH:** 7.0 ± 0.05
- **NH_4^+-N concentration**: 20 mg L^{-1}

Effect of different pH

- **Contact time**: 240 min
- **Initial pH**: 2, 4, 6, 8 (± 0.05)
- **NH_4^+-N concentration**: 20 mg L^{-1}

Adsorption isotherm

- **Contact time**: 240 min
- **Initial pH**: 4 ± 0.05
- **NH_4^+-N concentration**: 10-1000 mg L^{-1}

Results

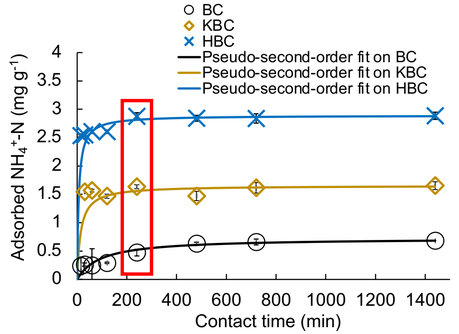

Fig.1 Adsorption kinetics of biochars

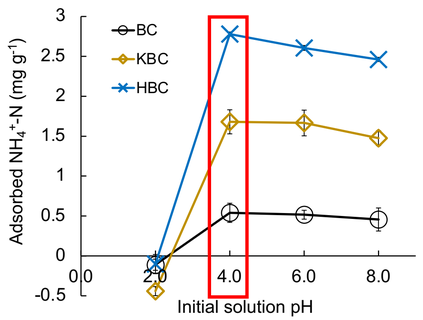

Fig.2 Effect of solution pH on adsorption capacity

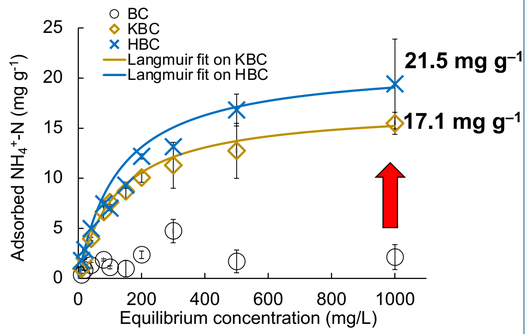

Fig.3 Adsorption isotherm of biochars

- The equilibrium adsorption was achieved at **240 min**.
- Pseudo-second-order model indicates the **chemical adsorption mechanism**.

- The equilibrium adsorption was achieved at **pH 4.0**.
- This is mainly due to **electrostatic interaction**[4] and **cation exchange**.

- The langmuir maximum adsorption amount was **21.5 mg g^{-1}** by HBC.
- Langmuir model indicates **mono-layer adsorption mechanism**.

Conclusions

- There was a significant increase in adsorption by the modified biochars compared to untreated.
- **Main mechanism is chemical adsorption**
  - Mostly cation exchange
  - Some electrostatic interaction

Acknowledgments

Special thanks to the Laboratory of Restoration Ecology and the lab of Environmental Chemical Engineering lab at Soka University for providing experimental equipment.

References

[1]Wondie et al., 2012. *Biological Society of Ethiopia*.
[2]Wang et al., 2015. *Chemosphere*. **138**, 120-126.
[3]Hsu et al., 2019. *Applied Science*. **9**, 5249.
[4]Huff and Lee, 2016. *Journal of Environmental Management*. **165**, 17-21.