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Dataset for natural organic matter treatment by tailored biochars

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The dataset presented here are collected for tailoring biochars from pinecone biomass through chemical modification for the adsorption of natural organic matter (NOM) from lake water. The data includes schematics, figures and tables. The characterization of biomass and tailored biochars by Brunauer, Emmett and Teller surface area measurement (BET), thermogravimetric analysis (TGA), energy dispersive X-ray (EDX) along with the adsorption of NOM from lake water by the tailored biochars and the desorption using alkaline solution are provided. This is complimentary dataset for the experimental set-up and data gathered related to the article [1] on biochar fabrication and lake water treatment. See this article [1] for further information and discussion.

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1. Data

Two methods illustrated in Fig. 1 were used to tailor four types of biochars, see for the complete fabrication process in Ref. [1]. The absorbance data measured for lake water samples was converted to concentration data using the CODMn calibration curve, depicted in Fig. 2. Thermogravimetric analysis of the pinecone biomass measured by TGA is displayed in Fig. 3a. Nitrogen adsorption-desorption isotherms for pinecone biomass and pristine biochar are given in Fig. 3b. Fig. 3c shows the EDX analysis of the tailored biochar (TB-N-I) [1]. Fig. 4a illustrates the optimized adsorbent dose for NOM adsorption from lake water by the tailored biochars. The shift of pH for the batch solutions before and after adsorption with optimized adsorbent under 24 h contact time and room temperature is given in Fig. 4b. The desorption data using alkaline solutions and re-adsorption kinetics of NOM from lake water by tailored biochar (TB-N-I) [1] are given in Fig. 5a and b, respectively.

2. Experimental design, materials and methods

Lake water samples were collected from Lake Pitkäjärvi in Espoo, Finland. The concentration of NOM was calculated via UV absorbance measurement on a UV-1201 Shimadzu spectrophotometer (254 nm wavelength). Table 1 compiles the kinetic and isotherm models used for modeling kinetics and isotherm of NOM adsorption, see for more discussion in Ref. [1]. The materials were characterized by Brunauer, Emmett and Teller surface area measurement (BET) (Tristar II-Micromeritics USA), thermogravimetric analysis (TGA) (TA instruments – TGA Q500 USA), energy dispersive X-ray (EDX) (JEOL JSM-7500FA analytical field emission scanning electron microscope), adsorption and desorption batch experiments, spectrophotometer (UV-1201 Shimadzu).

Value of the data

- This dataset is complimentary for experimental design and data gathered for the article [1] on biochar fabrication and lake water treatment
- It provides the steps involved in tailoring biochar from biomass
- BET and TGA and EDX data for characterizing the tailored biochars and biomass
- NOM desorption data from the spent biochar using alkaline solutions and NOM reabsorption data by the regenerated biochar from the lake water
- Further illustrations for the readers of this article [1].
Fig. 1. Schematic illustration of steps involved in tailoring mesoporous biochars from pinecone biomass for NOM adsorption from lake water.

Fig. 2. Lake water calibration curve.

\[ y = 0.3059x + 0.0438 \]

\[ R^2 = 0.9993 \]
adsorbent dose was optimized within the range 0.1–1 g/L. The shift of pH was observed by adjusting the solution pH at values 2, 4, 8, and 10 using HCl and NaOH. The solution pH was re-measured after adsorption. After the desired contact time, the solutions were filtrated through Sartorius Minisart 0.45 μm filters for the CODMn concentration measurement. The desorption data were determined with three desorption solutions, deionized water, 3 mM NaOH, and 30 mM NaOH at several time intervals from below 1 min to 24 h.

Fig. 3. a) Thermogravimetric analysis of the pinecone biomass. b) Nitrogen adsorption-desorption isotherms for raw materials (biomass and pristine biochar). c) EDX analysis of TB-N-I (note that the negligible amount of silicon in EDX data was due to its migration from quartz tube during the fabrication).

Fig. 4. a) Optimized adsorbent dose for NOM adsorption from lake water by the tailored biochars. b) The shift of pH for the batch solutions before and after adsorption (Experimental condition: optimized adsorbent dose; 24 h contact time; room temperature; lake water).
Acknowledgements

We thank Aino Peltola for her help with NOM measurements at analytical water laboratory, Aalto University. The first author would like to acknowledge the financial support from Doctoral School of Aalto University and Foundation for Aalto University Science and Technology.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References


Table 1

Kinetic and isotherm models used for studying kinetics and isotherm of NOM adsorption.

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<td></td>
<td>$q_t = q_e(1 - e^{-k_1 t})$</td>
<td>$q_t = \frac{k_2 q_e^2 t}{1 + k_2 q_e t}$</td>
<td>$q_t = k_{id} t^{1/2} + C$</td>
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<tr>
<td></td>
<td>$q_e = K_F C^{1/n}_e$</td>
<td>$q_e = \frac{q_L K_L C_e}{1 + K_L C_e}$</td>
<td>$q_e = \frac{q_S K_S C_e^{n_S}}{1 + K_S C_e^{n_S}}$</td>
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Determination coefficient

$$R^2 = \frac{\sum_{i=1}^{n}(q_e - \bar{q}_e)^2}{\sum_{i=1}^{n}(q_e - \bar{q}_e)^2 + \sum_{i=1}^{n}(q_e + \bar{q})}$$

$$\Delta q = \sqrt{\frac{\sum (q_e - q_c)^2}{n - 1}}$$

$q_e$: adsorbate uptake (mg/g) at time t (min), $q_c$: the uptake of adsorbate at equilibrium, $k_1$: rate constant of pseudo-first order, $k_2$: rate constant of pseudo-second order, $k_{id}$: intra-particle diffusion rate constant (mg/min$^{1/2}$/g), C: intercept, n: adsorption intensity $K_F$: empirical constant of Freundlich ($[\text{mg/g}] / ([\text{mg/L}]^{1/n})$, $q_L$: maximum monolayer adsorption capacity, $K_L$: equilibrium constant related to adsorption rate (L/mg), $q_S$: Sips maximum adsorption capacity (mg/g), $K_S$: Sips equilibrium constant ([L/mg]$^{n_S}$), and $n_S$: Sips model exponent, $q_e$: calculated equilibrium uptake, and $q_c$: experimental equilibrium uptake (mg/g).