Environmental Remediation of Antibiotics and Herbicides Using Hydrothermally Derived Artificial Humic Substances

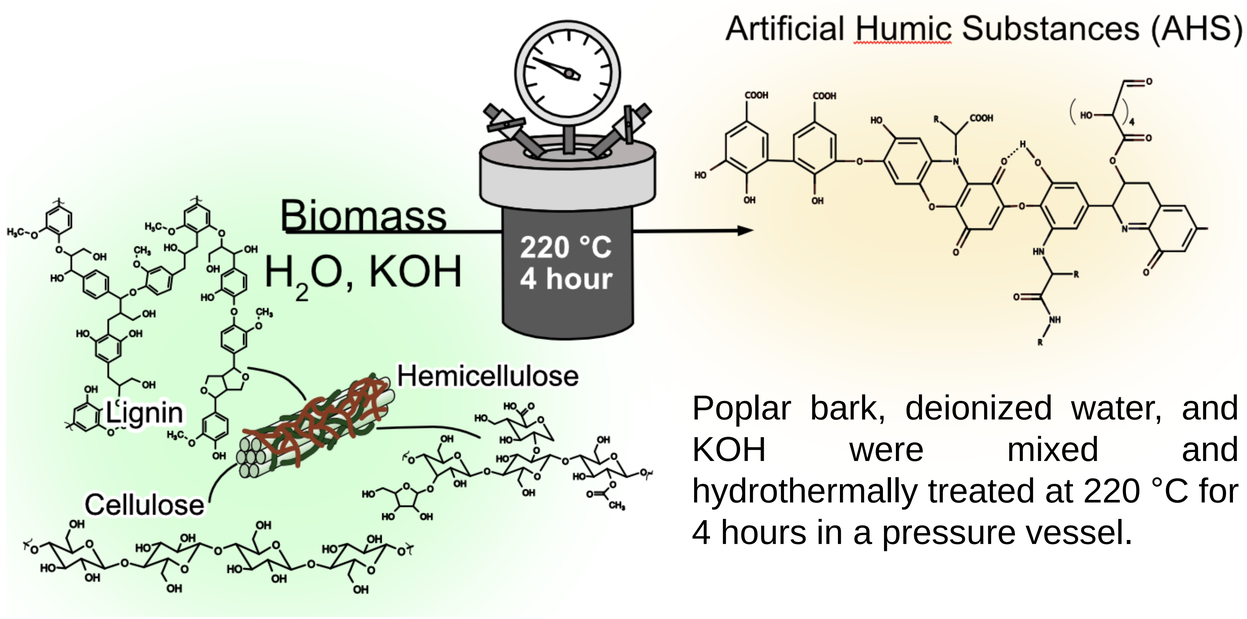
Khatereh Pakzad, Alexander Volikov, Markus Antonietti

Max-Planck Institute of Colloids and Interfaces, Potsdam Science Park, Am Mühlenberg 1, Potsdam 14476, Germany

Introduction

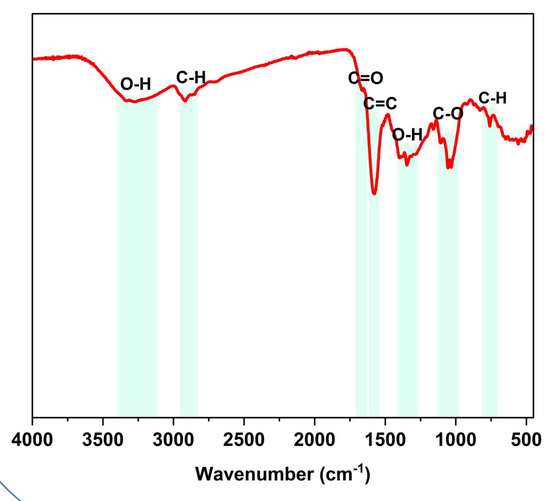
Humic substances (HS), known as “black gold,” are key components of soil organic matter formed naturally over long periods. This research explores the rapid, eco-friendly production of artificial humic substances (AHS) from biomass via hydrothermal humification [1], aiming to optimize synthesis, study their structure, and assess applications in pollutant removal [2, 3].

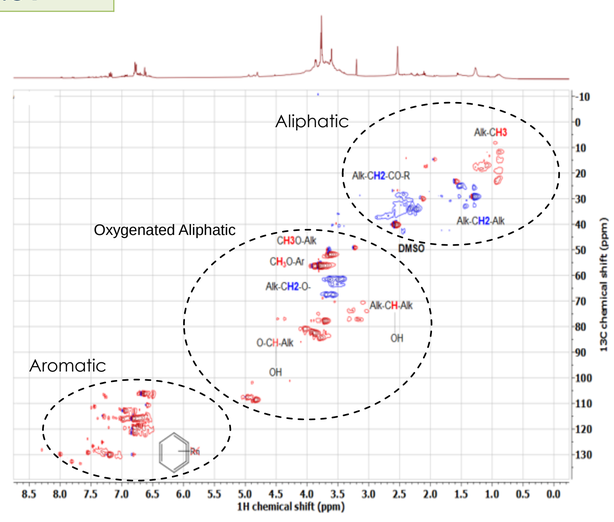
Synthesis of AHS from Poplar Bark under Hydrothermal Process



Poplar bark, deionized water, and KOH were mixed and hydrothermally treated at 220 °C for 4 hours in a pressure vessel.

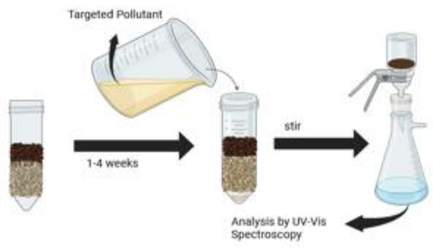
Sample	Surface Area (m^2/g)	Pore Width (nm)	Pore Volume (cm^3/g)
AHS	5.12	20.65	0.01

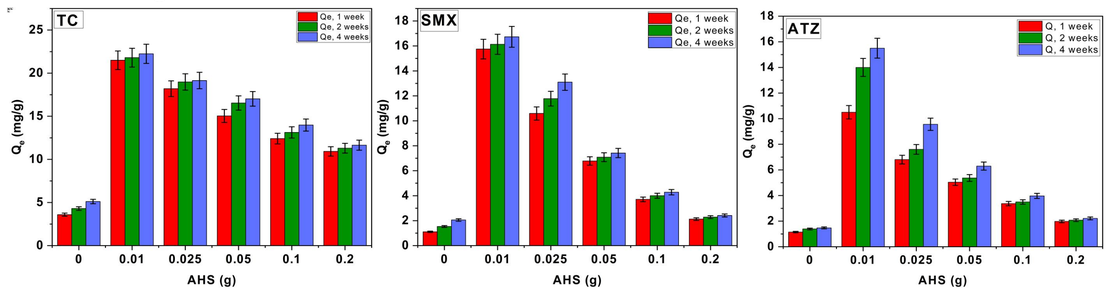




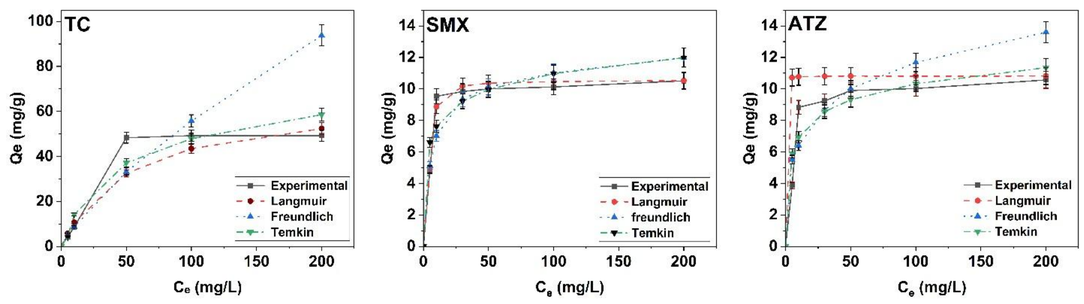
Soil Batch Adsorption of Contaminants

Soil batch experiments evaluated tetracycline (TC), sulfamethoxazole (SMX), and atrazine (ATZ) adsorption in AHS-amended sandy soil after 1–4 weeks of incubation. Pollutants concentrations were determined by UV–Vis spectroscopy following filtration.





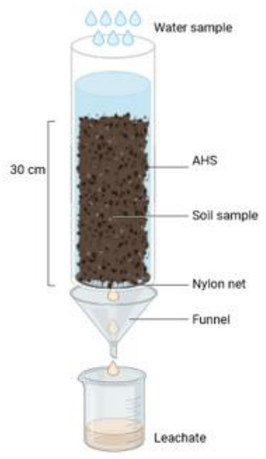
✓ AHS-modified soils enhanced time-dependent removal of TC, SMX, and ATZ, achieving more than 95% removal for TC and SMX and 88.5% for ATZ after 4 weeks.

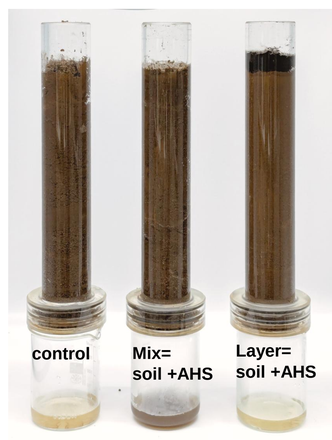


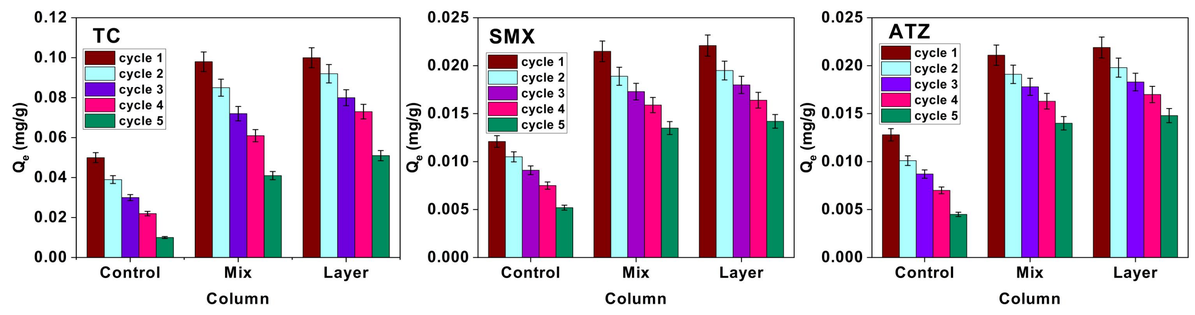
✓The Langmuir model provided the best fit ($R^2 \geq 0.985$), suggesting monolayer adsorption of TC, SMX, and ATZ onto AHS.

Leaching Experiments of Contaminant Adsorption

Column experiments (30 cm × 5 cm PMMA; 300 g soil + 22 g AHS) with mixed and layered setups showed pollutant breakthrough of TC (50 mg/L), SMX (10 mg/L), and ATZ (10 mg/L) over five cycles, quantified by UV–Vis in triplicate runs with controls.







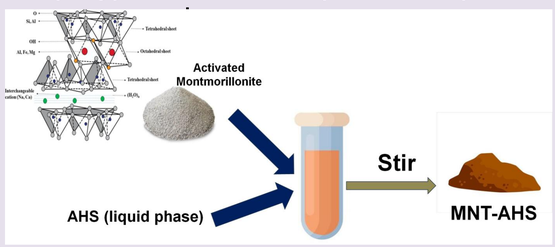
✓Layered AHS columns showed stable pollutant removal over five cycles, with TC (0.10–0.05), SMX (0.022–0.014), and ATZ (0.022–0.015) outperforming mixed and control systems.

Conclusions

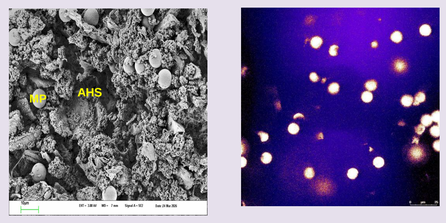
Hydrothermal humification of poplar bark produced AHS rich in functional groups with strong adsorption toward TC, SMX, and ATZ. The Langmuir model best described the isotherm behavior, indicating monolayer adsorption with high capacity, especially for TC. In soil systems, AHS maintained >95% immobilization of TC and SMX after aging, particularly in layered configurations, demonstrating stable long-term sequestration

Ongoing Projects

- Preparation of Montmorillonite (clay)-AHS (MNT-AHS)



- Removal of microplastics (MP) from the environment using AHS



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Reference

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contact

Email: Khatereh.Pakzad@mpikg.mpg.de

LinkedIn: