Removal of Sulfamethoxazole and Sulfapyridine Antibiotics by Engineered Biochar Derived from Agricultural Waste and Its Application in Stormwater and Wastewater Treatment

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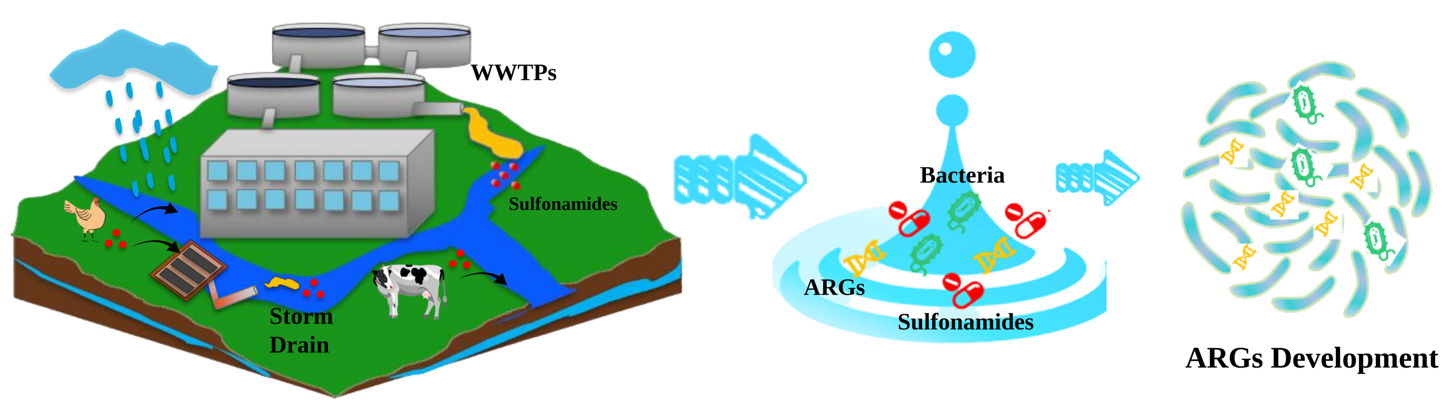
1 Background

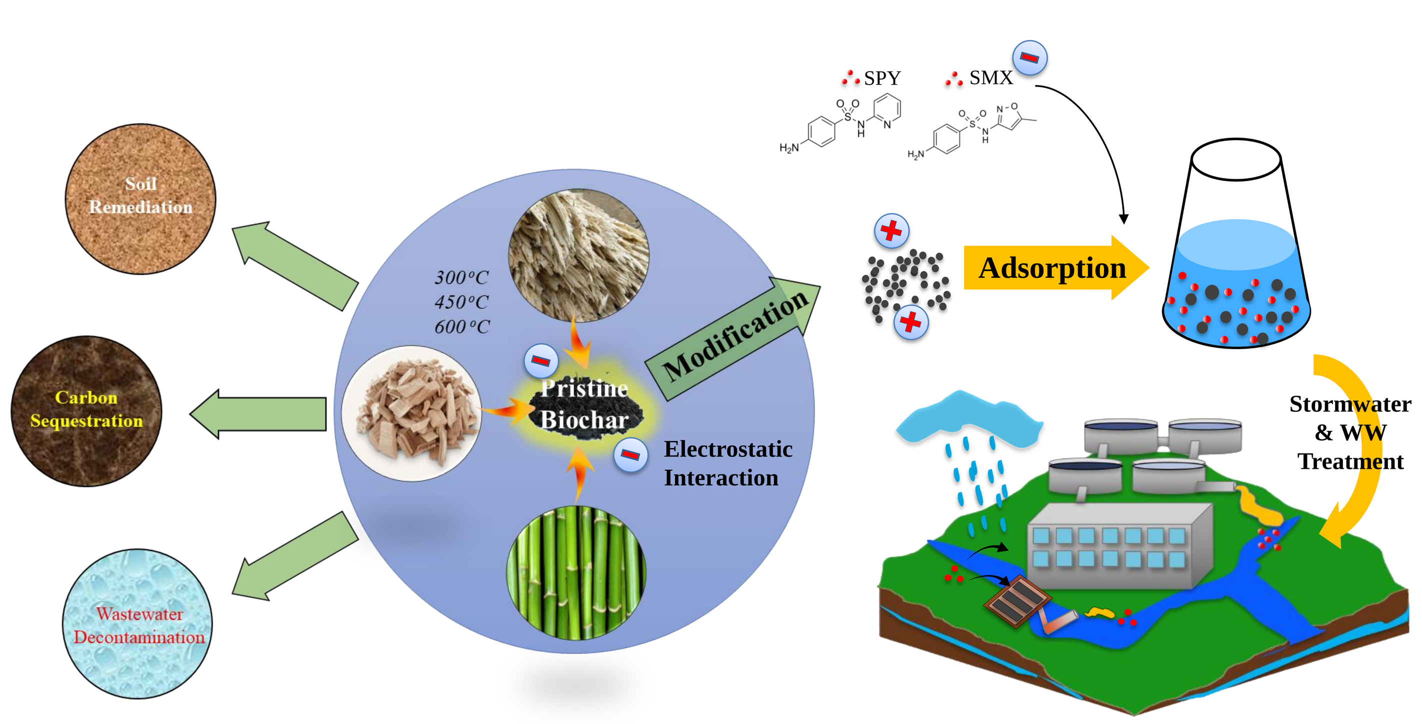
- Sulfonamide antibiotics that are widely added to animal feed for disease treatment. They may release into the environment through wastewater and animal excretion due to low metabolization.
- They are further dispersed to local water bodies through stormwater runoff due to high mobility and low biodegradation rate, leading to unprecedented health risks such as carcinogen risk and skin allergic reactions.
- If disposed of improperly, bacterial communities may undergo selection pressures, leading to antibiotic resistance genes (ARGs) development.



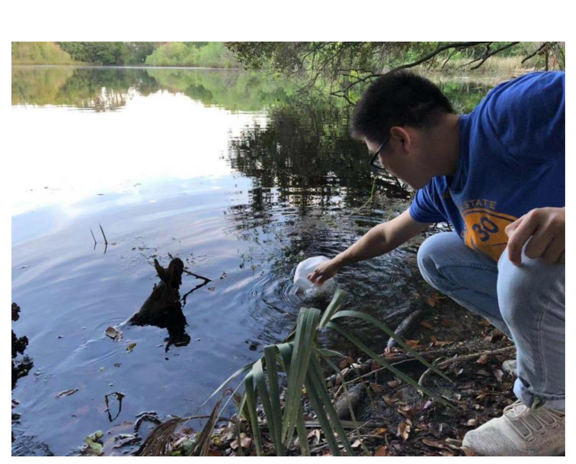
- The UF campus has more than 400 storm drains. About **77%** of these drains eventually direct stormwater to Lake Alice. Meanwhile, Lake Alice also receives wastewater effluent directly from UF wastewater treatment plants (WWTPs).

2 Objectives

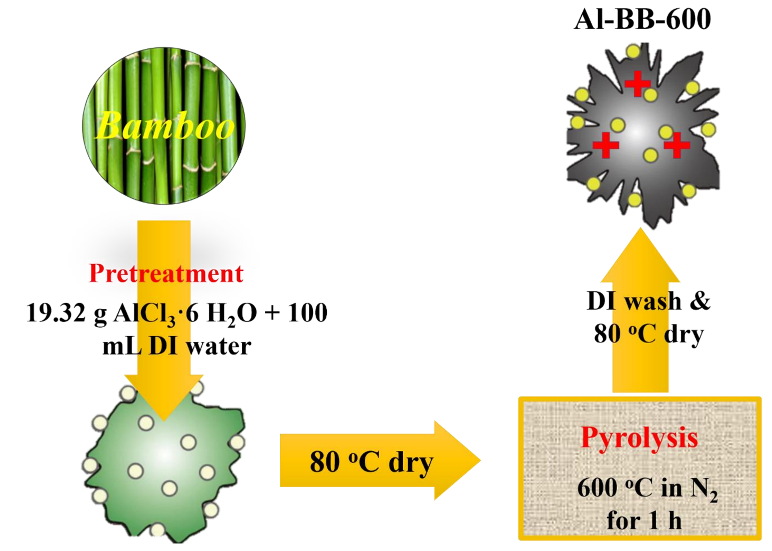
- Prepare engineered biochar derived from agricultural waste (e.g., bamboo and bagasse) and conduct characterization analyses such as SEM, XRD, and FTIR
- Collect wastewater samples from the UF WWTPs and stormwater samples from Lake Alice, and measure related parameters such as pH, total organic carbon, and other ions' concentration
- Determine the removal efficiency of sulfonamides antibiotics in stormwater and wastewater samples on engineered biochar by batch sorption and column filtration



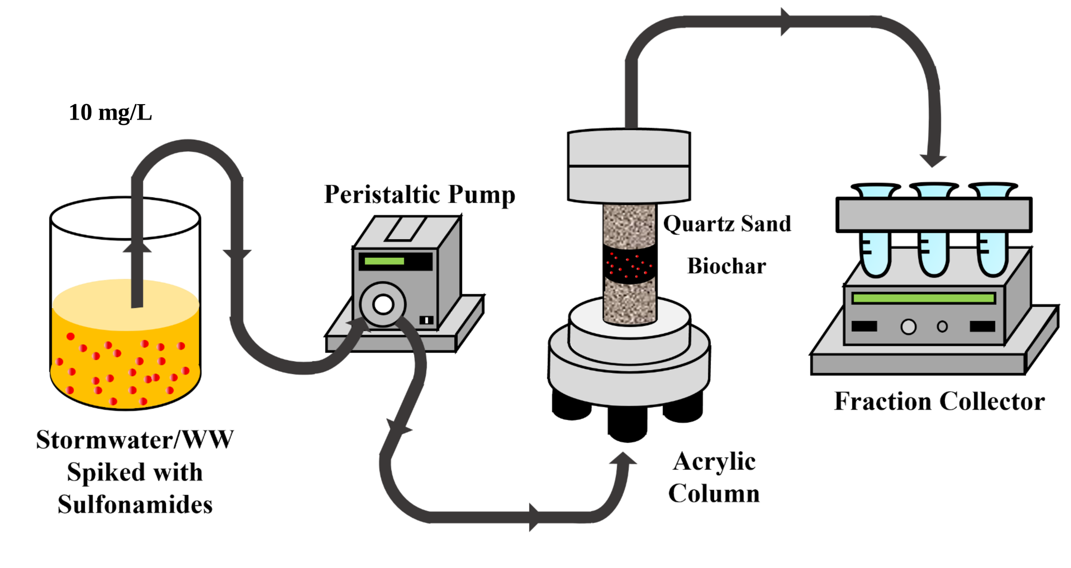

Wastewater sample collection from UF WWTPs


Stormwater sample collection from Lake Alice

3 Methodology

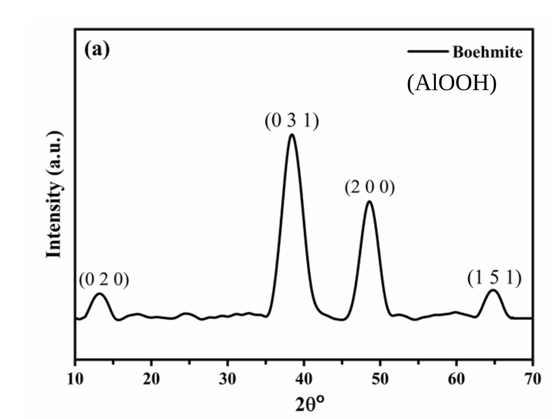


Preparation of engineered biochar (Al-BB-600)

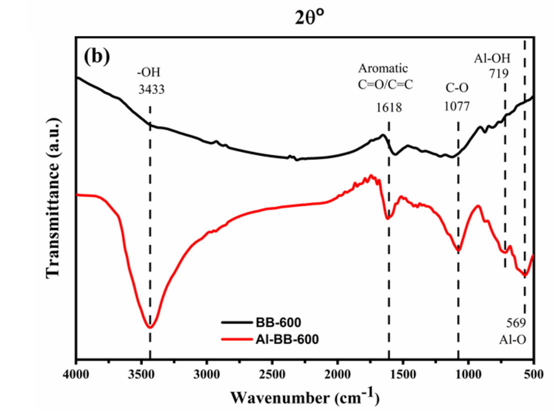


Schematic diagram of column filtration systems

4 Preliminary Results



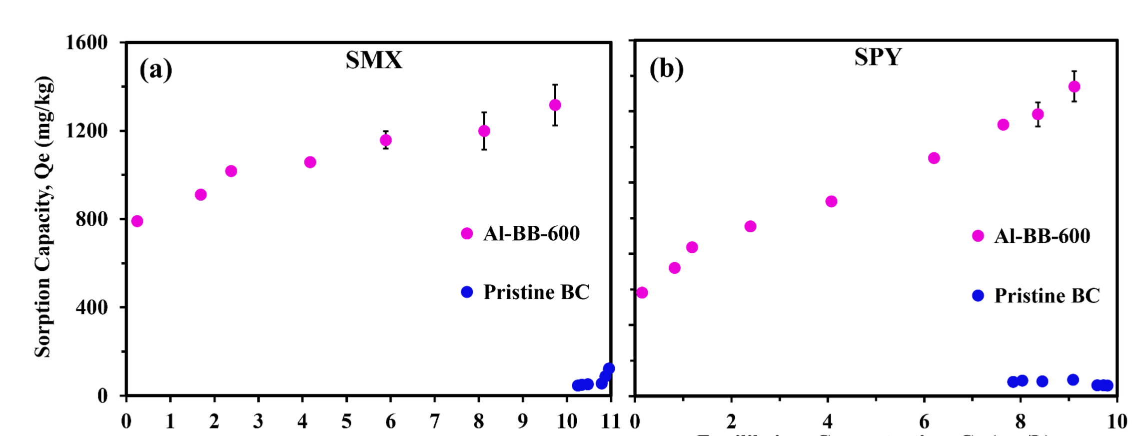
XRD spectra of Al-BB-600



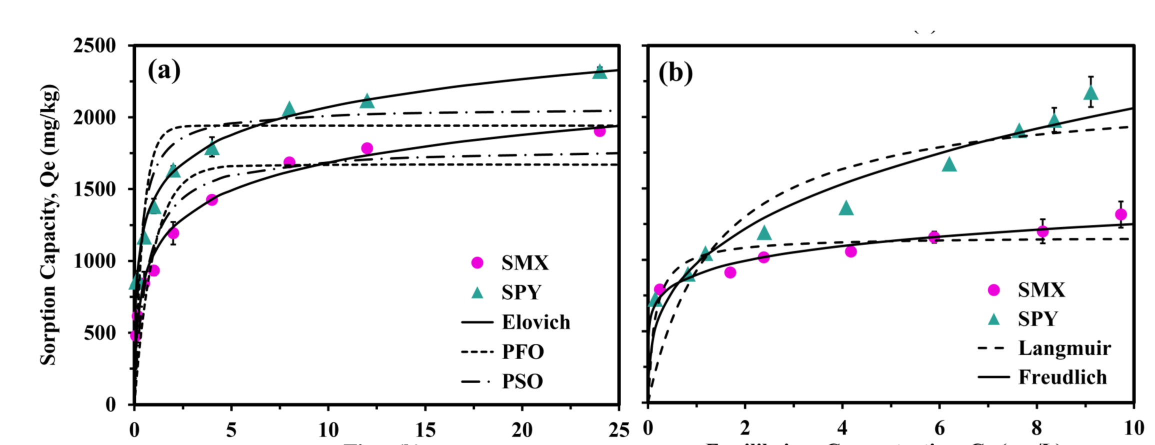
FITR spectra of pristine biochar (BB-600) and Al-modified biochar (Al-BB-600)

Parameters	Range	Mean
TOC	4.08–9.40 mg/L	7.11 ± 1.46 mg/L
Na^+	54.18–76.99 mg/L	61.55 ± 5.00 mg/L
K^+	11.94–35.82 mg/L	24.53 ± 9.54 mg/L
Ca^{2+}	44.23–53.26 mg/L	47.81 ± 2.61 mg/L
Mg^{2+}	28.35–44.92 mg/L	31.37 ± 4.21 mg/L
NH_4^+-N	0.04–0.81 mg/L	0.22 ± 0.29 mg/L
NO_3^--N	0.35–2.68 mg/L	1.35 ± 1.02 mg/L
Cl^-	84.97–120.93 mg/L	103.41 ± 14.70 mg/L
Total P	0.90–6.40 mg/L	2.68 ± 1.60 mg/L
pH	7.14–8.16	7.61 ± 0.34

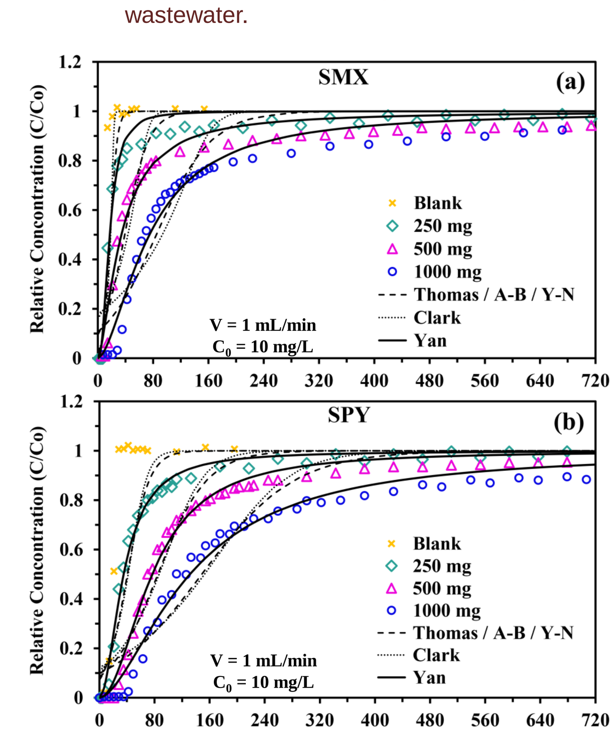
Major components in the secondary treated wastewater



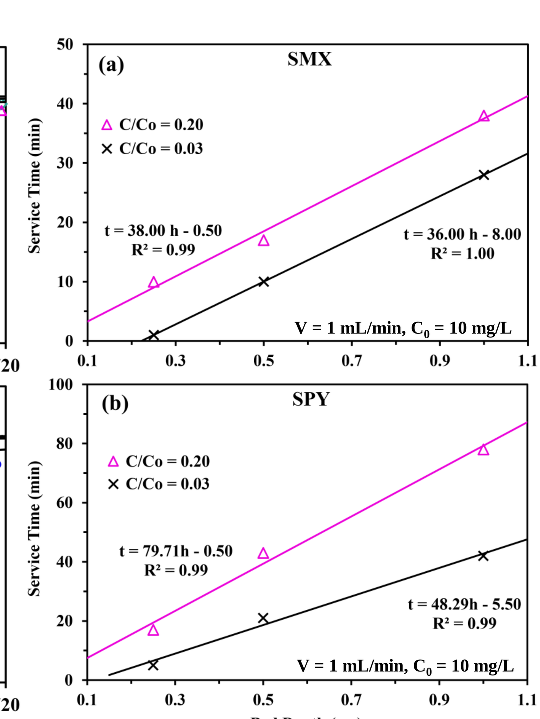
Adsorption isotherms of (a) SMX and (b) SPY onto pristine biochar and Al-BB-600 in wastewater.



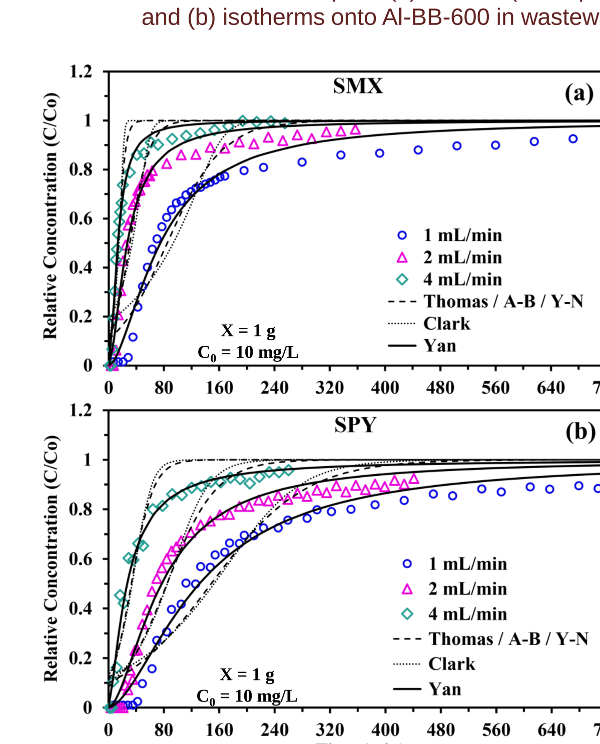
SMX and SPY sorption (a) kinetics (PFO: pseudo-first-order; PSO: pseudo-second-order), and (b) isotherms onto Al-BB-600 in wastewater.



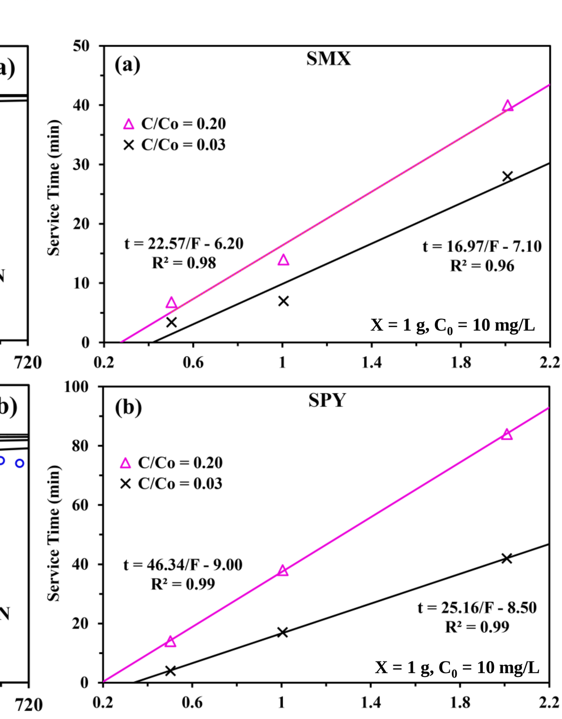
BT performance of (a) SMX, and (b) SPY at different dosages. The dashed line is the simulations of Thomas, Adams-Bohart (A-B) and Yoon-Nelson (Y-N) models (same results).



BDST model plots relating the bed depth (h) and service time (t) for (a) SMX, and (b) SPY.



BT performance of (a) SMX, and (b) SPY under different flow rates.



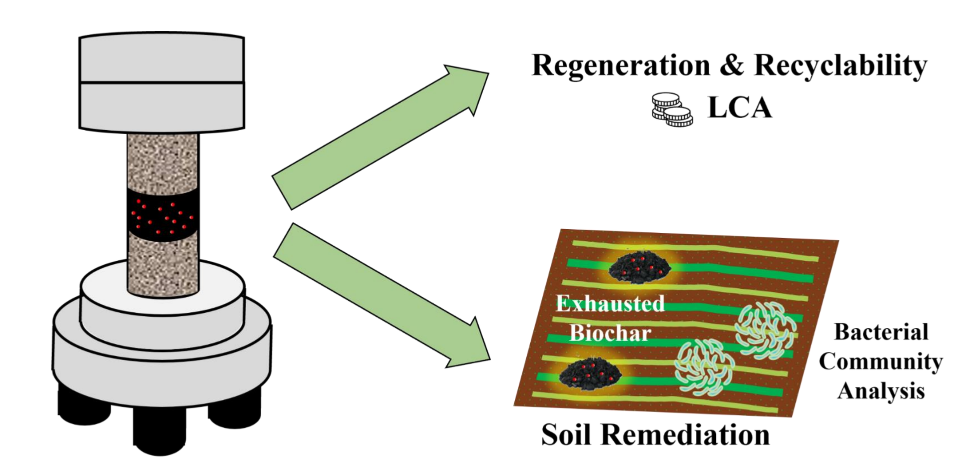
BDST model plots relating the reverse of linear flow velocity (1/F) and service time (t) for (a) SMX, and (b) SPY.

5 Conclusions

- Fixed bed column packed with Al-modified biochar effectively removed SMX and SPY from wastewater
- SMX and SPY adsorption on Al-modified biochar was controlled by multiple mechanisms including hydrophobic, π-π EDA & electrostatic interaction
- Yan model best described the breakthrough behaviors of SMX and SPY
- BDST model showed a strong linear relationship between service time and biochar dosage/reverse of flow rate

6 Future Works

- Removal performance of Al-BB-600 in stormwater
- Recyclability, regeneration potential, and Life cycle assessment (LCA) of Al-BB-600
- Pilot scale evaluation
- Bacterial community analysis when the exhausted Al-BB-600 is applied as soil amendments



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Acknowledgments

USDA

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