National Water Reuse Action Plan
Completed Action

Action 4.7: Evaluate and Optimize Low-Input Treatment Methods to Remove Pharmaceutical Residues from Treated Wastewater Used for Irrigation

Background

Emerging contaminants (ECs), such as pharmaceuticals, hormones, personal care products, and industrial byproducts can interfere with metabolic functions. Conventional wastewater treatment may not fully remove ECs, and it is not always well understood if residuals in effluent impact irrigated crops. Municipal wastewater effluent is increasingly viewed as a potential supply source in water resources planning, and effluent quality is a critical determinant of the potential uses of recycled wastewater. The ability to cost-effectively and efficiently remove contaminants from recycled water is crucial for ensuring its continued use on food crops.

This action evaluated the use of biochars for removing pharmaceutical residues from effluents prior to their use in micro-irrigation. Biochars, a low-input treatment technology, are products formed from pyrolysis of biomass materials that studies show to be low-cost and highly effective sorbents for a variety of organic compounds. This project entailed two major research phases:

- The first phase involved selection of biochar material with high sorption potential for selected ECs. Because pyrolysis alters important adsorption-related properties of the biochar (such as porosity, surface area, crystallinity, and surface functional groups), researchers compared several candidate biochar materials for their EC sorption properties. Researchers also conducted batch experiments to develop adsorption isotherms and evaluate reaction kinetics.
- The second phase sought to 1) evaluate the use of cotton gin waste and walnut shell-derived boichar as low-cost solutions to removing pharmaceuticals and 2) study the physiochemical characterization of the cotton gin waste and walnut shell-derived biochar as a means for removing contaimants from water.

Action Team

Action Leaders

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Action Partners

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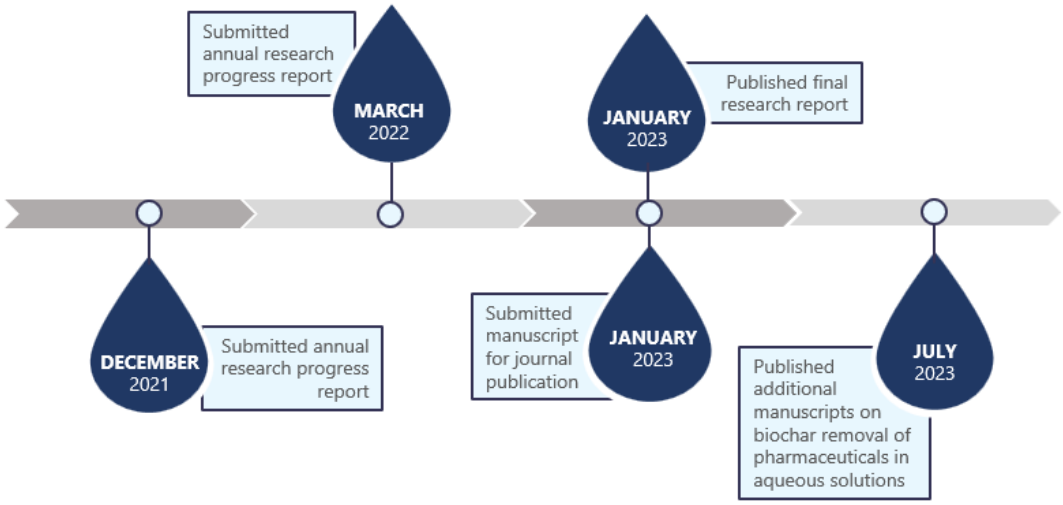
Accomplishments/Impact

- Published a dissertation titled *Cotton Gin Waste and Walnut Shells Derived Biochar for the Removal of Pharmaceuticals and Humic Acids from Aqueous Solutions* in January 2023, which studied how biochars derived from these materials can be a cost-effective and environmentally-friendly treatment technology for removing pharmaceuticals and humic acids (HA) from effluent prior to irrigation.
- By July 2023, published two articles characterizing cotton gin waste and walnut shell-derived biochar and how biochar removes pharmaceuticals from aqueous solutions: *Physicochemical Characterization of Biochar Derived from the Pyrolysis of Cotton Gin Waste and Walnut Shells* and *Fixed Bed Column Experiments Using Cotton Gin Waste and Walnut Shells-Derived Biochar as Low-cost Solutions to Removing Pharmaceuticals from Aqueous Solutions*.

Conclusions and Lessons Learned

- Biochar made from cotton gin waste and walnut shells can be used as a cost-effective, environmentally friendly adsorbent to remove pharmaceutical residues and naturally occurring organic compounds from aqueous solutions.
- Biochar produced from cotton gin waste and walnut shells were characterized physically and chemically and linked to organic sorption characteristics allowing prediction of different environmental applications, providing sustainable alternatives for contaminant removal from water.
- Biochar produced from cotton gin waste and walnut shells could be used as cost-effective, environmentally friendly alternatives to activated carbon for the removal of pharmaceuticals from aqueous solutions.

Action Implementation Process



Potential Future Activity

- USDA and Clemson University are collaborating to evaluate the potential for biochar to remove per- and polyfluoroalkyl substances (PFAS) from irrigation water. The team is also evaluating the potential for microplastics found in wastewater to sorb antibiotics and PFAS.
- Potential future activities as stated in the *Cotton Gin Waste and Walnut Shells Derived Biochar for the Removal of Pharmaceuticals and Humic Acids from Aqueous Solutions* dissertation include the following:
    - More standardized experiments (e.g., related to feedstock used, pyrolysis temperature, biochar production holding times) should be conducted to improve experiment replicability and reduce contradictory findings.
    - Various studies have proved that biochar can effectively remove contaminants from aqueous solutions; however, more research is needed to determine how biochar could be implemented in operational water treatment systems rather than experimental treatment systems. These pilot experiments will also help estimate the cost of biochar-based water treatments.
    - Future research could focus on modifying biochar using pretreatment methods to improve its ability to adsorb water contaminants and studying used biochar to evaluate how absorbed substances may be released.

Additional Resources

- USDA ARS Water Management and Conservation Research. (2021). *Biochar Removal of Emerging Contaminants from Wastewater Effluent Irrigation Water.* https://www.ars.usda.gov/research/project/?accnNo=430727