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Review

Pristine and modified biochar applications as multifunctional component towards sustainable future: Recent advances and new insights

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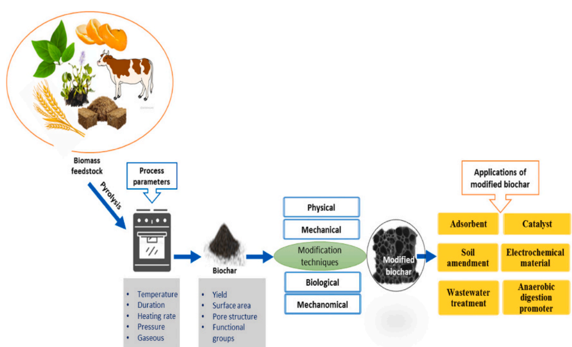
HIGHLIGHTS

- Waste to biochar is a sustainable partway to a conceivable future.
- Research on the applications of pristine and modified biochars was assessed.
- Biochar modification methods were emerged in enhancing physicochemical properties.
- Biochar applications using physical, chemical, and biological systems are reviewed.
- Advances research of biochar in environmental sustainability were outlined.
- Existing issues are outlined, and new insights are proposed.

GRAPHICAL ABSTRACT



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ABSTRACT

Employing biomass for environmental conservation is regarded as a successful and environmentally friendly technique since they are cost-effective, renewable, and abundant. Biochar (BC), a thermochemically converted biomass, has a considerably lower production cost than the other conventional activated carbons. This material's distinctive properties, including a high carbon content, good electrical conductivity (EC), high stability, and a large surface area, can be utilized in various research fields. BC is feasible as a renewable source for potential applications that may achieve a comprehensive economic niche. Despite being an inexpensive and environmentally sustainable product, research has indicated that pristine BC possesses restricted properties that prevent it from fulfilling the intended remediation objectives. Consequently, modifications must be made to BC to strengthen its physicochemical properties and, thereby, its efficacy in decontaminating the environment. Modified BC, an enhanced iteration of BC, has garnered considerable interest within academia. Many modification techniques have been suggested to augment BC's functionality, including its adsorption and

Abbreviations: AD, anaerobic digestion; AEC, anion exchange capacity; AOPs, advanced oxidation processes; BC, biochar; CE, circular economy; CEC, cation exchange capacity; DCFCs, carbon fuel cells; EC, electrical conductivity; EDLC, electrochemical double layer capacitors; EPFRs, environmentally persistent free radicals; GHGs, greenhouse gases; HTC, hydrothermal carbonization; HMs, heavy metals; LCA, life cycle assessment; MB, methylene blue; MFCs, microbial fuel cells; MWAP, Microwave-assisted pyrolysis; nZVI, nano zerovalent iron; OM, organic matter; SSA, specific surface area; VFAs, volatile fatty acids; VS, volatile solids; VOC, volatile organic compounds; WHC, water holding capacity.

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