An advanced water treatment approach: upcycling municipal organic wastes

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Introduction

- The demand for efficient, sustainable and eco-friendly adsorbents is growing across various industrial applications, boosting interest in waste-based activated carbon (AC).
- Converting organic waste into carbon-rich products like AC supports material circularity and contributes to sustainability goals such as achieving net zero emissions.
- Waste-derived AC have shown comparable effectiveness to commercial AC in removing heavy metals, dyes, and other pollutants from water.
- This study explore the performance of the novel lab made waste-based carbon material as a circular economy product to remove pollutants from water.

Research Purposes

This study includes the following:

- Thorough characterization and thermal conversion of municipal organic (food and garden) waste into AC.
- Physico-chemical characterization of prepared AC.
- Lab-scale Methylene Blue (MB) adsorption study.
- Performance investigation to remove organics from reservoir water in a long-term filtration process.
- Monitoring the development of biofilm during the operational period.
- Comparison of the performance of waste-based AC with a commercial AC (CGAC).

Research Methodology

Figure 1: Pyrolytic conversion of organic wastes into AC and its key features

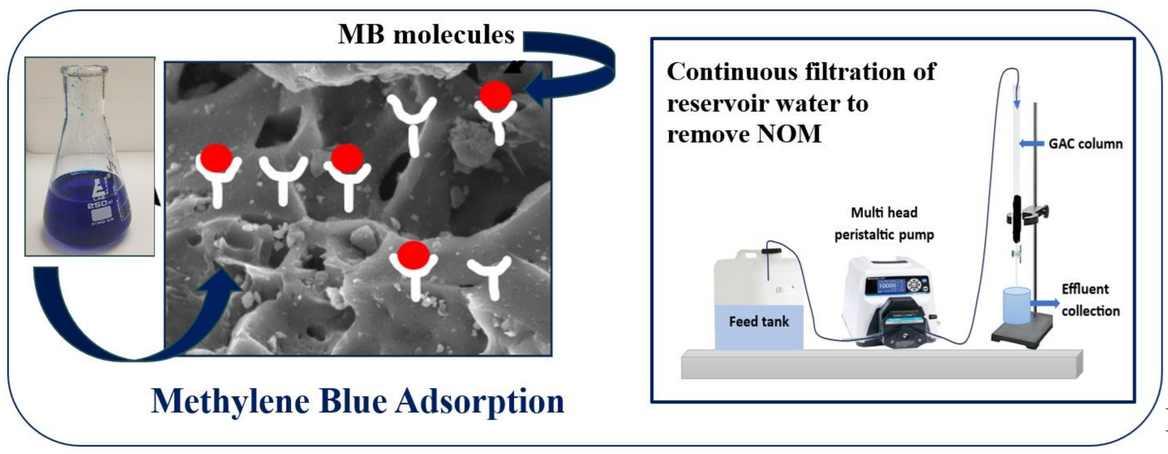

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Figure 2: Application of lab-made activated carbon as adsorbent in water treatment

Experimental Results

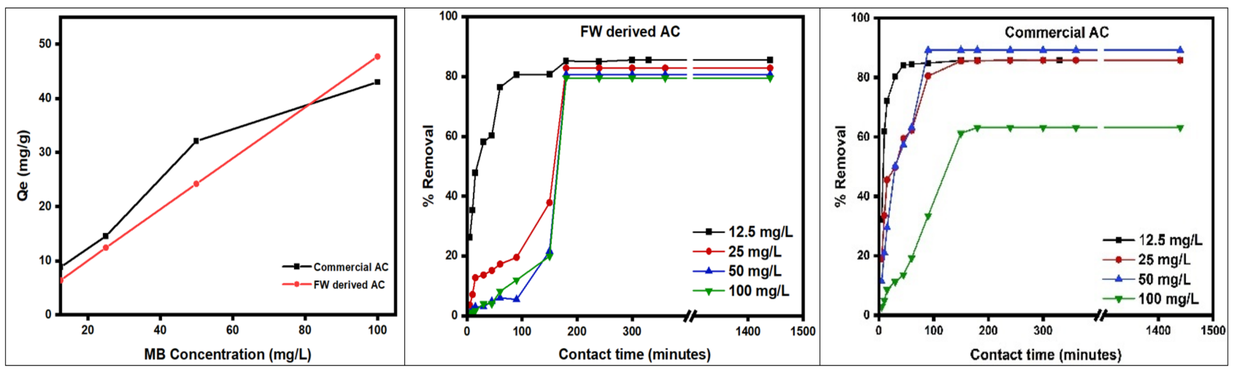

Figure 3: (a) Methylene blue (MB) adsorption capacity and percentage removal by AC (b) derived from food waste (c) commercial AC

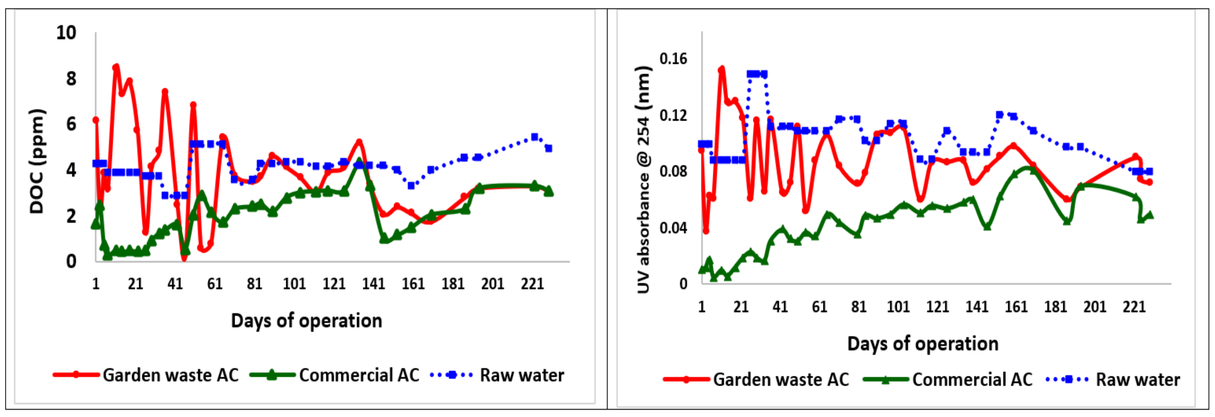

Figure 4: Performance of garden waste derived AC in water treatment (a) DOC removal (b) UV absorbance at 254 nm

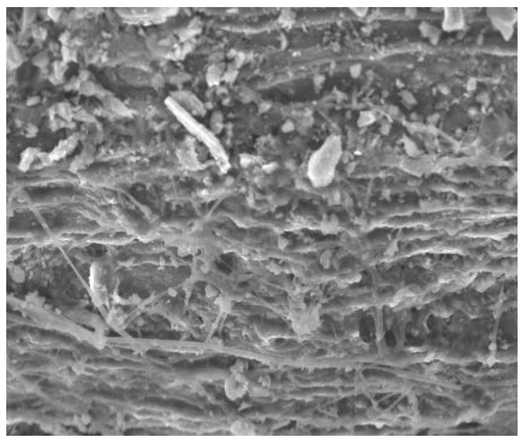

Figure 5: SEM image of biofilm developed on AC after 8 months of operation

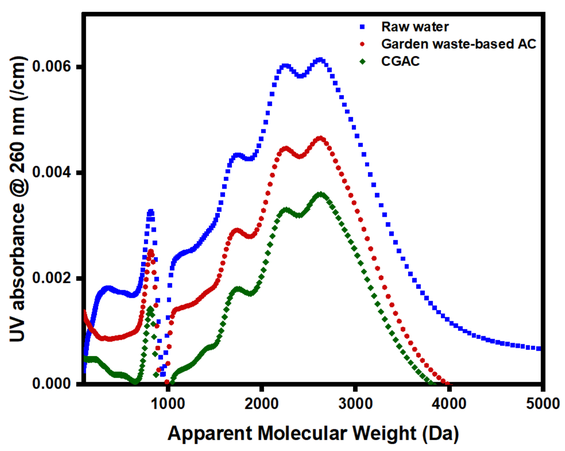

Figure 6: The molecular weight distribution of raw and treated water

Key Findings

- Activation of wastes has been demonstrated to eliminate volatile matter, create internal pores, enhance thermal stability and increase the proportion of various surface functional groups, such as O─H and C=O groups (Fig. 1).
- Activated carbon derived from food waste shows excellent adsorption properties in MB study and can outperform commercial activated carbon in both the rate of MB adsorption and the maximum adsorption capacity at equilibrium. The adsorption of MB on waste derived AC can be explained by chemisorption. (Fig. 3).
- In a long-term continuous filtration system, garden waste derived AC demonstrated its efficiency to reduce organic matters, aromatic content, color, turbidity from reservoir water.
- Three distinguished phases in effluent's DOC were observed over the operational period (Fig. 4). From day 1 to 50, organics removal was occurred mostly by adsorption, in 2nd phase from day 50 to 146 adsorption and biodegradation took place simultaneously on the biologically active surface. And in the third phase (>146 d) organics were removed by biodegradation (Fig.3).
- Biological conversion of garden waste-based AC were confirmed after 8 months of filtration and is evident by the steady DOC removal and SEM images (Fig. 4a & Fig. 5).
- Although having lower removal efficiency garden waste AC performed almost similar to the commercial AC at the end of the experimental period.
- Waste-based AC has the similar removal efficiency to Commercial ACs in removing substances with a molecular weight less than 3000 Da (Fig 6).

Conclusions

- Municipal organic wastes are sustainable and alternative AC precursor.
- Organic waste-based AC shows great potential to remove organic matter from water treatment facility, utilizing both adsorption mechanism and biological process.
- Particularly, lab-made organic waste-based AC has promising capability to act as a substrate to hold the biofilm and support biological activity to remove organics that present in natural water.

Acknowledgements

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