Abstract No: STEM 21 Science, Technology, Engineering and Mathematics

Methylene blue adsorption on coconut vinegar activated wood biochar

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Activated wood biochar plays a significant role in water purification. However, many biochar activation methods utilize higher temperatures and corrosive chemicals, which may be expensive and unavailable for rural communities. Therefore, the focus of this study was to examine the ability of Gadumba (*Trema orientalis*) wood biochar activated using natural coconut vinegar to remove methylene blue (MB) dye from aqueous solutions.

Gadumba wood was collected and air dried. Next, they were carbonized (300 ˚C, 2 h) to produce biochar. For the activation, biochar (<0.5 mm) was soaked in natural coconut vinegar (biochar: vinegar, 1:2 V/V) for 24 hours and completely dried on a hot plate (200 ˚C). Then they were left to cool to room temperature, washed with deionized water, dried in an oven (80 ˚C, 8 h) and stored in sealed containers. Effect of initial MB concentration on adsorption was determined by batch studies using a series of MB solutions with concentrations ranging from 50-300 mg/L.

Activated biochar showed a three-fold higher MB adsorption capacity compared to raw biochar. The maximum adsorption capacity of activated biochar increased from 19.63 to 58.27 mg/g, while removal percentage decreased from 98.19 to 48.56% with increasing initial MB concentration. Isotherm data best-fitted to the Freundlich model. Kinetic data best-fitted to both pseudo-second order and intraparticle diffusion models suggesting that the adsorption was governed by a pore filling mechanism where electrostatic attractions were predominant and the rate of the reaction was diffusion controlled. FTIR, XPS and water contact angle measurements showed the increased surface oxygenated functional groups and hydrophilicity of the activated biochar. XPS showed a three-fold increase in O/C atomic ratio after the vinegar treatment. Contact angles of the water droplets placed on raw and activated biochar were in the range of 102–113º and 30–62º, respectively. SEM images did not show significant changes in the porosity of biochar after the activation. This could be due to the mild activation process utilized using a mild acid and low temperatures. Therefore, the enhanced MB adsorption capacity of activated biochar could be attributed to increased surface oxygenated functional groups suggesting coconut vinegar as an abundant and effective activating agent for activating biochar for methylene blue removal.

Keywords: *Trema orientalis*, Biochar, Methylene blue, Adsorption, Water purification, Dye removal

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