

Evaluation and correlation of the influence of production parameters on biochar characteristics and its influence on the adsorption of three industrial dyes

Dineth Saumya¹, Chathuri Peiris¹, Sachith P. Abeyesundara² and Sameera R. Gunatilake^{1*}

¹ College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya 10107, Sri Lanka

² Department of Statistics and Computer Science, Faculty of Science, University of Peradeniya, Peradeniya 20400, Sri Lanka.

*Corresponding author: ranmal@ichemc.edu.lk

Remediation of waste water containing hazardous dyes using biochar (BC), as an adsorption technique, is a cost effective and efficient method. As a statistical approach, this study was focused on how feedstocks, pyrolysis temperature, production method and modification affect to the physiochemical properties of BC and how these properties affect to the adsorption of methylene blue (MB), crystal violet (CV) and rhodamine B (RB) from aqueous medium. Since there was no studies have been conducted to evaluate and correlate its specific impact on the adsorption of these cationic dyes, utilized approximately 151 peer-reviewed articles with 240 entries from years 2015 to 2020, to predict reasonably the influence of these physiochemical properties quantitatively to dye adsorption with the aid of statistical correlation and regression meta-analysis using the R programming language in RStudio, to help to understand the factors and characteristics used to produce BC commercially fulfilling the necessity of industrial applications. Pore volume and surface area of BC produced by plant-based materials had significant ($p \leq 0.05$) positive correlations, $r = 0.22$ and $r = 0.17$ with pyrolysis temperature respectively whereas, at low temperatures (250-450 °C), they were enhanced by basic

modifications. The stability was seen to be greater in basic modified wood-based BCs, pyrolyzed at medium to high temperature which was confirmed by the statistically specified regions of Van-Krevelen diagrams. Maximum adsorption capacity of BC in MB adsorption had a higher variability on plant-based materials which were modified by acids and metal salts produced at high temperatures whereas CV had a higher variability on animal-based materials. In RB adsorption, BC made up by plant-based materials which modified mostly using bases, at low pyrolysis temperatures (250 °C - 450 °C) had a higher variability. Pseudo-second-order kinetics and Langmuir isotherm models were fitted for the adsorption of these three dyes. MB and CV were most adsorptive at neutral to high pHs (6-10) whereas RB it was low to neutral (1-9), Therefore, this data collected could be used to improve the effectiveness of cationic dye removal from wastewater, considering pyrolysis conditions and useful physiochemical properties of specific BC types.

Keywords: Biochar, Methylene blue, Crystal violet, Rhodamine B, Modifications, Van-Krevelen diagrams, meta- analysis