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Comparison of raw and modified activated carbon and rice industry wastes for methylene blue sorption

Maria Befani (1), Ioannis D. Manariotis (2), Hrissi K. Karapanagioti (3), and César E. Quintero (1)

(1) Entre Ríos National University, College of Agricultural Sciences, Argentina , (2) University of Patras, Department of Civil Engineering, Patras, Greece (idman@upatras.gr), (3) University of Patras, Department of Chemistry, Patras, Greece

In Argentina the average paddy rice production was 1.3x106 tn/year in the last decade. Entre Ríos province (E.R.) accounts for 60% of national milling, resulting in a significant accumulation of waste in the local environment; husk and ashes are used as fuel in drying grain plants. The use of rice wastes, as low-cost sorbents for the removal of synthetic dyes and other contaminants may be a sustainable option. The aim of this work is the investigation of the removal capacity of methylene blue (MB) from aqueous solutions using: (a) rice husk from a rice mill located in E.R. of size between 0.15 to 1.18 mm (RH2), (b) ash from rice husk burned at 800ºC in oven for the grain drying unit of the rice mill (RHA800), and (c) biochar obtained from pyrolysis of RH2 material at 850°C (RHA4). Commercial activated carbon (AC), which is a porous material of high sorption capacity, was also used to compare its sorption capacity with the rice husk products. Furthermore, the incorporation of iron in the AC was studied using two different AC/Fe weight-by-weight ratios (AC-Fe and AC-0.5 Fe). The solution pH effect was studied in a range from 2 to 6.9. The maximal MB removal was achieved at pH of 6.8 to 6.9 for all materials studied, and at pH of 6.4 for AC.

Kinetic experiments were conducted for a period of 48 h at pH 7 and C0 = 50 mg MB/L. Equilibrium was reached after 24 h and the adsorption capacity was 156, 104, 90, 79, 26, and 9 mg/g for AC, AC-Fe, AC-0.5 Fe, RHA4, RH2 and RHA800, respectively. The pseudo-second-order model expressed better the sorption kinetics of MB for all adsorbent materials. The AC-based materials presented better performance. The experimental data were fitted with the Freundlich and Langmuir isotherm models. The Langmuir model fits the data better in all cases. The maximum adsorption capacity was 238, 125, 92, 91, 46 and 9 mg/g for AC, AC-Fe, AC-0.5 Fe, RHA4, RH2 and RHA800, respectively.

Agricultural wastes can be considered low-cost sorbents, but their capacity for MB, compared to AC, was quite lower. Biochar (RHA4) exhibited better sorption capacity, compared to other rice husk materials. The addition of iron on AC resulted in lower surface area, and this was reflected with lower sorption efficiency of MB.