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On alleviation of atrazine and imidacloprid contamination from single component aqueous systems using rice straw biochars: An Optimization Study

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Contamination of surface and ground water by pesticides from agricultural runoff and industrial discharge is one of the main causes of aqueous contaminations world over. Adsorption of pesticide on adsorbents is considered as the most feasible approach of decontamination. Biochar, agricultural waste derived highly aromatic substance produced after pyrolysis and carbonification of biomass have exhibited good adsorption capacity for pesticides and can be used to develop on-site bio-purification systems for organic contaminant removal from polluted waters.

Normal (RSBC) and phosphoric acid treated (T-RSBC) rice straw biochars were characterized for their physico-chemical properties. The yield parameters of biochar suggested higher biomass-biochar conversion ratio for the rice biochar. T-RSBC (pH=6.93) was neutral whereas RSBC was alkaline in nature. The cation exchange capacity (CEC) of the biochars were quite high. Elemental analysis (C, H, N, O) of biochars suggested a higher total carbon content (47.7-49.5%) and degree of aromaticity (H/C 0.62-0.63) indicating increased stability of biochars than the parent feedstocks. Polarity increased when T-RSBC (O/C 0.416) was synthesized from RSBC (O/C 0.410). The surface area, pore volume and micropore volume of the biochars, calculated using BET N_2 adsorption method, suggested that RSBC was the most porous biochar (220.2 m^2 g^{-1}) amongst the two studied. IR, SEM and XRD analysis of biochars suggested the presence of inorganic minerals, carbonates, aromatic moieties and carboxylic groups. Zeta potential measurement indicated that biochars' surfaces carried negative charges while Boehm titration results suggested abundant presence of surface acidic functional groups on both the biochars.

Fairly good atrazine and imidacloprid removal were shown by RSBC ($K_{Fads,Atrz}$ = 1363; $K_{Fads,Imida}$ =1706) and T-RSBC ($K_{Fads,Atrz}$=2716; $K_{Fads,Imida}$= 3140). Results obtained by fitting the atrazine and imidacloprid adsorption data to the Freundlich adsorption isotherm were modelled to develop single or multistage batch sorption systems.

Amounts (kg $1000L^{-1}$) of RSBC and T-RSBC required for 95% of atrazine removal from 10 g L^{-1} solution in single-, two- and three-stage systems were 8.84, 2.44, 1.61 kg and 4.47, 1.42, 0.98 kg, respectively. Corresponding amounts for imidacloprid removal were 3.97, 1.22, 0.84 kg and 3.98, 1.38, 0.96 kg, respectively. Thus, two-stage system suggested 65-72% reduction in amount of adsorbent required over single stage system while three-stage system suggested 30-34% adsorbent saving over two-stage system. Single and two stage adsorber plant model findings were validated using the jar test appratus simulation of a low-cost water treatment plant.

Rice straw based biochars were highly effective in removing pesticides from water and have great potential to replace costly commercial activated carbons for on-site remediation of contaminated water. Furthermore, the jar test validation results suggested the amounts, calculated using modelling studies, to be fairly accurate and thereby optimizing the performance of the water treatment plant.

Key words: Biochar, Freundlich isotherm, Low-cost water treatment plant