Environmental Pollution 345 (2024) 123452

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Adsorptive behavior of engineered biochar /hydrochar for tetracycline removal from synthetic wastewater☆

Yanushiya Jeganathan, Thusalini Asharp, Kannan Nadarajah *

Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna, Sri Lanka

ARTICLE INFO

Keywords:
Wastewater irrigation
Engineered biochar
Engineered hydrochar
Paddy husk
Tetracycline
H_3PO_4
Isotherm
Kinetics
Thermodynamics

ABSTRACT

In this research, engineered biochar and hydrochar derived from paddy husk were compared for the adsorption tetracycline (TC) in water effluents. Biochar was produced at three different pyrolysis temperatures (e.g., 250 °C, 300 °C and 350 °C) while hydrochar was produced using three different HTC temperatures (e.g., 180 °C, 200 °C and 220 °C). The adsorptive experiments were performed for both biochar and hydrochar using well-defined experimental conditions: pH (3); initial TC concentration (10 mg/L); adsorbent dosage (1 g/L); and temperature (27 °C) to study their adsorptive performances (q_e in mg/g). After selecting the best q_e values for both biochar and hydrochar, both materials were modified using 20% H_3PO_4. A comprehensive scientific evaluation of both engineered biochar (EBC 350) and hydrochar (EHC 220) was performed using adsorption isotherm, adsorption kinetics, rate-limiting, and thermodynamics tests along with their characterization using FTIR and point of zero charge (pzc). The effects of temperature, dosage, and initial TC concentration on the adsorption process were studied for both EBC 350 and EHC 220. Acid activation improved the adsorptive performance of EHC 220 almost four times (from 1.9 to 7.5 mg/g), whereas adsorptive performance of EBC 350 improved 2.4 times from 3.8 to 9.1 mg/g. The best pH for TC adsorption onto EHC 220 was 5, whereas it was 3 for EBC 350. EBC 350 exhibited a good fit with the Freundlich model, whereas EHC 220 followed the Langmuir model. At 100 mg/L TC concentration, EHC 220 exhibited higher q_e value (46.9 mg/g) compared to EBC 350 (41.7 mg/g). The Pseudo-first order kinetic model was the best fit for EHC 220 adsorption, whereas Pseudo-second order model was most suitable for EBC 350. The adsorption mechanisms involved in TC adsorption by EHC 220 included hydrogen bonding, hydrophobic effect, and $\pi - \pi$ interaction, whereas cation exchange, mass diffusion, and $\pi - \pi$ interaction were involved for EBC 350. The results of this study will facilitate the development of cost-effective filters with the incorporation of engineered biochar/engineered hydrochar for the active removal of emerging contaminants, like tetracycline, from wastewater so as to increase its reusable potential.

1. Introduction

tion is recognized as one of the main global consumers of irrigation, however, also involves difficulties and concerns and proper treatment is crucial to guarantee that fit-for-purpose water is used (Shakir et al., 2017).