

Rakesh Kumar Ghosh
 D. Damodar Reddy

Division of Crop Chemistry and Soil
 Science, Central Tobacco Research
 Institute, Rajahmundry, Andhra
 Pradesh, India

Research Article

Crop Residue Ashes as Adsorbents for Basic Dye (Methylene Blue) Removal: Adsorption Kinetics and Dynamics

In the quest for identifying low-cost, locally available and effective adsorbents, pigeon pea (*Cajanus cajan* L.) residue ash (PRA) and sunflower (*Helianthus annuus* L.) residue ash (SRA) were evaluated as adsorbents for sequestering a basic dye, methylene blue (MB), from aqueous solution. Effects of contact time, initial solution pH and adsorbent dose on MB adsorption were investigated. MB adsorption onto PRA and SRA was dependent on initial solution pH, with adsorption being greater at higher pH. Percent MB removal increased with increase in adsorbent's dose. Adsorption followed pseudo-second order kinetics. Intraparticle diffusion was not the sole rate-controlling step. Both film diffusion and intraparticle diffusion controlled the adsorption process. The equilibrium data fitted well to Langmuir isotherm as compared to Freundlich isotherm, on the basis of coefficient of determination and error analysis. The maximum MB adsorption capacities of PRA and SRA were found as 58.8 and 62.5 mg g⁻¹, respectively. The free energy change and dimensionless equilibrium parameter revealed spontaneous and favorable nature of MB adsorption onto crop residue ashes. Results demonstrate that the PRA and SRA have high adsorptive potential as compared to many previously reported ash based adsorbents, and hence can be used for treating water contaminated with cationic dyes.

Keywords: Adsorption kinetics; Crop residue ash; Dye removal; Isotherm models

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1 Introduction

Industries such as textile, rubber, paper, leather, plastics, cosmetic, printing, etc., use a wide variety of synthetic dyes to produce a myriad of products to satisfy dynamic and ever evolving consumer's demand. About 5–10% of dyes used in these industries are, however, lost in industrial wastewater [1, 2]. Through the disposal of untreated dye-containing industrial wastewater to streams, dyes enter aquatic environments and pose a threat to the aquatic ecosystem not only by altering the physicochemical properties or biological activities of water [3], but also from toxicological stand point [4]. Through water bodies, dyes may gain entry to food chains and pose serious threat to human health [5, 6]. Proper treatment of dye-contaminated water is, therefore, an important issue for environment friendly disposal of stained wastewater.

As a result of extensive research work, a number of dye removal techniques such as adsorption, biosorption, biodegradation, electrochemical degradation, photochemical degradation, coagulation/flocculation, sonicated degradation, membrane filtration, etc., are

available for treating stained wastewater [7]. Of all these techniques, dye removal through adsorption is most effective and practically less life [8, 9]. Activated carbon is an undoubtedly effective adsorbent, but its high cost limits its large-scale usage, particularly in developing countries. In order to circumvent these problems, there is a growing interest in the use of low-cost and easily available adsorbents, including various natural materials, waste/by-products from agriculture or industry, for treatment of dye-contaminated wastewater [1, 10, 11]. However, not much research attention is paid to evaluate the potential of crop residue ash, the secondary by-product, as adsorbents to remove dye.

Crop residues are generated in huge quantities as a primary by-product of intensive agricultural production system. For example, in India about 52.3 Mt per annum crop residue is generated [12]. Crop residues of low lignocellulosic composition are used as a resource either in manure/compost preparation or as cattle feed. But, substantial quantities of high lignocellulosic residues of crops such as pigeon pea (9 Mt per annum in India) and sunflower (1 Mt per annum in India) are neither used for feeding cattle nor preparing manure [12]. Keeping these large volumes of high lignocellulosic crop residues in field often cause obstruction for agro-machinery/ implements and also harbors pests. Burning of these crop residues, either in situ as farmer's common practice or off the field as fuels for thermal energy purposes generates a large quantity of crop residue ash, the secondary byproduct, for which there is no alternative use.

Correspondence: Dr. R. Kumar Ghosh, Central Tobacco Research Institute, Rajahmundry 533005, Andhra Pradesh, India.
 E-mail: rkghosh@gmail.com

Abbreviations: FTIR, Fourier transform IR; MB, Methylene blue; OC, organic carbon; pH_{zpc}, pH of zero point charge; PRA, pigeon pea residue ash; SRA, sunflower residue ash; TOC, total OC

Ashes No More Releasing The Residue And Embracing The Strength

Peter Hewlett



Ashes No More Releasing The Residue And Embracing The Strength:

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