

Original Research

**AMBROSIA-BASED BIOSORBENTS FOR REMOVAL OF RHODAMINE B
FROM AQUATIC SOLUTION**

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Abstract

The utilization of different natural materials and their application as low-cost biosorbents in water treatments represents an efficient approach in environmental protection. In this study, the biosorption efficiency of Ambrosia-based biosorbents was analyzed before and after modification with magnetite. The biosorption process with both biosorbents was evaluated using the cationic dye Rhodamine B (RB). After 2h of contact time at an initial RB concentration of 25 ppm, the maximum removal efficiency for RB was 59.2% with non-magnetic, and 91.7% with magnetic biosorbent. Quantification of RB was performed using UV-Vis spectroscopy, while FTIR analysis confirmed the biosorption of RB onto both biosorbents. The results of this study demonstrated that Ambrosia-based biosorbents are economical and effective materials for the removal of RB from aqueous solution.

Keywords: biosorbents, Ambrosia, Rhodamine B.

INTRODUCTION

Clean and uncontaminated water has become a challenge for the global population. Preventive measures, such as water purification and recycling are crucial to ensure the availability of clean water and environmental protection. Industrial effluents, including contamination from agriculture, domestic, and clinical sources also contribute to the water pollution. Synthetic organic dyes in wastewaters are indestructible, carcinogenic, and resistant to environmental degradation [1]. Rhodamine B (RB) is a cationic, water-soluble synthetic organic dye, used in the manufacturing of dye lasers, stamp pads, fireworks, carbon sheets, etc. Because of its non-destructible nature and inherent structural stability, RB has been identified as a neurotoxic and carcinogenic compound [2]. Because of all of the above, it is very important to establish an environmentally acceptable approach that will enable the efficient and inexpensive removal of polluting compounds from wastewater so that they do not reach the environment.

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A weed species of concern in Europe is *Ambrosia artemisiifolia*, known as an alien plant responsible for significant health and economic impacts in the most affected areas including Hungary, Serbia, Croatia, Slovenia, Slovakia, Romania, France, and Italy. *A. artemisiifolia* is a highly invasive annual plant, with the ability to generate allergenic pollen [3]. The focus of this study was on the development and implementation of novel non-magnetic and magnetic biosorbents, derived from the *A. artemisiifolia* biomass, for the removal of the synthetic organic dye Rhodamine B (RB) from aqueous solution. The concentration of RB was determined using UV-Vis spectrophotometry. Magnetic vs. non-magnetic biosorbent offer several advantages for RB removal, particularly in simple and efficient separation from aqueous solution through the application of an external magnetic field. Also, the incorporation of magnetite enabled the functionalization of the biosorbent so that the newly created magnetic biosorbent exhibits greater sorption efficiency. These characteristics make magnetic biosorbent a cost-effective material with strong potential for future applications in wastewater treatment processes.

MATERIALS AND METHODS

Preparation of biosorbents

The *A. artemisiifolia* was collected from the peripheral of Belgrade, the capital of Serbia, by cutting the aboveground plant parts. The plant biomass was washed with tap water and dried at room temperature for one week. Dried biomass was chopped in an electric mill, and sieved to obtain biosorbent particles with a size smaller than 300 μm . The obtained non-magnetic biosorbent was washed with distilled water, and then dried overnight in an oven at 50 $^{\circ}\text{C}$ [4].

The preparation of the magnetic biosorbent was carried out using modified coprecipitation method, which involved dissolving of 3.9 g of $\text{FeCl}_3 \cdot \text{H}_2\text{O}$, and 1.7 g of $\text{FeCl}_2 \cdot \text{H}_2\text{O}$ in 190 cm^3 of deionized water, under a nitrogen (N_2) atmosphere at 80 $^{\circ}\text{C}$, with stirring at 450 rpm for 20 minutes. Subsequently, 10 M NaOH was added, and the reaction mixture was stirred under the same conditions for an additional 30 minutes. Afterward, 0.2 g of the non-magnetic biosorbent was introduced into the reaction mixture, and stirring was continued under the same conditions for another 30 minutes. Finally, the prepared magnetic biosorbent was filtered, washed until neutral pH, and dried overnight in an oven at 50 $^{\circ}\text{C}$ [5].

Biosorption of RB

The biosorption process of RB was performed in a batch system. Both biosorbents (0.1 g) were added separately to the 10 ml of 25 ppm RB solution. The samples were shaken at 400 rpm at room temperature (25 $^{\circ}\text{C}$), and a pH of 6.2. The RB concentration before and after biosorption in the water solution was determined spectrophotometrically at 554 nm (NOVEL-102S UV-Vis Double Beam Spectrophotometer, COLO Lab Experts, Slovenia). The removal efficiency of RB with *Ambrosia*-based biosorbents at equilibrium (E (%)) was determined using Equation (1) [4,5]:

$$E(\%) = \frac{c_0 - c}{c_0} \times 100 \quad (1)$$

where: C_0 (ppm) and C (ppm) are the concentrations of RB before and after biosorption process.

Fourier Transform Infrared Spectroscopy (FTIR)

FTIR spectra of Ambrosia-based biosorbents, before and after biosorption of RB, were taken in the range of 400–4000 cm^{-1} , in ATR mode using a Nicolet SUMMIT FTIR Spectrometer (Thermo Fisher Scientific, Waltham, MA, USA), in order to identify the functional groups of biosorbents that interact with dye molecules.

RESULTS AND DISCUSSION

The results obtained with UV-Vis spectroscopy showed efficient RB removal by both Ambrosia-based biosorbents. For non-magnetic biosorbent removal efficiency of RB was 59.2%, while for magnetic it was 91.7% (Figure 1). The difference in the biosorption efficiency of magnetic compared to non-magnetic biosorbent can be attributed to magnetite.

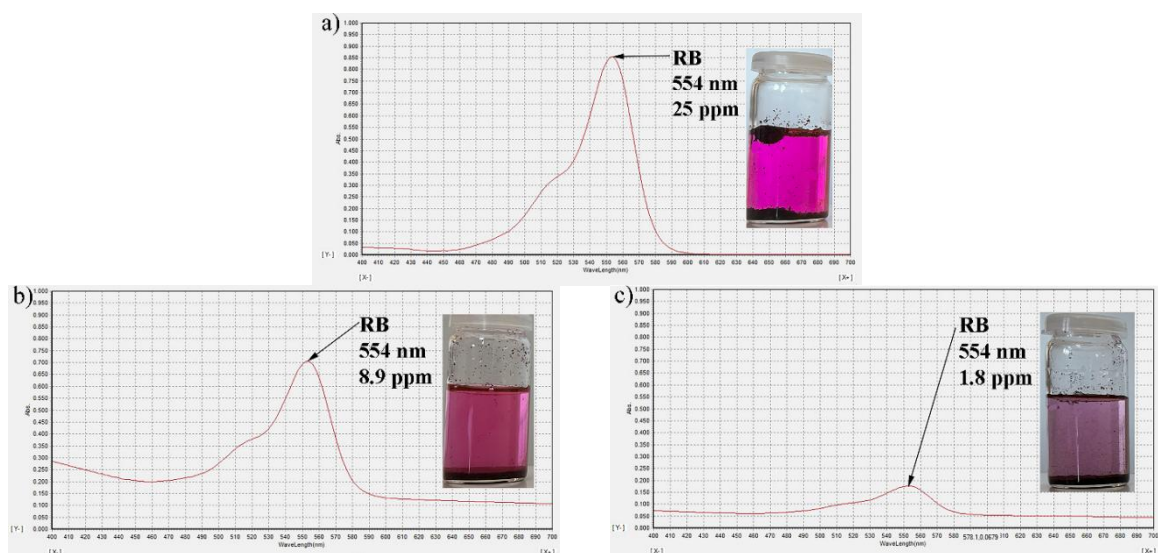


Figure 1 UV-Vis spectrum: a) before biosorption of RB; b) after biosorption of RB with non-magnetic biosorbent; c) after biosorption of RB with magnetic biosorbent

FTIR spectroscopy is a useful technique for identifying the characteristic functional groups present on the surface of biosorbents. A comparison of the FTIR spectra of the both biosorbents, before and after biosorption of RB, is presented in Figure 2. The FTIR spectra show broad bands around 3400 and 3300 cm^{-1} , which are attributed to the stretching vibrations of $-\text{OH}$ and $-\text{NH}_2$ groups originating from cellulose, hemicellulose, and lignin [5]. The peaks observed at ~ 2920 and ~ 2850 cm^{-1} correspond to the stretching vibrations of $-\text{CH}_2$ and $-\text{CH}$ groups of cellulose and hemicellulose [4]. Absorption bands at ~ 1600 cm^{-1} are associated with the stretching vibrations of aromatic structures [5]. The bands recorded at ~ 1420 and ~ 1418 cm^{-1} are due to $\text{C}=\text{C}$ stretching vibrations [6]. Also, the absorption peaks at ~ 1600 and ~ 1420 cm^{-1} indicate the presence of $-\text{COO}$ of carboxyl, and $\text{C}-\text{O}$ groups on the biosorbents surface [4]. The peaks at ~ 1330 and ~ 1030 cm^{-1} signifies the $-\text{OH}$ and $\text{C}-\text{N}$ bonds [7]. In addition, the peak observed at approximately 560 cm^{-1} corresponds to magnetite,

indicating a clear difference between the non-magnetic and magnetic biosorbent [4,5]. Based on the FTIR spectra, the functional groups that exhibit affinity for RB were $-\text{OH}$, $-\text{NH}_2$, and $-\text{COOH}$. Furthermore, several peaks shifted or disappeared after the biosorption process, which clearly indicates that the biosorption of RB onto the Ambrosia-based biosorbents occurred.

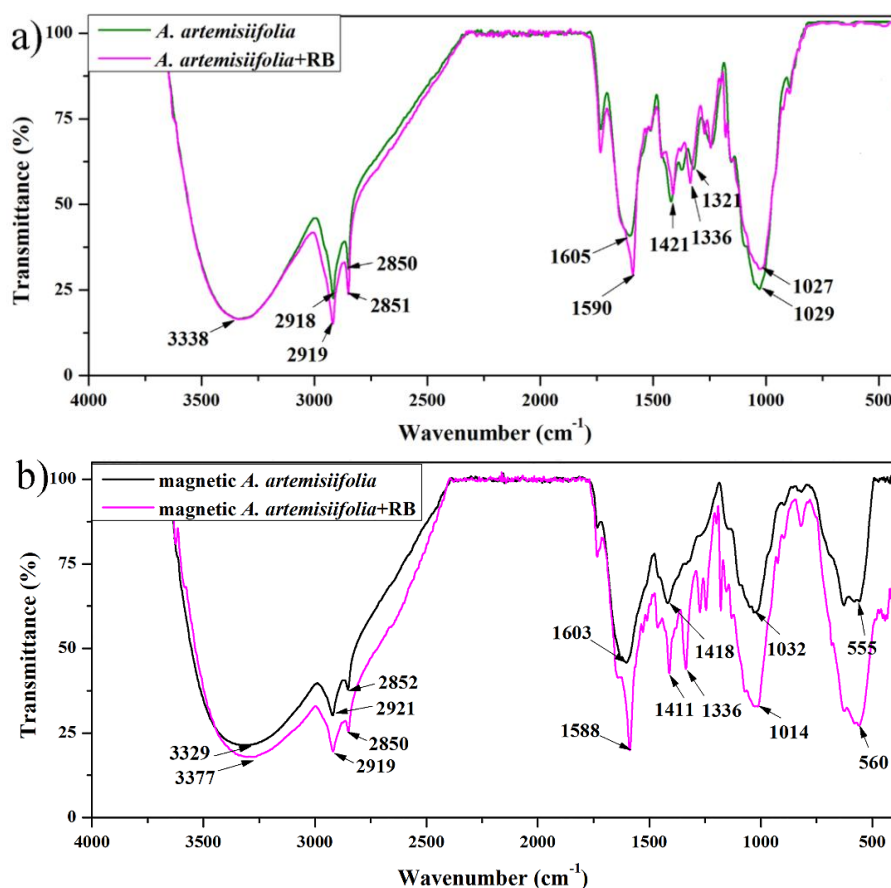


Figure 2 FTIR spectra of: a) non-magnetic biosorbent; and b) magnetic biosorbent, before and after biosorption of RB

CONCLUSION

Experimental results showed that both biosorbents, based on the biomass of *A. artemisiifolia*, can be used for the removal of RB from aqueous solutions. Biosorption capacities obtained in batch experiments at 120 min and 6.2 pH were 1.3 and 2 mg/g for non-magnetic and magnetic biosorbent, respectively. Higher RB removal efficiency was obtained for the magnetic biosorbent, which, combined with its easy separation, gives the magnetic biosorbent a potential advantage for application in industrial wastewater treatment in the near future. FTIR analysis revealed shifts of characteristic biosorption bands, particularly 1605 to 1590 cm^{-1} and 1603 to 1588 cm^{-1} , together with changes in band intensities after biosorption, providing evidence of RB binding onto both biosorbents. This green approach has the potential to be implemented in the future, as a cost-effective method for the treatment of industrial wastewater, which will be the focus of future research.

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