

## Remazol black B removal capacity of economic organic wastes

Gizem Bayazit<sup>1,\*</sup> , Özge Kapusız<sup>2</sup> , Ülküye Dudu Gül<sup>3</sup> 

<sup>1</sup>Bilecik Şeyh Edebali University, Graduate Education Institute, Biotechnology Department, Bilecik, Türkiye

<sup>2</sup>Bilecik Şeyh Edebali University, Graduate Education Institute, Bioengineering Department, Bilecik, Türkiye

<sup>3</sup>Bilecik Şeyh Edebali University, Engineering Faculty, Bioengineering Department, Bilecik, Türkiye

\*Corresponding author: gizemkirimli88@gmail.com

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### Abstract

One of the most vital natural resources for the survival of life is water. Water is used in a variety of industries, including human consumption, economic growth, ecological maintenance, and energy production. Water contamination is becoming more and more of an issue as a result of population growth and industrial development. One of the most important pollutants causing water pollution is textile dyes. Remazol Black B (RBB) dye is a synthetic textile dye used in industry. One of the methods used for dye removal from wastewater is biosorption. Biosorption is an environmentally friendly, economical, and effective method with its low cost and capacity to bind pollutants such as dye. This study investigated the biosorption of RBB with orange peel, an organic waste. In addition to using orange peel powder simply, it was also used in a complex form with surfactant. The surfactant named Hexadecyltrimethyl ammonium bromide (HTAB) was used to see the change in biosorption capacity. pH, dye concentration, temperature, time and adsorbent dosage parameters were investigated. The best removal results were obtained using the following conditions: pH 2, 12.5 ppm dye concentration, 50°C temperature, 1440th minute, and 1g/L adsorbent quantity. According to the test results for both orange peel and orange peel with surfactant under the same conditions, the highest yields were respectively; 91.92% and 83.84%. Consequently, it has been determined that orange peel, which is organic waste, can be used for the removal of dyes from wastewater with high efficiency.

**Keywords:** wastewater, dye pollution, biosorption, surfactant, organic waste

### Introduction

Urbanization caused the first signs of environmental contamination, which then got worse as industries grew. Due to the acceleration of population growth, environmental contamination increased, particularly in the second half of the twentieth century, which worsened the ecosystem and polluted more living resources. [1]. When utilized as a receiving and removing zone for used water and other pollutants, the aquatic environment, which is a part of the ecosystem, has become the most extensively contaminated element of the ecosystem when compared to air and soil. In the production of energy and fuel, fertilizer and pesticides, metallurgy, iron and steel, leather processing, and photography, wastes containing dyes are either directly or indirectly released into the environment. This condition has started to seriously pollute the environment, especially in developing nations, and risk human lives [2]. Dyes are extremely dangerous contaminants for aquatic life. Due to their propensity for bioaccumulation and the fact that they are stored more quickly than they are metabolized, these contaminants are extremely hazardous. In addition, they harm organs, disrupt the nervous system, and bring on deadly conditions like cancer [1]. Therefore, a variety of methods, including photochemistry, coagulation, bioremediation, flocculation, membrane treatment, adsorption, and oxidation, have been used to remove colours from industrial effluents [3]. Water pollutants can be removed from wastewater in an economical and environmentally friendly way via biosorption, especially those that are difficult to biodegrade, like dyes. Bacteria, fungus, algae, yeasts, and other living or dead organisms, as well as agricultural waste, are thought to be effective biosorbents that can remove contaminants from wastewater [4]. Both natural resources and waste can be used to form biosorbents for biosorption. Furthermore, no extra waste is produced at the end of the procedure [5]. Studies on the biosorption of dye ions into the cell structure in wastewater containing contaminants like a dye by various microorganisms have started to gain prominence in recent years [6]. As a basic definition, biosorption is the use of biomass to remove pollutants from a solution, such as dye [7]. The removal of the Remazol Black B (RBB), a dye that is commonly used

in the textile industry, was tested in this work to determine biosorption capacity of the orange peel (OP) and surfactant coated orange peel (SOP).

## Materials and Methods

### Dye solution preparation

A textile factory located in Bilecik provided the Remazol Black B (RBB) dye. Fig. 1 depicts the structure of RBB, and the stock solution (1000 mg/L) was prepared with distilled water and stored at 4 °C. The desired quantity of dye solutions were used in the experiments.

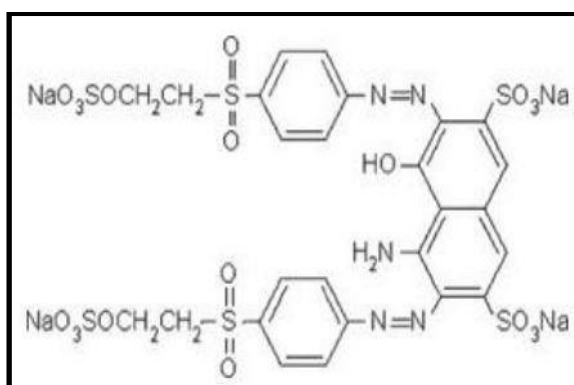


Figure 1. The structure of RBB [8]

### Biosorbent preparation

Orange peel waste was gathered from the orange juice producer wastes and used as a biosorbent. The obtained peels were first dried overnight at 100°C in an oven and given Fig. 2. The grinder was used to pulverize the dried peels. Surfactant coated orange peel biosorbent is prepared according to Gül and Yildiz (2020) [7]. Both orange peel and surfactant-coated orange peels were utilized as biosorbents in this study.



Figure 2. The drying of obtained OP

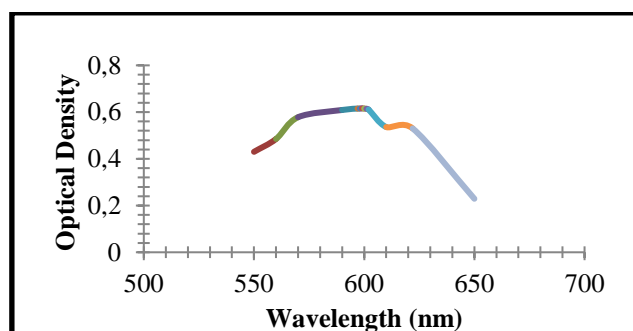
### Biosorption experiments

10 mL of dye-containing solutions were used in each experiment, which was conducted in 20 ml Erlenmeyer flasks. To determine the effect of solution pH on dye biosorption, tests were conducted at various pH levels, including 2, 4, 6, 8 and 10 (the pH of the solution was adjusted using 1 M HCl or NaOH). Orange peel and surfactant-coated orange peel were employed as the biosorbent types for the experimental solutions at a concentration of 1 g/L [9]. Additionally, a series of experiments were conducted to examine the effects of starting dye concentrations (12.5 ppm, 25 ppm, and 50 ppm), biosorbent dosage (0.5, 1, 2, and 4 g/L), and temperature (25° and 50°C). Every experimental series were carried out twice.

### Analytical method

The samples were taken at the end of each experiment and the quantity of RBB dye in the supernatant was determined using a spectrophotometer (Labomed INC. 22 model spectrophotometer). The RBB dye

solution's maximum wavelength was determined by scanning it between 550 and 650 nm. By measuring the absorbance at 600 nm (Fig. 3), the wavelength at which dye shows its greatest absorption peak, and the quantity of RBB were ascertained. Fisher Brand, 12V DC centrifuge (6000 rpm) was used to centrifuge the samples (2 mL) for three minutes. For dye analysis, the supernatant was employed.



**Figure 3.** The UV spectrum of RBB

Using Equations (1) and (2), the dye biosorption rate was estimated as a percentage; The percentage of dye biosorption rate;

$$(B \%) = (C_o - C_f) / C_o \times 100$$

**Equation 1**

Following are the formulas used to determine the amount of dye is absorbed by a unit mass ( $q_m$ ) at any particular time ( $q_m(\text{mg/g})$ ):

$$(q_m) = (C_o - C_f) / X_m$$

**Equation 2**

$C_o$ : the initial dye concentration (mg/L)

$C_f$ : final dye concentration at any time (mg/L)

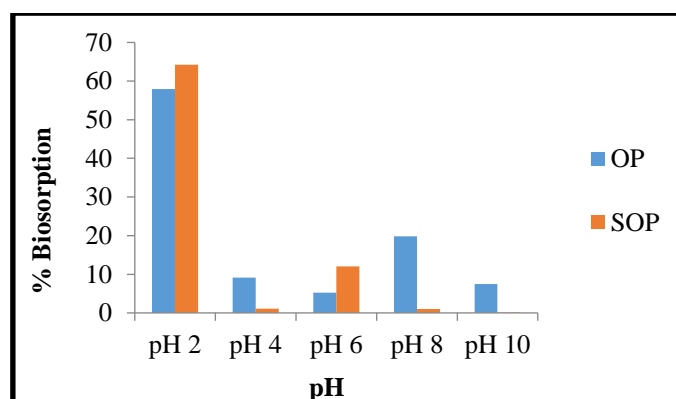
$X_m$ : the amount of biosorbent (g/L)

## Results and Discussion

At the batch scale level, the effects of pH, starting dye concentration, temperature, and biosorbent dosage were examined.

### *The effect of pH and contact time*

The amount of dye ionization and the mechanical contact between the dye and ionic charge of the functional groups on the adsorbent surface are both impacted by the pH of the solution. Different pH (2, 4, 6, 8, 10) values were used to examine the impact of pH on RBB biosorption of both 1 g/L orange peel and surfactant-coated orange peel at 25°C in a orbital shaker (SHO-1D, Daihan Scientific). The results of the studies on RBB biosorption by dried organic waste peels (simply and surfactant-coated) are shown in Fig. 4. The highest dye biosorption rates and capacities for all dried biosorbent types were observed at pH 2. By raising pH levels, the dye biosorption rate of all biosorbents was reduced (Fig. 4). Similar to this, Fernandez and Murguía (2020) demonstrated that tartrazine (acid yellow 23) dye biosorption onto modified peanut shell was decreased when the pH values were increased and claimed that the pH 2 value was the optimal one for dye removal [10]. At pH 2, the highest biosorption capacity of the orange peel and surfactant-coated orange peel was 36.65 mg/g and 48.73 mg/g, respectively. The RBB dye biosorption capabilities of all bio-sorbents at various pH values are shown in Table 1. Also, biosorption efficiencies in percent are; 57.9% and 64.3%. According to a study conducted in the literature, it was stated that the removal capacity of basic blue 9 dye was higher in orange peels modified with surfactant [11].



**Figure 4.** pH's impact on the biosorption of dyes (%)

**Table 1.** The ability of each biosorbent to adsorb RBB dye (qt: mg/g) at various pH levels

pH	OP* qm (mg/g)	SOP** qm (mg/g)
2	36,65	48,73
4	6,53	0,74
6	3,96	11,15
8	18,12	0,88
10	5,96	0,08

\* Orange peel

\*\* Surfactant coated orange peel

Over time, dye biosorption rates have risen. At minute 1440, the maximum dye biosorption rate was attained, and at all pH levels, there was no further discernible change.

#### **The effect of initial dye concentration**

At pH 2 and 25°C, the effect of the initial dye concentrations—8.80, 12.92, and 16.96 mg/L—was studied. The highest biosorption capacity of the orange peel and surfactant-coated orange peel was 7.08 mg/g and 7.27 mg/g with the dye concentration of 8.80 mg/L. In other words, as the dye concentration increased, the biosorption efficiency decreased. All the results are shown in Table 2. Also, biosorption efficiencies in percent are; 80.35% and 82.53%, respectively. Different dye concentrations have been studied in the literature; Jasper et al. (2022) studied different concentrations of Rhodamine 6G dyes (20, 30, 40 and 50 mg/L) dye, Öztürk et al. (2020) studied 44, 57, 83, 113 and 223 mg/L dye concentration [12]-[13].

#### **The effect of biosorbent dosage**

Different dosages of biosorbent (0.5g/L, 1 g/L, 2 g/L, and 4 g/L) were examined to see how they affected the RBB biosorption by orange peels, at 25°C in an orbital shaker and 8.80 mg/L dye concentration. Table 2 provides the experiment's outcomes. Biosorption effectiveness was reduced as the amount of biosorbent increased (Table 2). According to the literature, while the adsorbent dosage was increased, consequently the number of active sites on the adsorbent for dye sorption increased [14]-[15]. Contrary to the literature, as the amount of biosorbent increases, we can consider the decrease in yield as the discoloration of orange peels. Orange peels had a maximum dye biosorption rate (BR%) with a biosorbent content (1 g/L) of 81.48% and 82.53%, according to the study's findings.

**Table 2.** The RBB dye biosorption capabilities of all biosorbents at various biosorbent dosages

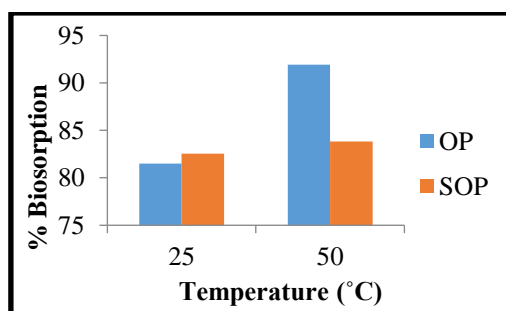
Biosorbent Dosage (g/L)	OP* BR%	SOP** BR%
0,5	75,55	78,60
1	81,48	82,53
2	81,01	77,29
4	68,77	50,87

\* Orange peel

\*\* Surfactant coated orange peel

### The effect of temperature

At two distinct temperatures (25°C and 50°C), the impact of temperature on dye biosorption was examined. Orange peel's RBB biosorption was determined to be 81.48% at 25°C and 91.92% at 50°C as a result of temperature (Fig. 5). The biosorption efficiency is seen to increase by about 10% as the temperature rises. In their biosorption studies, Dey et al. (2022) used mango leaves as biosorbents and noted that when the temperature was raised, the efficiency was 100% [16]. The increased temperature was no observed to have a variable impact on the RBB biosorption of surfactant-coated orange peel (Fig. 5). Surfactant-coated peel biosorbent determined that the RBB dye biosorption rate was 82.53% at 25°C and 83.84% at 50°C (Fig. 5). Because there was no discernible variation in these biosorption rate values, the dye biosorption by surfactant-coated orange peel was independent of the surrounding temperature. The removal abilities of the biosorbent created by the cationic molecule HTAB and the anionic orange peel (SOP) and orange peel (OP) biosorbent are not significantly different.

**Figure 5.** The effect of temperature on dye biosorption (%)

### Conclusion

The biosorption capabilities of Remazol Black B dye were examined in this work using orange peel and surfactant-coated orange peel. The parameters of pH, contact time, dye concentration, biosorbent dosage and temperature were examined. The optimum settings were pH 2, 1440th minute, 12.5 ppm dye concentration, 1 g/L biosorbent quantity and 50°C for both simply orange peel (max. yield 91.92%) and surfactant orange peel (max. yield 83.84%). The literature contains studies on the use of various agricultural wastes as low-cost adsorbents [17]. Malachite green has an adsorption capacity of 0.53 mg/g, according to Srivastava and Rupainwar's (2011) study, which used mango peel as an adsorbent [18]. When grape skin was used as an adsorbent to remove the dye known as Reactive blue 19, Abassi and Razzaghi (2009) found that it has a 12.53 mg/g removal capacity [19]. This study's findings indicate that the removal efficiency the suggested biosorbent has higher efficiency to that of examples in the literature. The adsorption capacities of OP and SOP were 36.65 and 48.73 mg/g, respectively.

The studies' findings suggested that the easily accessible and reasonably priced wasted orange peel might be employed in biosorption technique to remove dyes at lab-scale level. Both OP and SOP can be good candidates used as biosorbents in decolourization process for further industrial scale.

### References

- [1] San, N. O., (2007): Ağır Metal ve Boyar Madde İçeren Atıksuların *Rhodotorula sp.* ile Arıtımı. M. thesis, Ankara University Institute of Science and Technology Department of Basic Biotechnology, Ankara, Turkey.

- [2] Fu, L. Y., Wen, X., Xu, L. and Qian, Y. (2002): Removal of a copper-phthalocyanine dye from wastewater by acclimated sludge under anaerobic or aerobic conditions. *Process Biochemistry* 37: 1151-1156.
- [3] Azeez, R. A. and Al-Zuhairi, F. K. I. (2022): Biosorption of dye by immobilized yeast cells on the surface of magnetic nanoparticles. *Alexandria Engineering Journal* 61: 5213-5222.
- [4] Al-Zuhairi, F. K., Azeez, R. A., Mahdi, S. A., Kadhim, W. A. and Al-Naamee, M. K. (2019): Removal oil from produced water by using adsorption method with adsorbent a Papyrus reeds. *Engineering and Technology Journal* 37: 157-165.
- [5] Vieria, R. and Volesky, B. (2003): Biosorption: a solution to pollution?. *International Microbiology* 3: 17-24.
- [6] Liu, H., Chen, B, Lan, Y. and Cheng, Y. (2004): Biosorption of Zn(II) and Cu(II) by the indigenous *Thibacillus thiooxidans*. *Chemical Engineering Journal* 97: 195-201.
- [7] Gül, Ü. D. and Yıldız, Y. (2020): Yüzey Aktif Madde ile Modifiye Edilmiş Atık Yer Fıstığı Kabuğunun Tekstil Boyası Biyosorpsiyonu Kapasitesinin Belirlenmesi. *Turkish Journal of Agricultural and Natural Sciences*. 7: 533-539.
- [8] Aksu, Z. and Akin, A. B. (2020): Comparison of Remazol Black B biosorptive properties of live and treated activated sludge. *Chemical Engineering Journal* 165: 184-193.
- [9] Gül, Ü. D. (2013): Treatment of dyeing wastewater including reactive dyes (Reactive Red RB, Reactive Black B, Remazol Blue) and Methylene Blue by fungal biomass. *Water S. A.* 39: 593-598.
- [10] Fernandez, M. E. (2020): Biosorption of an anionic dye by peanut shell modified with gemini surfactants: A study on the stability of the modification and the removal efficiency. *Journal of Molecular Liquids* 317: 1-8.
- [11] Khalili, H. et al., (2022): Recyclable magnetic orange peel residues modified by anionic surfactant for basic blue 9 removal: Experimental study and machine learning modeling. *Materials Today Communications* 33.
- [12] Jasper, P. M., Sumithra, S., Ahammad, S. J. and Madakka, M. (2022): Exploring biosorption properties of Litchi chine sis peel for a cationic dye Rhodamine 6G in Liquid/Solid phase system: Kinetics and equilibrium studies. *Watershed Ecology and the Environment* 4: 66-72.
- [13] Öztürk, A., Bayol, E. and Abdullah, M. I. (2020): Characterization of the biosorption of fast black azo dye K salt by the bacterium *Rhodopseu domonas palustris* 51ATA strain. *Electronic Journal of Biotechnology* 46: 22-29.
- [14] Molu, Z. (2020): Bir Antibiyotik olan Trimetoprimin Sütunlu Kil ile Sulu Ortamdan Uzaklaştırılması. *Dokuz Eylul University Faculty of Engineering Journal of Science and Engineering*. 22: 949-963.
- [15] Kahraman, H. T. and Edebali, S. (2016): Organo-Modifiye Nanokilin Alternatif Bir Adsorban Olarak Atıksulardan Cr(Vi) Uzaklaştırılmasında Kullanımı. *Sujest* 4: 173-181.
- [16] Dey, S. Sreenivasulu, A., Veerandra, G. T. N., Manoj, A. V. P. and Haripavan, N. (2022): Synthesis and characterization of mango leaves biosorbents for removal of iron and phosphorous from contaminated water. *Applied Surface Science Advances* 11: 1-20.
- [17] Sharma, N., Tiwari, D. P. and Singh, S. K. (2012): Decolourisation of Synthetic Dyes by Agricultural Waste- A Review. *International Journal of Scientific & Engineering Research* 3: 1-10.
- [18] Srivastava, R and Rupainwar, D. C. (2011): A comparative evaluation for adsorption of dye on neem bark and mango bark powder. *Indian Journal of Chemical Technology* 18: 67-75.
- [19] Abassi, M. and Asl, N. R. (2009): Removal of hazardous reactive blue 19 dye from aqueous solution by agricultural waste. *Journal of the Iranian Chemical Research* 2: 221-230.