The Investigation of Removal of Remazol Red Dye using *Aspergillus terreus*

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Abstract:

Today a number of such industries as textile, paper and printing whose processes involve dyes discharge wastewater containing heavy pollution load directly into a receiving environment. Dyes, which are mutagenic and carcinogenic, spread across the receiving environment, threatening aquatic populations and human health severely. It is possible to reduce the contamination caused by these dyes by using biological methods.
In this investigation, the biosorption technique is utilized for the treatment of textile industry wastewater. In order to achieve optimum efficiency, the optimal pH (4-5-6), temperature (30-40-50 °C), biomass (0.025-0.05-0.1 g.) and stirring speed (75-100-125 rpm) were determined with the help of Taguchi L_9 orthogonal array design. During the biosorption process, the sorption capacity of *Aspergillus terreus* with remazol red dye measured 16,4 (mg/g) and the removal efficiency measured % 75.3 in conditions of pH 4.0, temperature 30 °C, biomass 0.1 g. and the rotational speed 125 rpm.

Key words: *Aspergillus terreus*, Biosorption, Remazol Red, Water pollution, Wastewater.

1. Introduction

Since ancient times, dyes play an important role in human history. Dye, mechanism of action and in terms of adhering to the wastewater from the treatment of waste are chemicals that have occurred. When they are discharged to receiving waters without treatment because they have, highly toxic they cause serious problems [1]. The realization of photosynthesis by blocking the sunlight are significantly affected. Decolorization of dyes formed to dissolve oxygen concentration is very important. Aromatic stable complex molecular structures and synthetic origin is difficult to dye in biodegradation. These substances, chemicals, high temperatures, and exhibit resistance to light degradation of the enzyme. Pharmaceutical, oil, textile, paper, printing, steel, coke, waste water in many industries, such as pesticides and paint contains high amounts of organic chemicals. These are the dyes are an important group of organic pollutants [2].
The most widely used commercially are azo dyes. Azo dyes are not easily degraded by microorganisms is present in approximately 60-70 % of textile waste. The dissolution of these dyes in solution is difficult to treatment with conventional treatment methods. The main reasons for the commercial use consisting of bright color, is that the low cost and simple to use. Even at low concentrations, they change the aesthetic property by lowering the solubility of the water. Resolution is affected by a decrease in photosynthetic activity; life in the aquatic environment is adversely affected [3].

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Dyeing process is carried out in the textile industry to impart color to the fabric and Characterization of the wastewaters, due to differences in chemical structure of the dye is quite difficult. Treatment of present dyes are made with substantially the physical and chemical methods. However, the cost of this method is high and problems in the disposal of the resulting sludge is concentrated there. Therefore, it is a good way to physical and chemical purification biological treatment alternative to the use of my bulky waste removal of dye in the waters cheaply than effective and economically. The ability of bacteria [4], fungi [5], and the others biological materials to degrade dye and mainly azo dyes has been successfully investigated. Besides this, determination of optimum process conditions (pH of solution, biosorbent dosage, agitation period, temperature etc.) is also mandatory to achieve maximum biosorption capacity [6].

Taguchi method designed by Dr. Genich Taguchi in the 1950s. Taguchi method different parameters, is a useful method for determining the best combination of different levels. Each parameter requires a lot of experimental work for all combinations with each level. In these cases, much less using the Taguchi method it is possible to achieve the result by the number of experimental runs [7].

In this work, Taguchi design method was used to optimize Remozal Red biosorption by using *Aspergillus terreus*. With this aim firstly, Tacughi's L_9 experimental design was created and impacts of process variables (pH, biomass, temperature and stirring speed) on biosorption capacity were analyzed. Within the paper, experimental data were also applied to the removal efficiency and biosorption capacity.

2. Materials and Method

2.1. Preparation of biosorbent

The fungi was isolated automotive industry wastewater. The pure culture was maintained on the potato dextrose agar at 4 °C. *A. terreus* was grown in the potato dextrose broth for 7 days and the biomass collected by filtration through Whatmann filter paper No.1. The biomass was thoroughly washed with distilled deionized water to remove residual growth medium. The washed biomass (live biomass) was used immediately thereafter and then stored refrigerator for experiments.

2.2. Preparation of dye solution

The textile reactive dye Remazol Red (RR) (Fig. 1) was used in the experiment. RR is molar weight of 875 g/mol. RR stock solution (1g/L) was prepared by dissolving an appropriate weight amount of RR in 1 L ultrapure water. The experimental solutions of desired initial concentrations were by dilution of RR stock solution with ultrapure water. The maximum absorbance wavelength (λmax) of RR was found to be 543 nm usind UV-vi spectrometer (Hach, model DR 5000).

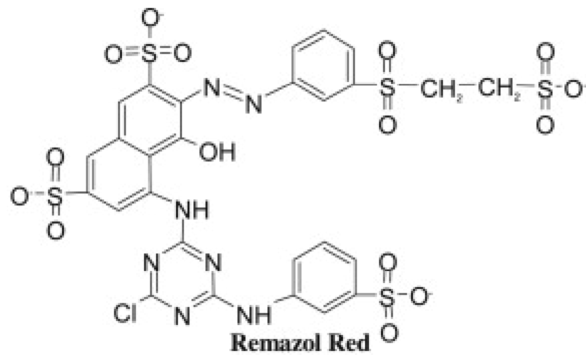

Figure 1. Structure of Remazol Red.

2.3. Batch biosorption experiments

Batch adsorption experiments were carried out in 100-mLErlenmeyer flasks containing 50 mL of RR solution (50 mg/L), and different biomass quantity, pH and temperature and stirring speed. The flasks were shaken in an orbital shaker 24 h. Controls without *A. terreus* were incubation under the same condition. All of the experiments were carried out in triplicate. The supernatant was collected measurements with UV-vis spectrophotometer (Hach, DR 5000). The amount of RR adsorbed per unit weight of *A. terreus* biomass at equilibrium, *qe* (mg/g), and percentage dye removal (*R*%), were calculated with the following equations:

$$qe = \frac{(Co - Ce)}{X} \qquad (1)$$

$$R = \frac{100(Co - Ce)}{Co} \qquad (2)$$

where C_0 (mg/L), C_e (mg/L) and *X* (g/L) are the initial RR concentration, the RR concentration at equilibrium and the sorbent concentration in the solution, respectively.

2.4. Design of experiments process

Experiments intended purpose of design or investigational results and any deviations from these results correctly analyze and plan the experimental group used effectively. For this purpose, various experimental design matrices were created. Tacughi L_9 experimental design is one of them. As known pH, biomass, concentration, rotational speed and temperature are among the most important factors in adsorption processes. Three levels were selected for each of the studied factors (pH:4.0, 5.0, 6.0, biomass: 0.025, 0.05, 0.1 g, temperature: 30, 40, 50 °C, stirring speed: 75, 100, 125 rpm). The ranges and the levels of the variables studied in this research are shown in Table 1.

Table 1. Factors and levels used in the Tacughi's L_9 experimental design

Independent variable	Levels		
pH	4	5	6
Biomass (g)	0.025	0.05	0.1
Temperature	30	40	50
Stirring speed	75	100	125

Optimization process and required calculations were performed by using Minitab 17 software package and Microsoft Excel 2010.

3. Results

3.1. Taguchi L_9 Experimental Design Results

Tacughi L_9 experimental design with an effect on the biosorption pH sorbents content, temperature and stirring speed values were determined. Each of the control factor 3 level. In order to fully determine the impact of these three levels of four factors in normal conditions should make $3^4 = 81$ experiments. This experimental design as in the orthogonal array on the experimental conditions needed to achieve optimum efficiency with much less number of experiments with the use was investigated. The most appropriate factors to provide optimum efficiency; pH (4-5-6), temperature (30-40-50 °C), the amount of biomass (0.025-0.05-0.1 g.) and stirring speed (75-100-125 rpm) were determined between. If the factor graph interactions determined using graphs in Figure 4.2 to ensure optimum efficiency and values are given in Table 4.1.

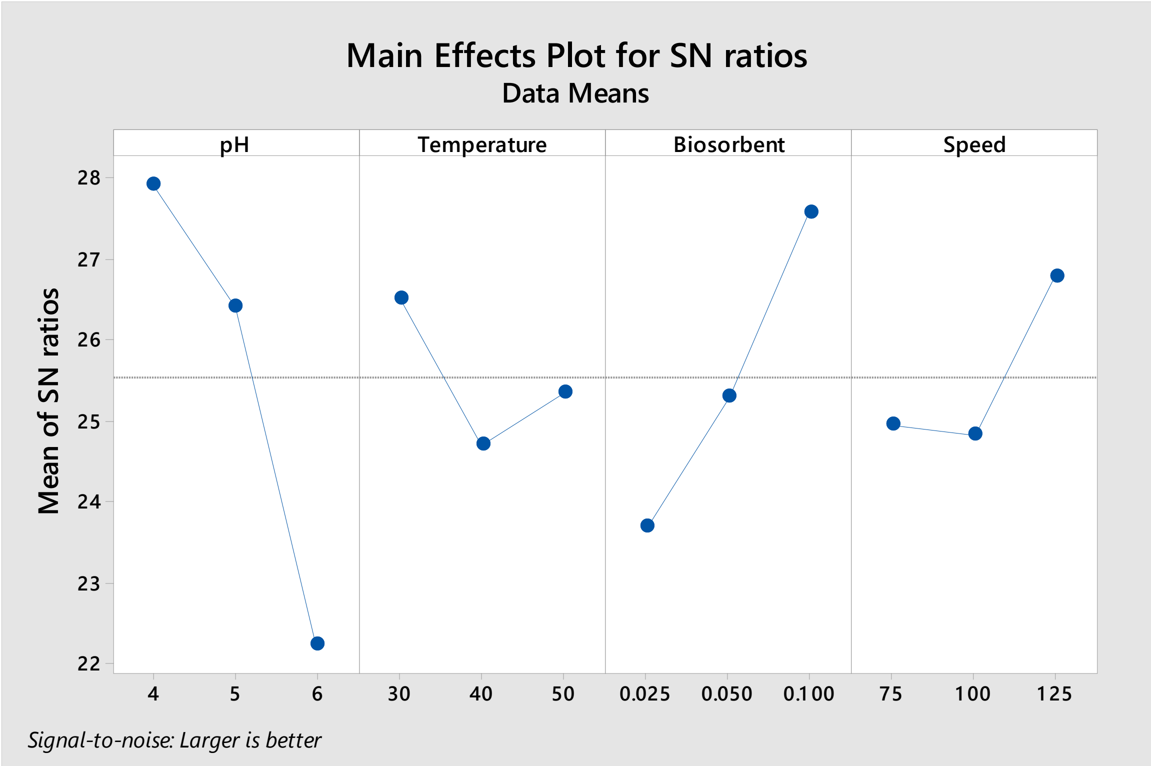

Figure 2. Taguchi L_9 experimental design factors interact graph

Table 2. Optimal experimental conditions

Parameters	data
Biomass	0.1 g
pH	4
Temperature	30 °C
Stirring speeed	125 rpm

3.2. Effect of contact time on biosorption

The effect of contact time on biosoption of Remazol Red by biomasses from *A. terreus* was carried out by varying time from 1 to 7 day. From Fig. 3, it can be seen that the percentage removal decreased after 5^{th} day. Therefore, in this study performed 5 day.

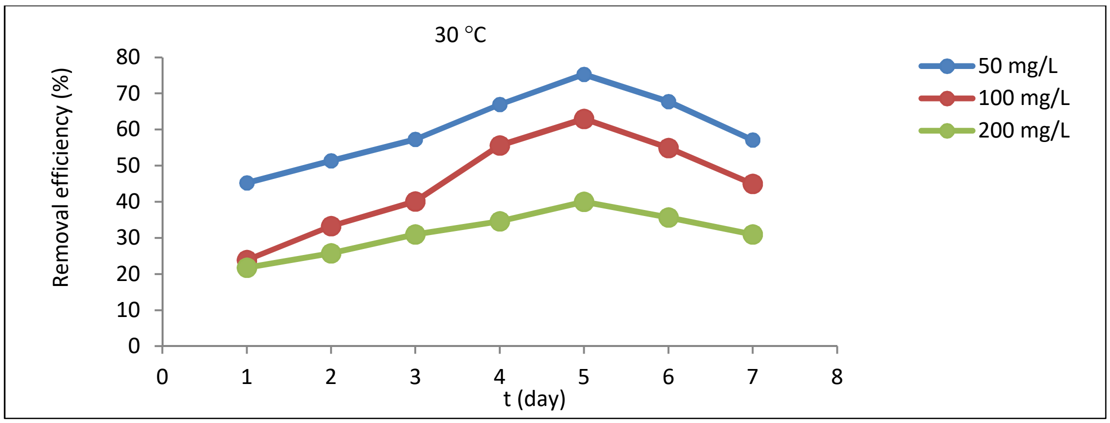

Figure 3. Effect of contact time on RR biosorption onto *A. terreus* at three different initial RR concentrations (biomass= 0.1 g., pH==4, stirring speed=125 rpm)

3.3. Effect of initial concentration and temperature on biosorption

Biosorption experiments were carried out at three initial RR concentrations (50-100-200 mg/L) and at temperature (30-40-50 °C). Removal efficiency of RR with *A. terreus* was decreased with increased initial concentration and temperature.

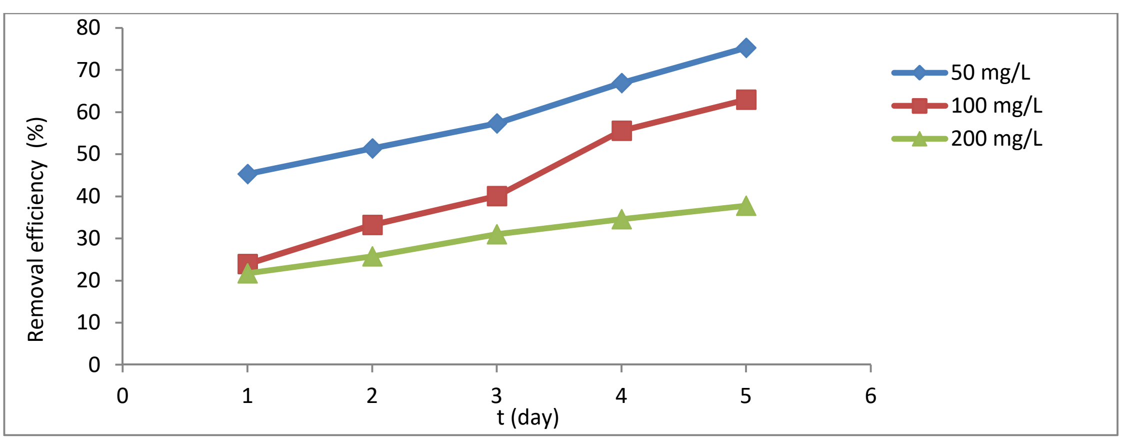

Figure 4. Influence of initial dye concentration and temperature on removal efficiency
(T= 30 °C, biomass= 0.1 g., pH==4, stirring speed=125 rpm)

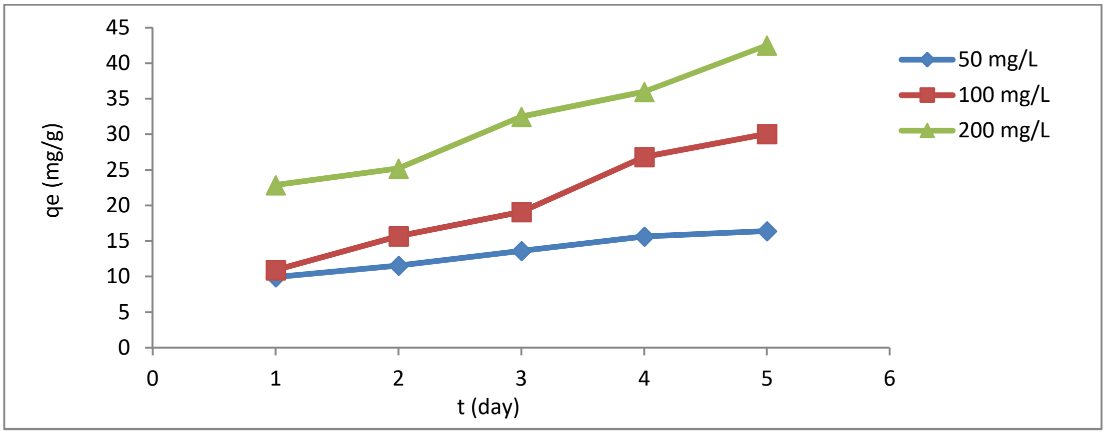

Figure 5. Influence of initial dye concentration and temperature on biosorption capacity
(T= 30 °C, biomass= 0.1 g., pH==4, stirring speed=125 rpm)

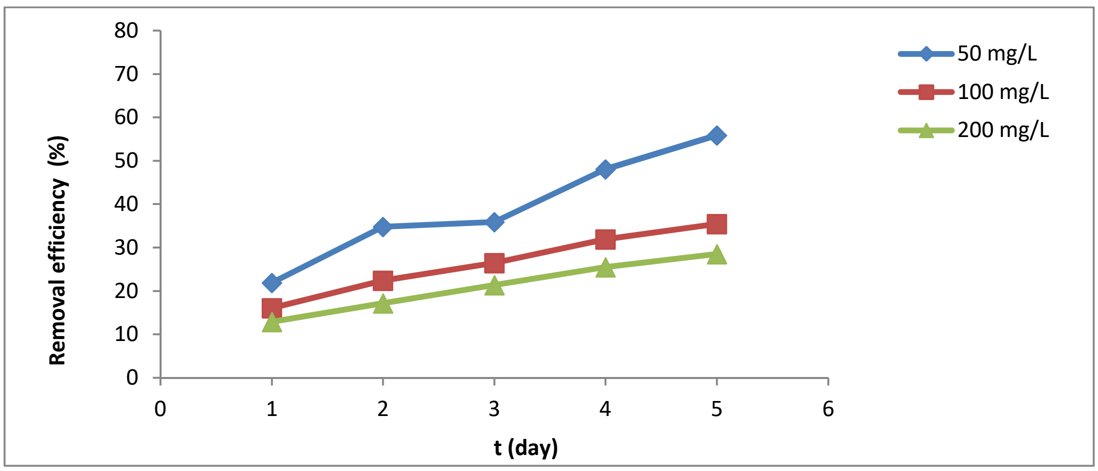

Figure 6. Influence of initial dye concentration and temperature on removal efficiency
(T= 40 °C, biomass= 0.1 g., pH==4, stirring speed=125 rpm)

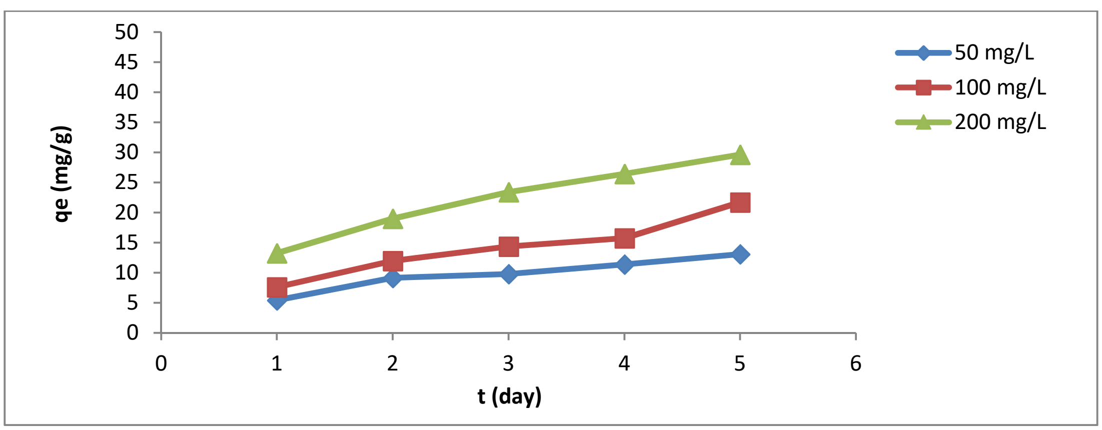

Figure 7. Influence of initial dye concentration and temperature on biosorption capacity

(T= 40 °C, biomass= 0.1 g., pH==4, stirring speed=125 rpm)

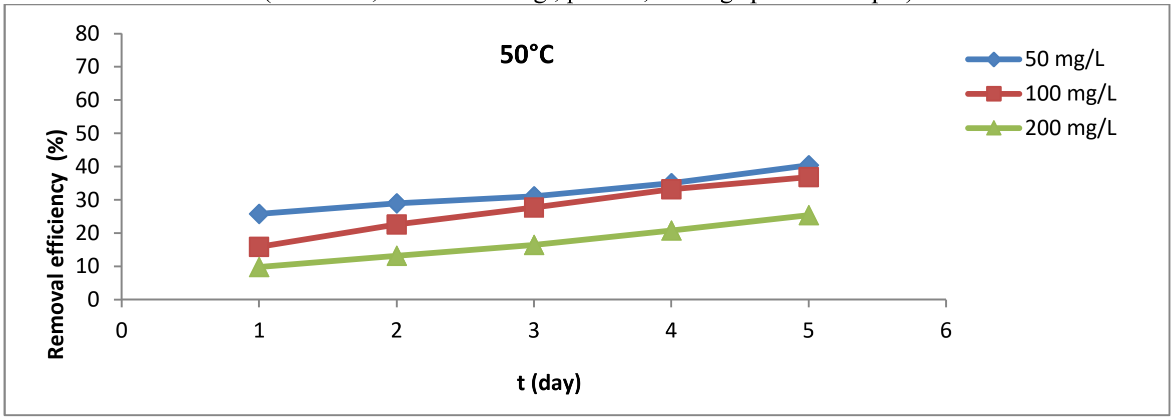

Figure 8. Influence of initial dye concentration and temperature on removal efficiency
(T= 40 °C, biomass= 0.1 g., pH==4, stirring speed=125 rpm)

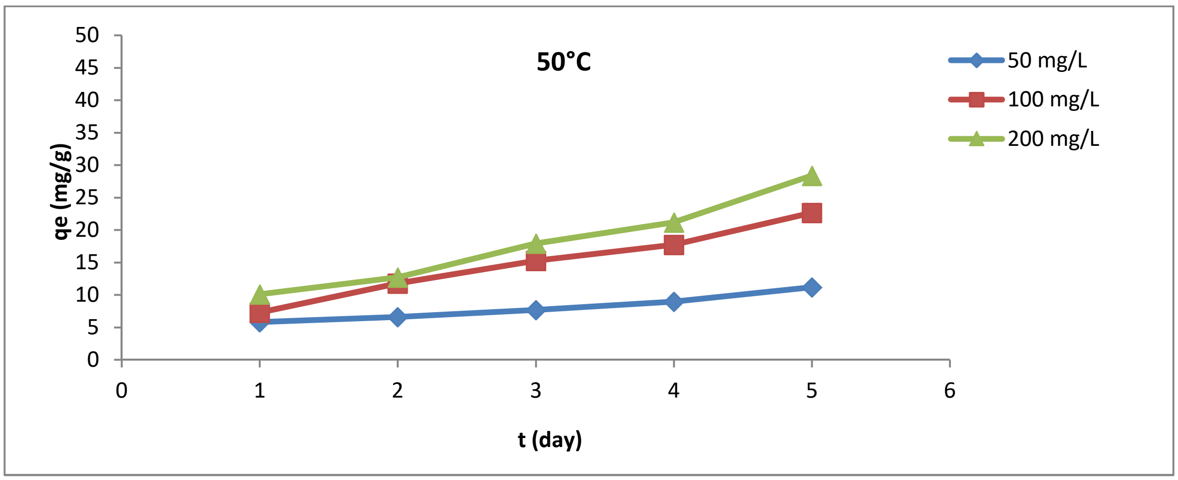

Figure 9. Influence of initial dye concentration and temperature on biosorption capacity
(T= 50 °C, biomass= 0.1 g., pH==4, stirring speed=125 rpm)

4. Discussion

This study demonstrates the usefulness of Taguchi L_9 experimental design to model remozal red biosorption from aqueous solutions by *A. terreus* biomass. The most significant factors affecting remozal red removal efficiency were pH, biomass, temperature and stirring speed. The selected model was adequate to represent the response surface and to obtain the optimal conditions for remozal red biosorption by *A. terreus* from aqueous solution; these were pH 4.0, 0.1 g of biomass, 30 °C and 125 rpm. At these conditions, remozal red removal efficiency was 75.3% and biosorption capacity 16.4 mg/g.

Biosorption work of finding the cause of the textile industry wastewaters in the light of the dye adsorption method for the elimination of pollution by *A. terreus* has proved to be a good sorbents. Remazol Red dye is not only for the material for the adsorption of other dyestuff sides may be used as an alternative adsorbent.
Given that, 700,000 tons of paint per year if the textile industry is one of the most polluting industries produce environmentally. Industrial effluent treatment plants with these dyes, dissolved oxygen content of 10% of the receiving environment because of living in the discharge of water along with the reduction affects the health of the community live. Dye, only made the post-production of wastewater treatment not because they cause damage to human health is extremely important to the aquatic ecosystem. Biological treatment methods, in addition to physical and chemical methods are both more environmentally friendly and more economical.
As a result, to reduce the treatment cost and can be effectively carried out the removal of pollution caused by dyes biosorption method is a method of biological treatment plant. In the direction of the mold *A. terreus*, suitable sorbents pollution would be useful as dyes used in removal. The contact time specified in the assay process, the pH is beneficial to the dye quantity and temperature parameters of subsequent biosorption operation. Nowadays, quite common dyes containing both the efficiency of the work presented as an alternative to the difficulties encountered in wastewater treatment has been judged positive benefits for both economies.

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References

[1] Priyaragini S, Swetha D, Kumar G, Bhaskara Rao KV. Evaluating the effectiveness of marine actinobacterial extract and its mediated titanium dioxide nanoparticles in the degradation of azo dyes. J Environ Sci 2014; 26:775-782.
[2] Chakraborty S, Basak B, Dutta S, Bhunia B, Dey A. Decolorization and biodegradation of congo red dye by a novel white rot fungus *Alternaria alternata* CMERI F6. Bioresource Technol 2013; 147:662-666.
[3] Almeida EJR, Corso CR. Comparative Study of Toxicity of Azo Dye Procion Red MX-5B Following Biosorption and Biodegradation Treatments with the Fungi *Aspergillus niger* and *Aspergillus terreus*. Chemosphere, 2014;112:317-222.
[4] Lu L, Zhao M, Wang TN, Zhao LY, Du MH, Li TL, Li DB. Characterization and dye decolorization ability of an alkaline resistant and organic solvents tolerant laccase from *Bacillus licheniformis* LS04. Bioresource Technol 2012; 115: 35-40.
[5] Sivasamy A, Sundarabal N. Biosorption of an Azo Dye by *Aspergillus niger* and *Trichoderma* sp. Fungal Biomasses. Curr Microbiol 2011; 62:351-357.
[6] Cerino-Córdova FJ, García-León AM, Soto-Regalado E, Sánchez-González MN, Lozano-Ramírez T, García-Avalos BC, Loredo-Medrano JA. Experimental design for the optimization of copper biosorption from aqueous solution by Aspergillus *terreus.* J Environ Manage 2012; 95:577-582.

[7] Ozdemir U, Ozbay B, Ozbay I, Veli S. Application of Taguchi L_{32} orthogonal array design to optimize copper biosorption by using Spaghnum moss. Ecotox Environ Safe 2014; 107:229-235.