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Research Article

Biosorption Reactive Orange 16 Dye from the Aqueous Environments by Brown seaweed Sargassum glaucescens

Moradi Ebrahim[1], Doleh Mohammad[2],
Porbahri zahra[3]and Zazouli Mohammad Ali [4]
[1]Master of environment Engineering-Islamic Azad University-Bandar Abbas branch-Bandar Abbas- Iran
[2,3]Master of environment Engineering- Hormozgan University of medical sciences, Bandar Abbas- Iran
[4]Department of Environmental Health, School of Health **and** Health Sciences Research Center, Mazandaran University of Medical Sciences, Sari, Iran
Ebi_mrd@yahoo.com

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ABSTRACT

Background and purpose: Dyes are oneof the most important environmental pollutants in industrial wastewaters. Due to the complex molecular structure, toxic removal of the pollutant is always challenging. This study aimed to evaluate the efficiency of Sargassum glaucescens in the adsorption of ReactiveOrange16 dyein aquatic environments.
Materials and Methods: This research was a lab study. S. glaucescens was used as an adsorbent to remove dye Reactive Orange 16. The effect of various parameters such as pH, initial dyes concentration, adsorbent dose, contact time, Equilibrium Isotherm were studied. Concentration was measured in the wavelength of 526 nm by spectrophotometer.
Results: The results showed that removal of the dye increases by increasing the amount of absorbent and contact time, and decreases by increasing PH solution and initial concentration of dye. The equilibrium constant was consistent with both Freundlich and Langmuir isotherm but it was more consistent with Freundlich isotherm (R^2: 0.989).
Conclusion: This study showed that Sargassum glaucescens having high absorption capacity, was economic and could be effective as an absorbent in water treatment especially in the removal of dyes from waste and textile sewage and other manufacturing industries and dye consumption.

Keywords: Biosorption, Brown seaweed, Reactive Orange 16, Sargassum glaucescens, Wastewater Treatment

INTRODUCTION:

Dyes are of the most dangerous groups of chemical compounds found in industrial effluents Presence Dyes pollutants even at levels less than 1 mg/L appearance is visible and important(1).Public acceptance and aqueous solution are greatly influenced by the dye and dye is the first contamination which is detected in water the use of synthetic dyes is constantly increasing in various industries (textile, paper, rubber and plastic, cosmetic, pharmaceutical and food industries) due to ease of use, low cost of synthesis and chemical stability in comparison with natural colors(2,3,4).Azo dyes are one of the most important group of artificial dyes which have a greater number of Azo bond of –N-N(5).They are used in many textile industries because of low price, high solubility and high stability. These dyes and their intermediate products are toxic, carcinogenic and mutagenic to aquatic life. The industrial effluents contain dye require to be treated with a suitable method before discharge to the environment (6). Reactive dyes are water-soluble and anionic dyes and used to a large extent in various industries, especially in textile industry, due to easy use and low energy consumption Reactive dye of orange 16 with chemical formula: $C_{20}H_{17}N_3Na_2O_{11}S_3$ and molecular mass: 617.54 is of the most used dyes of Azo group (7).

There are several physical methods such as coagulation, adsorption, and filtration … to eliminate and reduce the dyes in industrial effluents (8, 9). In order to treat the effluent containing dyes, some of these methods are naturally limited because of economic efficiency, energy consumption, be harmful, production of toxic sludge or waste products. The methods such as biological accumulation and biodegradation are proposed as the methods with good capacity to remove dyes from effluents (3, 5).Brown algae are one of the biggest groups of macro-algae which are found in most regions of the world and also Iran abundantly. Sargassum is also one of the most famous abundant groups of brown algae that grows in tropical regions (10, 11).

In this study the biomass potential of Sargassum algae has been investigated as a low-cost and abundant adsorbent of Oman and Persian Gulf to absorb the reactive dye of orange 16 from aqueous solutions.

MATERIALS AND METHODS:

The Reactive dye of orange 16 is a single Azo dye. The used dye was the analytical grade which was purchased from company "AlvanSabet/Iran. The chemical structure of the used dye is shown in figure 1. Also some properties of used dye are given table 1.

The dye concentration was measured by the ultraviolet (UV) - visible spectrophotometer (model UV - 1700) at a wavelength of 526 min(12). Hydrochloric acid and sodium hydroxide were used for pH adjustment. The algae that have been collected Washed with ordinary tap water they were rinsed with distilled water and after that they were exposed to the sunlight in order to dry. Then, the dried biomass was activated by using 0.1 M hydrochloric acid for 5 h. after that it was washed 3 times with the distilled. Water that has gone through distillation twice, and it was exposed to sunlight in order to dry again. Moreover, then by using a 10-18 mesh sieve, the biomass was turned to the sizes 1-2 mm and was prepared to be used.. In order to determine the optimum pH by keeping constant other variables, the Experiments will be done in 200 ml beaker with a constant concentration of dye. Then this combination was shaken with a shaker device of enforce model with 175 rmp and room temperature. In the first stage, the pH optimum was obtained by keeping constant the other variables. After that, the optimum dose of absorbent was obtained. Finally, the effect of contact time on efficiency was reviews. The equilibrium experiments of adsorption process will occur after the determination of equilibrium time in Order to evaluate the effect of adsorbent mass on dye removal to obtain the adsorption isotherms. In order two models of Langmuir and Freundlich were used to investigate absorption isotherms.

RESULTS:

The effect of pH:

Absorption test with colored solution with different pH were performed by fixing other laboratory conditions such as concentration of dye, absorption dose and contact time. The test showed that by changing the pH, the percentage of removal of dye will change (Fig. 2). It was observed that the removal efficiency decreases with increasing pH.

The effect of contact time:

The effect of contact time between the absorbent material and absorbed material is shown in Figure 3.

Bio sorption of reactive dye of orange 16 increased with increasing the contact time and reached equilibrium after 120 minutes. After this time, absorption or removal of dye by processed biomass is almost constant.

Effect of the initial dye concentration

The effect of the initial dye concentration on the adsorption efficiency was shown in (Figure 4).

Showed that by increasing the initial dye concentration, the adsorption efficiency has a

Decreases. The most adsorption was obtained in 25 mg/L of the dye concentration

Effect of adsorbent dose:

The results showed that the removal efficiency increase with increasing the dose of absorbent material (Fig.5). The results were achieved with mg of selected compounds in terms of grams per liter of absorbent material with different dose. The maximum and minimum removal was achieved at 10 mg/Land 2mg/L,respectively.

Investigation of absorption isotherm:

To determine the isotherm models, data from experiments was adjusted with linear model of Freundlich and Langmuir isotherms. The linear models of these two models are the equations of 1 and 2 The results are shown in Figure 6and7

$$\frac{1}{q} = \frac{1}{q_m k_{ads}} \left(\frac{1}{c}\right) + \frac{1}{q_m} \qquad (1)$$

$$\log q_e = \log k + \frac{1}{n} \log c_c \qquad (2)$$

Discussion and conclusion:

Effect of pH on removal of dyes:

One of the factors affecting the process of the absorption of dyes is pH that acts by impacting on the structure of dye and surface charge of absorbent material. According to the results, the removal efficiency decreases with increasing pH that the maximum absorption of Reactive Orange 16 was obtained at pH of 5. When pH increases to more than 5, the biomass has more negative charge and as a result, a smaller amount of anions were absorbed on it and the rate of absorption decreases. It can be justified that the efficiency of algae in acidic environment is more appropriate to remove the anionic dyes. These results are consistent with the results of the studies by Rasgar, Saghi, Shokoohi (13, 14, 15).

In the study on the removal of different of dyes with algae by the process of bio sorption by optimum pH was reported 1, 4 and 4.5, respectively that are consistent with this study (3, 5). Gholizadeh and Rastegar reported that the pH of 5 was appropriate in removing dye by different species of algae (13).

Effect of contact time

The results showed that the maximum percentage of absorption for reactive dye of orange 16 was obtained in the first 60 minutes and then it almost decreased steadily. The bio sorption of reactive dye of orange 16 increased by increasing the contact time and equilibrium was reached in 120 minutes. According to the studies by, Sivemni et al and Hajira et al on the removal of industrial dyes by different species of brown and green algae, the optimum time for the removal of dyes were reported 15 and 25 (16, 17). Mahmoud et al and their study on the removal of dye by biomass, reported that the optimum time was 60 minutes (8). Kermani et al. reported the optimum time was 60 minutes (18).

Effect of the dose of bio sorbent:

The results showed that the absorption of dye increased by increasing the absorbent material. The increase of bio sorption can be due to the increase of accessible surface for absorption (13, 19). Based on the results of this study, the maximum percentage of removal was observed at the concentration of 10mg/L and more than this amount, the percentage of removal was not appropriate due to high turbidity and the minimum removal was observed at the concentration of 2 mg/L. This study is consistent with the studies by Rasgar,Saghi, Shokohi , Kermani and Saravanan (13,14,,15,18,20).

Effect of the concentration of dye:

The results showed that the removal of reactive dye of orange 16 decreased by increasing the initial concentration of dye. It suggests that the adsorption greatly depends on the initial concentration of dye. According to the results, there is a linear inverse relation between initial concentration of dye and the percentage of removal by algae. It is consistent with the studies by Kermani, Malakotian (18, 21)

On the removal of metals by using algae and also the studies by, Rastegar, Shokohi (13, 15).

On the removal of dye by different types of algae and other bio sorbent materials such as palm fiber, coral and Azolla plant. Also, it is consistent with the studies by Tahir and Saravanan (17, 20).

Absorption isotherm:

Absorption isotherms are sorption properties and balanced data that describe how the contaminants react with absorbent materials and have a major role in optimizing the the use of absorbent materials.

Absorption equilibrium occurs when the amount of contaminant/ absorbed dye on the absorbent materials is equal to the amount of desorption. Data from tests were evaluated by the absorption isotherm models of Freundlich and Langmuir. The results showed that the absorption of reactive dye of orange 16 follows the isotherms of Freundlich. A better match of Freundlich isotherm model indicates that the absorption at the uneven surface had been done in terms of energy Freundlich isotherm is an empirical.

Table 2: shows the comparison of surveys conducted in connection with the removal of contaminants, especially dyes with process adsorption variables such as, pH, the adsorption, isotherms model of rate of removal of the separately was demonstrated**.**

CONCLUSION:

The results of this study showed that the method of bio sorption has been approved to remove environmental contaminants, especially dyes, in terms of technology and compared to the conventional method, can be economically feasible. However, more research needs to be done to use in practical scale. Due to the abundance, low cost, ease of preparation and revival of this type of adsorbent, the use of this kind of absorbent material can be justified.

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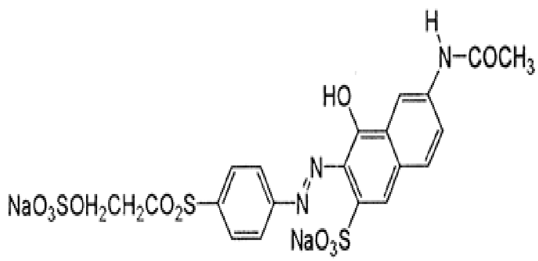
Table1. The properties of the Reactive Orange 16 Dye

Molecular formula	$C_{20}H_{17}N_3Na_2O_{11}S_3$
Class	Single AZO
Molecular Weight g/mol	:617.54
λ_{max} (nm)	526

Figure 1. Chemical structure Reactive Orange 16 Dye



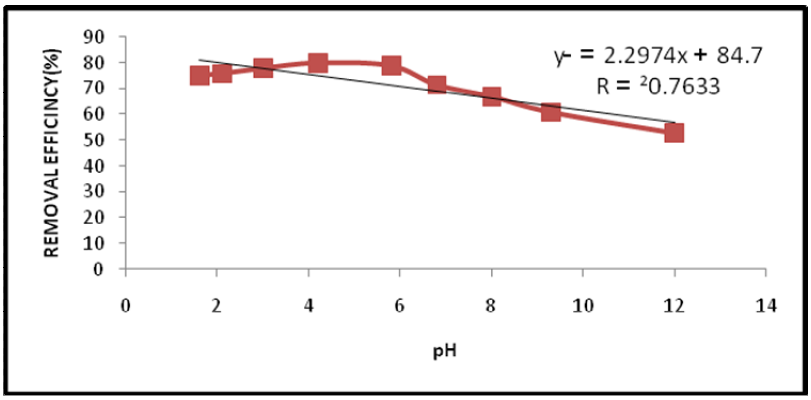


Figure 2. Effect of pH (T = 120 min, adsorbent 10 g/L dye con: 25 mg/L)

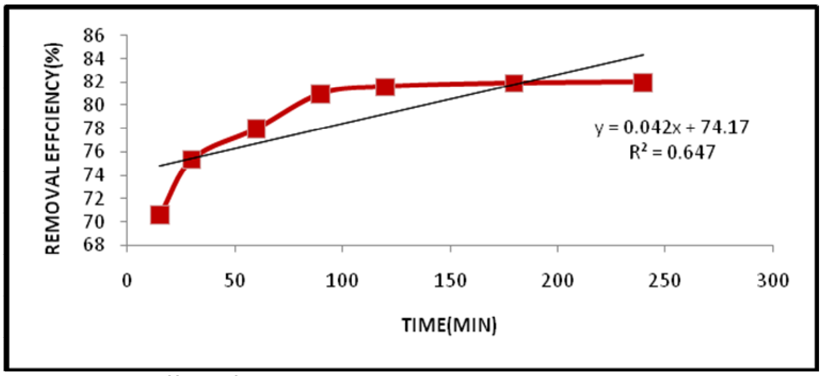


Figure 3. Effect of contact time (pH 5, adsorbent10 g/L, con: 25 mg/L)

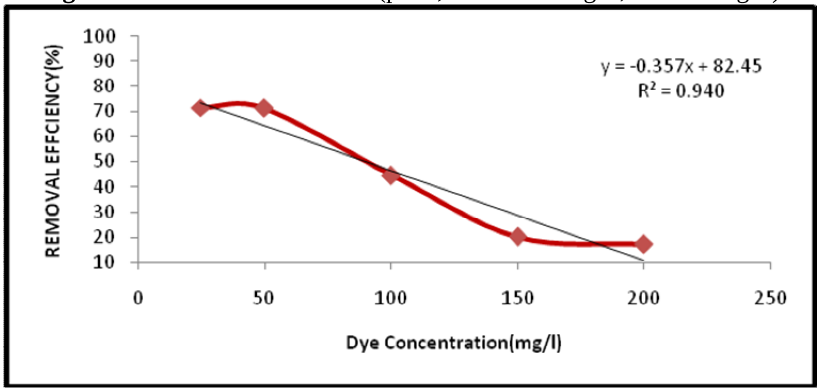


Figure 4. Effect of solute concentration (T = 120 min, adsorbent dosage 10 g/L, pH = 5)

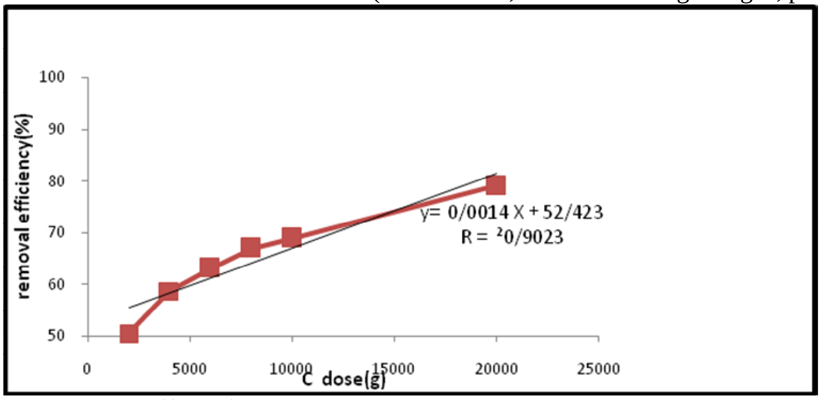


Figure 5. Effect of adsorbent dose (T = 120 min, pH = 5, con: 25 mg/L)

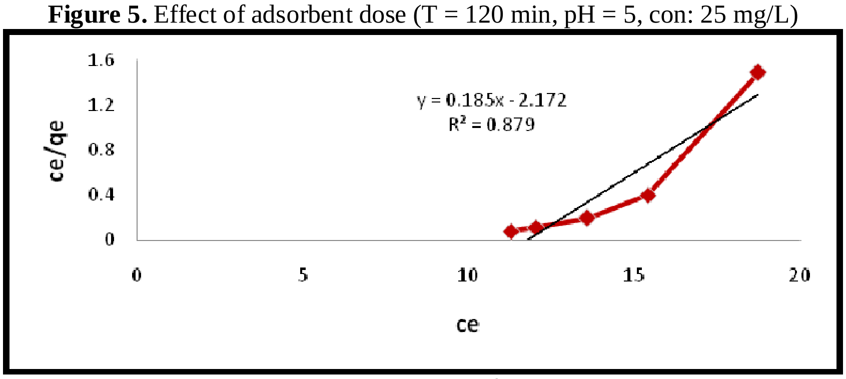


Figure 6. Langmuir isotherms fits the adsorption

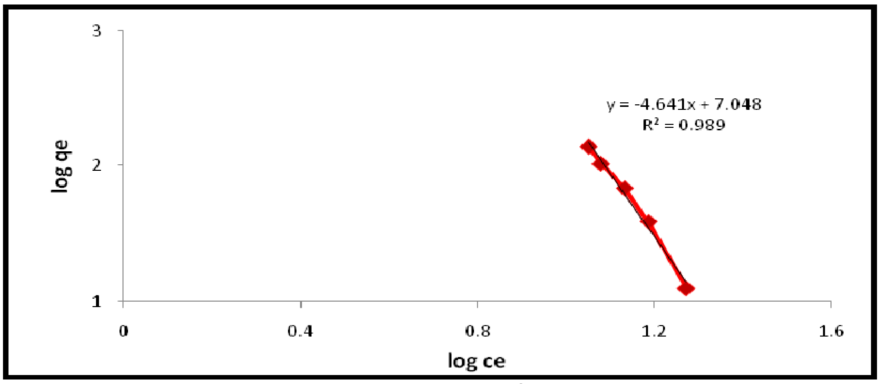


Figure 7. Freundlich isotherms fit the adsorption

Table 2. Comparison of the various adsorbents in contaminants removal a basis on literature reviews

Researcher	Year	Adsorbent	Contaminant	Optimum time min	optimal pH	adsorption isotherms
Aravindhan, et al(3)	2007	Green Alga	yellow dye	125	4.5	Freundlich
Tahir, et al(17)	2008	Brown Algae	methylene blue	25	7	Freundlich
Sivarajasekaret al (9)	2009	Spirogyra Algae	Brown dye	120	3	Langmuir
Sreeramanan et al.(20)	2010	Yam Leaf Fibers	Methylene Orang 7	45	3	Freundlich
Esmaeili et al(22)	2012	Sargassum	Cr (VI)	120	2	Langmuir
Zazouliet al(23)	2014	Azolla	Acid Black 1	120	2	Langmuir
Samarghandi et al(24)	2015	Active carbon	Acid Orange 7	180	3	-
moradi et al(25)	2015	Sargassum	Acid Red 18	120	6	Freundlich
Balarak et al(26)	2015	Lemna minor	Acid Red 88	60	3	Langmuir
Ahmed Nemr (27)	2015	Red Algae	chrome	120	10	Langmuir
Amouei et al(7)	2016	Sunflower Stem	Reactive Orange 16	120	3	-
Ingrid Johanna (28)	2106	Cu-TiO2	Acid Blue 80	45	1	Langmuir
Balarak et al(29)	2016	Azolla	Acid Green 3	90	3	Langmuir