AL-QADISIYAH JOURNAL FOR ENGINEERING SCIENCES

Vol. 11, No. 2
ISSN: 1998-4456

REMOVAL OF TERASIL BLUE DYE FROM SYNTHETIC WASTEWATER USING LOW COST AGRO-BASED ADSORBENTS

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Abstract: *Natural materials that are readily available in large amounts in nature and easily accessible may be used as low cost additives. The aim of this study is to measure the susceptibility of these locally available materials, conocarpus plant, to improve the quality of wastewater discharged from textile industry.*

In addition to conocarpus plant, carbonized conocarpus and activated carbon were used as adsorbents in order to make a comparison, and to test which one of the three types give the best efficiency for removing dye. The ability of adsorbents to adsorb dye was studied using batch system; studied parameters were effect of pH, dose of adsorbents, time, and agitation speed. The experimental results showed that the maximum removal efficiency of conocarpus was found to be 87.5% at 50 rpm mixing speed, pH value 3 , mixing time 120 min and the dose of adsorbent was 0.25 g. The maximum removal efficiency for carbonized conocarpus was up to 98.7% at 150 rpm mixing speed, pH value 3 , mixing time was equal to 7 hours and the dose of sorbent was 1.25 g. For activated carbon the maximum removal efficiency was found to be 99% at mixing speed of 200 rpm, pH value 3 or 11, mixing time was equal to 7 hours and the dose of the sorbent was 1.25 g. The above removal efficiencies were obtained at temperature 20 °C.

Keywords: Terasil blue dye, Wastewater, Adsorption, Low cost adsorbent, Batch study.

INTRODUCTION

The lack of water on the surface of the earth has become one of the biggest problems faced by humans. The population is growing rapidly and thus increasing the need for industrial processes and the consumption of the goods produced by the industries, thus increasing water consumption and increasing pollution. More than half the water is used to meet the needs of the humans and the second half in agriculture and industrial processes (Tang and Chen, 2002).

Vol. 11, No. 2
ISSN: 1998-4456

In addition to water shortages, industrial processes, through the discharge of waste water in the water bodies, lead to serious environmental problems. Although the treatment of contaminated water is the responsibility of the environmental protection legislation, most industrial companies in the world do not have processing units, and they are not sufficiently efficient. All these facts are the pressure of industrialists to consider the development and reuse of contaminated water (Gökşen et al., 2005).

The textile industry is one of the oldest and largest industries which release the contaminants to the environment. The subject of pollutants has been studied by many researchers for many years because it poses a significant risk to the environment due to its chemical nature. The spinning and weaving industries are made up of a large number of steps that are produced by converting natural elements such as cotton, wool, and silk, converting them into fibers and then converting them into cloth through textile and knitting processes and finally finishing them with dyeing, printing and finishing. These steps include processing textiles in chemical baths and often require washing and rinsing. Thus, these sequential steps lead to large consumption of water and the production of contaminants in large quantities. Textile dyeing is the most important process in terms of pollutant generation and large environmental impacts (Gökşen et al., 2005)

The polluted water produced by the fabric processes is characterized by large quantities of dye produced by pigments; salts, derived from additives used to stabilize dyes, detergents, complexity factors, fiber residue, high temperature and pH fluctuation. The textile industry, including the textile and dyeing industry, typically produces 200-500 liters of contaminated water per kg of the final product (Marcucci et al., 2001).

Many chemical, physical, and biological processes have been used such as image oxidation and adsorption processes; to remove the chemical dyes used in the dyeing process. At all times, the adsorption process is used to collect chemical dyes on a solid matrix before the biological and chemical treatments (Ozmihci and Kargi, 2006; Aydın et al., 2007).

The process of selecting a method of treatment depends on the nature, type, concentration and other components of the liquid contaminants, cost and removal efficiency. Common treatment processes such as rainfall and ion exchange are either costly or ineffective in removing pollutants from water. There is a great need for new, cost-effective and efficient ways of treating effluents (Ghodbane et al., 2008; Figueira et al., 2000).

The choice of adsorbent type is an important point in the development of the absorption process. Several materials can be used to remove industrial dyes. One of the materials used as a adsorbent is activated carbon powder although it has a high price but it is the most effective material used to remove organic compounds because of large area (1000 m2 G-1) and its high ability to absorb (Mohan and Karthikeyan, 1997; Kestioglu and Yalili, 2006; Akdemir and Ozer, 2013).

Therefore, it would be correct to use alternative and low cost materials such as agricultural products to be used as an adsorbent; and that these agricultural products are not used only to remove metals but to remove dyes and all solid waste. (Satyawali and Balakrishnan, 2008; Febrianto et al., 2009; Sousa et al., 2009).

Many kinds of agricultural crops have been studied to dispose of dye from sewage, like mud produced by the sugar industry (Magdy and Deifullah, 1998), rice husk (Mckay et al., 1986), peel of orange (Namasivayam et al., 1996) and other agricultural crops like wood (Ho and Mackay, 1998), cassava peels and Kenaf (Hussein, 2016).

In this study a new, environment friendly, non-conventional, cost-effective, and locally available conocarpus was investigated for the adsorption of terasil blue dye from synthetic wastewater. The effects of different parameters such as pH, dose of the adsorption, contact time, and agitation speed were studied.

AL-QADISIYAH JOURNAL FOR ENGINEERING SCIENCES

Vol. 11, No. 2

ISSN: 1998-4456

1. EXPERIMENTAL PROCEDURE AND METHODS

1.1 PREPARATION OF TERASIL BLUE

The solution was prepared by dissolving (20) mg of terasil blue dye in 1000 ml of tap water. The dye components (Table 1) were examined using Eds device (Type X – act , USA). The measurements were conducted at the Central service laboratory - College of Education Ibn Al Haitham , Baghdad .

Table 1. the components in terasil blue dye

Element	Weight%	Atomic%
C	37.45	50.29
O	35.52	35.81
Na	9.89	6.94
S	8.52	4.29
Cl	3.72	1.69
Br	4.90	0.99
Totals	100.00	100.00

1.2 PREPARATION OF THE ADSORBENTS

Three adsorbent materals are prepared for adsorption study.

1.2.1 Preparation of conocarpus adsorbent

Conocarpus leaves was taken from the campus of Wasit University to be used in this study. The previous studies (Hussein et al 2016) was adopted as a working method for preparation of conocarpus in the following steps: cutting the plant's leaves , and washing them three times by using distilled water to get rid of any dust. After finishing washing, they were dried in the oven at 110 ° C for 3 hours; then grinded in a mill to a small volume of less than 500 microns. The last step of the preparation process is sieving through (150 - 300) µm. Figure 1 shows the Preparation of conocarpus adsorbent.

Figure 1. Preparation of conocarpus adsorbent.

1.2.2 Preparation of carbonized conocarpus

The previous studies (Ramadan et al. 2005) was adopted as a working method for carbonization of conocarpus plants in the following steps:

1. Cutting the plant into small pieces.
2. Washing it three times with distilled water to to clean it.
3. Dry it with a 110 ºC for three hours and repeat the drying step for anther quantities until the required quantity is obtained.

4. The dried plant is grinded into small granules using grinder.
5. 1: 0.5 of the conocarpus and sodium hydroxide are mixed well.
6. Put the mixture in oven at temperature 300 ^{o}C for half an hour with continuous flipping.total time for carbonization process was two hours.
7. Wash the product in the filtration device twice with distilled water and then washed with hydrochloric acid at a concentration of 10% once to remove the effect of base solution then wash it with water once to remove acidic excitation.
8. The product is then dried in oven at 110 ° C for three hours,then grinded into small granules.
9. Sieving the product through (150-300 μm).

1.3 ACTIVATED CARBON

The powder activated carbon (PAC) (German origin) was used as adsorbent if the experiments (figure 2), its composition are shown in Table 2.

Table 2. Specifications of activated carbon.

Specification	Value
MW	12.01 g/mol
Soluble in water	<0.2%
Soluble in HCL	< 1%
Soluble in C_2H_5OH	< 0.2%
Chloride Cl	<0.001%
Cooper Cu	<0.05%
Iron Fe	<0.002%
Lead Pb	<0.001%

Figure 2. Activated carbon

1.4 BATCH EQUILIBRIUM STUDY

100 ml of 20 mg / L terasil blue was poured in flasks of 250 ml size, 0.5 g of adsorbents of activated carbon , conocarpus, and carbonized conocarpus is placed in flasks. pH of the mixture was determined using pH-meter. The flasks then placed in orbital shaker (Type TS-2,Turki) for two hours. Centrifugal separator (Type 80-1 Electric Centrifugal ,Taiwan) was used for 15 minutes then filtration process was achieved using filtration device. The final step was analyzing the amount of dye removal using spectrophotometer (Type ufb1105014 ,German) with a maximum wavelength of 663 μm (Hussein et al 2016). The effect of various parameters, adsorbent dose, pH, contact time and agitation speed were studied. The adsorbed amount q_e was calculated using the following equation:

Vol. 11, No. 2
ISSN: 1998-4456

$$q_e = \frac{V_L (C_o - C_e)}{W_o}$$

Where: q_e is the equilibrium uptake (mg/g), V_L is the volume of the solution(l), C_o is the initial concentration(mg/l), C_e is the equilibrium concentration(mg/l), W_o is the mass of biosorbent.

The biosorption removal efficiency was calculated by the difference of the initial and equilibrium concentration of terasil blue dye according to the following equation:

$$\text{Removal\%} = \frac{(C_o - C_e)}{C_o} \times 100$$

2. RESULTS AND DISCUSSION

2.1 CALIBRATION CURVE

Solution of terasil dye (1000 mg / L) was used to find the calibration curve. Different dilute concentrations were prepared for calibration curve as shown Figure 3.

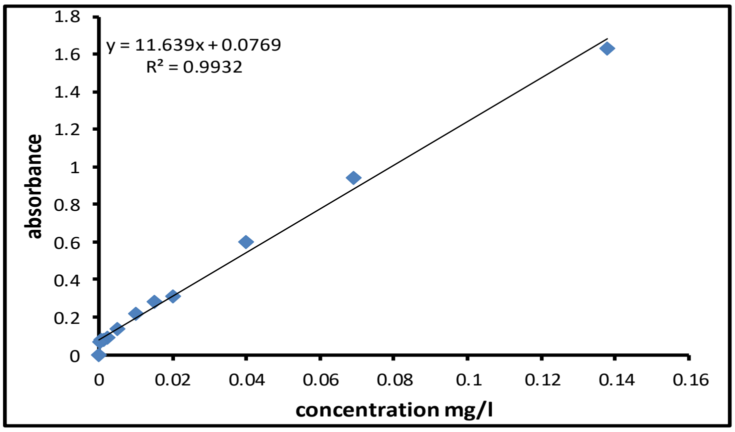

Figure 3. Calibration curve of terasil blue solutions

2.2 EFFECT OF CONTACT TIME ON REMOVING OF TERASIL BLUE

Using activated carbon, carbonized conocarpus and conocarpus as absorbent materials, the percentage of removal of terasil blue was obtained at different contact times , keeping other parameters constant such as pH solution, sorption dose and shaker rotary velocity.

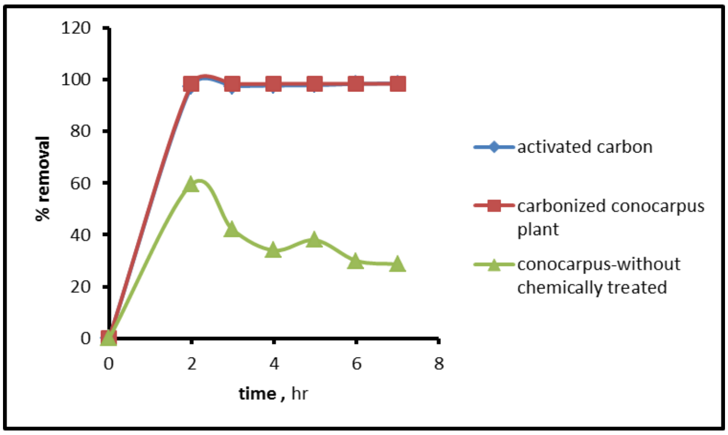

Figure 4. Percentage of terasil blue removal onto activated carbon , conocarpus plant and carbonized conocarpus at different contacting time, keeping other parameters constant such as pH solution, sorption dose, shaker rotary velocity and temperature 20℃.

Figure 4 shows when activated carbon was used and carbonized conocarpus that dye adsorption increase with increasing time and remains constant after reaching equilibrium. This is due to a larger area of absorbent material at the beginning of the adsorption process. As surface adsorption sites are exhausted, the absorption rate controls the rate at which adsorption from external sites is transferred to the interior of the sorbent molecules. The upper percentage was achieved to remove the dye after about 7 hours of shaking time. The result is consistent with those obtained by Sumanjit et al. (2008).

When conocarpus is used ,it is apparent that the removal of dye decreases with increasing time, because the plant did not undergo carbonation processes, but only drying, so it kept green color , the more time increases the ability to give the color. The best time for adsorption is at the second hour.

From figure 4 it is shown that activated carbon and carbonized conocarpus were more effective in the process of adsorption where the efficiency of removal 98.56% and 98.53% respectively followed by the dried conocarpus plant 59.57%.

2.3 EFFECT OF ADSORBENT DOSAGE ON REMOVAL OF TERASIL BLUE

The influence of adsorbent dosage on removal efficiency of terasil blue dye has been investigated. Five amounts of each adsorbent (0.25, 0.5 ,0.75 ,1, and 1.25 g) were used; at the following conditions: 20 mg/l concentration of terasil blue solution, rotating speed 150 rpm, and temperature 25 ºC.

Figure 5 shows the relationship between the ratio of removal efficiency and different dose of sorbent, of activated carbon , carbonized conocarpus and conocarpus.

When the activated carbon and carbonized conocarpus was used, it appears that the efficiency of removal of the terasil dye increases with increasing dosage of the absorbent materials because of the availability of more adsorption sites and increase in the surfaces area of adsorbent , the result is consistent with those obtained by Selvaraj et al. (2003).

AL-QADISIYAH JOURNAL FOR ENGINEERING SCIENCES

Vol. 11, No. 2

ISSN: 1998-4456

When conocarpus is used, the efficiency of the dye removal decreases with the increase of mass of sorbents, because the plant was used without carbonization and it is added a green dye to the solution, so the greater the dose the greater the ability to give color and reduce the process of adsorption.

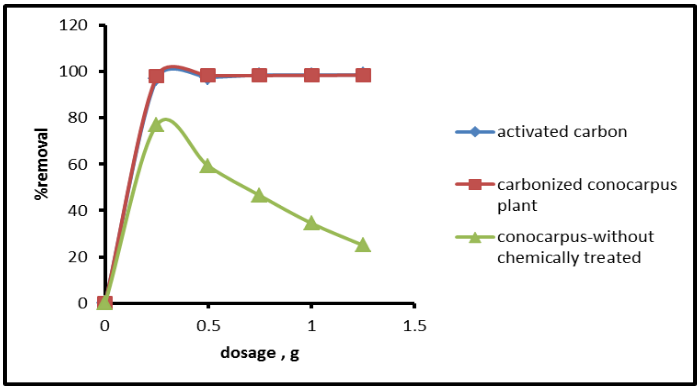

Figure 5. Percentage of terasil blue removal onto activated carbon, carbonized conocarpus and conocarpus , at different dosage, keeping other parameters constant such as pH solution, contact time, shaker rotary velocity and temperature 20℃.

From figure 5 which represents the relationship between the efficiency of removal and adsorbent dosage, it is shown that activated carbon and carbonized conocarpus were more effective in the process of adsorption where the efficiency of removal 98.63 % and 98.48 %, respectively at adsorbent dosage 1.25 g while the removal efficiency of conocarpus was 76.95 at dosage 0.25 g.

2.4 EFFECT OF PH ON THE ADSORPTION OF TERASIL

pH have a significant effect in the adsorption process.pH of solution is effecting the surface charge of the adsorbent and the influences structural stability of terasil blue dye. The effect of pH solution has been study in the adsorption on terasil blue dye and the range was(pH 3-11). Figure 6 represents the effect of pH value on each adsorbent of terasil blue dye. The result is consistent with those obtained by Woolard et al. (2002).

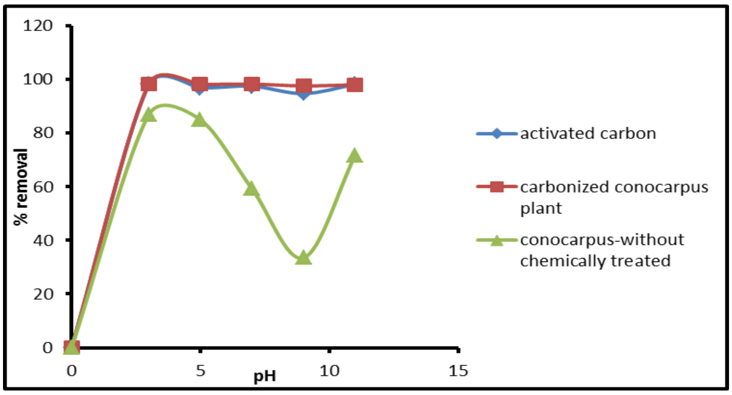

Figure 6. Percentage of terasil blue removal onto activated carbon, carbonized conocarpus plant and conocarpus plant, at different pH values, keeping other parameters constant such as contact time, sorption dose, shaker rotary velocity and temperature 20℃.

Vol. 11, No. 2
ISSN: 1998-4456

The optimum solution pH values for activated carbon were found to be 3 and 11,the removal efficiency was 98.18 % at the two values of pH. The maximum adsorption of terasil blue onto carbonized conocarpus was 98.43% followed by conocarpus 87**%** at pH 3**.**

2.5 Effect of Agitation Speed on the a dsorption of terasil blue

From figure 7 using the three sorbents (activated carbon , carbonized conocarpus plant , conocarpus), which represents the relationship between the efficiency of removal and agitation speed , keeping other parameters constant such as pH solution, sorption dose and contact time, it is shown that activated carbon, is more efficiency of removal 98.33 % at 200 rpm. Followed by carbonized conocarpus plant, where the maximum efficiency of removal 98.31% at 150 rpm, and for the dried conocarpus plant where the maximum efficiently removed 63 % at 50 rpm.

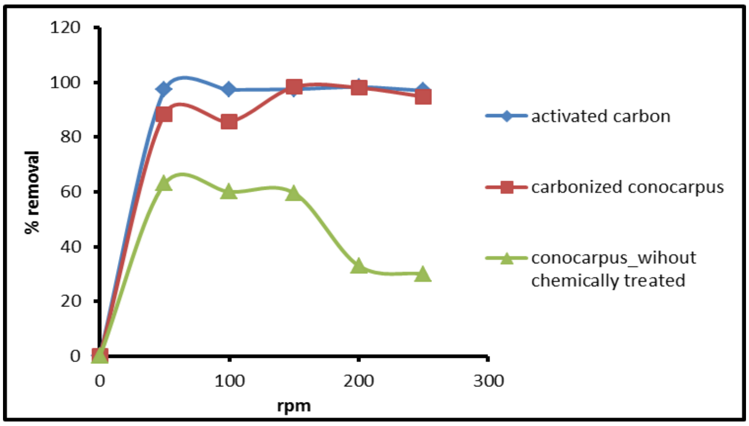

Figure 7. Effect of agitation speed in the adsorption of terasil blue onto activated carbon , carbonized conocarpus plant and conocarpus plant**.** at different agitation speed, keeping other parameters constant such as contact time, pH solution, sorption dose, and temperature 20℃.

The speed of vibration affects the physicochemical interaction between the sorbent molecules and the terasil blue dye in the solution. The reduction in the removal efficiency after the speed of 200 rpm is due to the accumulation of part of the sorbent (activated carbon, carbonized conocarpus plant and conocarpus) on the inner surface of the flask neck during the operation of the device which reduces absorption of the dye. Therefore 200 rpm considered the optimum agitation speed for the adsorption process. These results are similar to those found by pehlivan and Altun., (2008).

In the case of ideal conditions for all effects and for all sorbents, the removal efficiency are as follows: the removal efficiency of conocarpus was found to be 87.5% at 50 rpm mixing speed, pH value 3 , mixing time 120 min and the dose of adsorbent was 0.25 g. The removal efficiency for carbonized conocarpus was up to 98.7% at 150 rpm mixing speed, pH value 3 , mixing time was equal to 7 hours and the dose of sorbent was 1.25 g. For activated carbon the removal efficiency was found to be 99% at mixing speed of 200 rpm, pH value 3 or 11, mixing time was equal to 7 hours and the dose of the sorbent was 1.25 g. The above removal efficiencies were obtained at temperature 20 °C.

AL-QADISIYAH JOURNAL FOR ENGINEERING SCIENCES

Vol. 11, No. 2
ISSN: 1998-4456

CONCLUSION

1. According to the results, it was found that using higher dosage of the sorbent, activated carbon and carbonized conocarpus plant ; led to greater efficiency of the removal of terasil blue dye. In case of using conocarpus, less efficiency of removal was obtained with increasing the dose of absorbent.

2. It has been shown that pH 3 is the optimum value for the best adsorption process.

3. A higher adsorption efficiency was obtained when more contact time between the adsorbent, activated carbon and carbonized conocarpus plant, and terasil dye. In case of using conocarpus as adsorbent, the increase in time lead to less efficiency of removal.

4. it was found that 200 rpm is the optimum speed for the adsorption process when was used activated carbon,150 rpm when carbonized conocarpus plant use ,and 50 rpm when conocarpus were used.

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