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Evaluate the Efficiency of Ashes from Palm and Pistachio Wastes in Removal of Reactive Red 120 Dye from Aqueous Solutions

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Abstract: Many industrial wastewaters contain toxic and carcinogenic dyes. Health and environmental problems will occur by discharging such wastewaters into the environment. This study was conducted to evaluate the efficiency of ashes from palm and pistachio wastes in removal of reactive red 120 dye from aqueous solutions. In order to perform this experimental study, initially synthetic wastewater was prepared at a concentration of 20 mg L^{-1}. Then the effects of variables of ashes obtained from palm and pistachio wastes were assessed at 30, 60, 90, 120, 150 and 180 min and pH of 3, 5, 7, 9 and 11 on the removal efficiency of dye by adsorption method. The dye concentration in various samples was measured using a spectrophotometer at a wavelength of 525 nm. The levels of dye removal at pH 3-11 for the dye concentration of 20 and 0.05 g L^{-1} palm ash absorbent in mentioned time were respectively 75.5, 79.4, 84.4, 89.3, 91.3 and 92.8% as well as for pistachio ash absorbent in mentioned time were respectively 84, 88.2, 91.6, 92.2, 93.7 and 94.6% adsorption isotherm for the both absorbents was compatible with Langmuir Model (R^2 0.876 for pistachio ash and R^2 0.980 for palm ash). The dye removal value enhanced with increasing reaction time. The highest efficiency for the palm ash and pistachio ash was at acidic and neutral pH, respectively. The use of palm ash in removal of reactive red 120 dye is efficient and cost-effective.

Key words: Palm ash, pistachio hull, textile wastewater, red 120 dye, adsorption, isotherm

INTRODUCTION

Industrial effluents such as leather, tanning, resins, plastics, paper, food and cosmetics are some of the most important sources of dye wastewater. Textile industry is another important source to produce strong dye wastewaters with a concentration of 10-200 mg L^{-1} (Celekli *et al*., 2009; Bazrafshan *et al*., 2012a, b; Biglari *et al*., 2016a-d). These wastewaters contain a variety of sustainable synthetic dyes that are often toxic

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and even carcinogen considered as a serious risk to aquatic organisms and human health. Discharge the wastewaters into the environment cause health, aesthetic and environmental problems (Moussavi and Mahmoudi, 2009). Entering dye wastewaters into the receptive water resources prevents sunlight transmission to aquatic environments, reduces photosynthesis and disrupts biological processes (Alver and Metin, 2012). Currently, about one hundred thousand different types of pollution such as commercial dyes are produced around the world with production of over 700000 tons per year (Mahmoodi *et al*., 2012; Yilmaz *et al*., 2011; Biglari *et al*., 2012a, b; Mohammadi *et al*., 2015; Mirzabeygi *et al*., 2016; Ozdemir *et al*., 2009; Sajjadi *et al*., 2016). Among the existing dye, reactive Azo dyes comprise about 60-70% of dyes used in the dyeing process which about 10-50% of them enter the effluents due to relatively low consolidation efficiency compared with other dyes (Yu *et al*., 2010; Kyzas *et al*., 2012). Reactive dyes are toxic, mutagen and resistant to biological treatment. Depletion of these dyes into the ecosystem can cause high environmental risks (Kyzas *et al*., 2012). The dyes are soluble in water, resistant to light and chemical agents and are not removed easily by common methods of treatment (Engin *et al*., 2008; Gok *et al*., 2010). Therefore, the management of wastewaters containing reactive dye is very important. There are several methods to dye removal from wastewater such as adsorption, biodegradation, coagulation, chemical oxidation, electrochemical processes, filtration and reverse osmosis (Yu *et al*., 2010; Han *et al*., 2010; Santhi *et al*., 2010; Alipour *et al*., 2014). Adsorption is one of the effective ways in dye removal from textile wastewater using numerous absorbent such as activated carbon, sawdust, oat bran, rice hull, chitosan and eggshell (Ghaneian *et al*., 2010; Khorramfar *et al*., 2009). Activated carbon, in this regard is one of the most widely used absorbents to control environmental pollution. However, due to high cost of production, restoration and treatment, researches have been focused on alternative absorbents with low cost and high absorption capacity (Ghaneian *et al*., 2010; Alizadeh and Borghei, 2006; Ghanizadeh and Asgari, 2009). Therefore, the current study was aimed to assess the efficacy of ashes obtained from palm tree and pistachio hull in reactive red 120 dye removal from aqueous solutions.

MATERIALS AND METHODS

In this descriptive and analytical research, all tests were evaluated experimentally in a batch reactor by applying study variables on reactive red 120 dye absorption process using palm and pistachio hull ashes. The required samples in this study were prepared synthetically. In addition, the ashes derived from palm tree and pistachio hull wastes were prepared in laboratory conditions using an electric furnace at 600°C for 2 h. To do the experiments, the stock solution of reactive red 120 dye was prepared with a concentration of 1000 mg L^{-1} and exposed to certain amount of palm and pistachio hull ashes with concentrations of 0.01, 0.02, 0.03, 0.04 and 0.05 mg L^{-1}, pH of 3, 5, 7, 9 and 11 and contact times of 30, 60, 90, 120, 150 and 180 min. To establish better contact between the pollutant and absorbent, the samples were placed on a magnetic stirrer. Finally, solutions containing absorbent were passed through the filter study 0.45 μm. The final concentration of dye in solution was measured by spectrophotometer at a wavelength of 525 (Gholami *et al*., 2013). Langmuir and Freundlich isotherms were used to determine the adsorption isotherm.

RESULTS AND DISCUSSION

The results of dye removal from textile wastewater by palm and pistachio ashes with initial dye concentration of 20 mg L^{-1}, absorbent concentration of 0.01 g L^{-1} and contact time of 60 min have been presented in Fig. 1. As can be seen, the optimal pH for the dye removal from textile wastewater was 5 for pistachio ash and 7 for palm ash. The solution pH is considered one of the most important factors influencing chemical and biological reactions of wastewater (Khorramfar *et al*., 2009; Ghanizadeh and Asgari, 2009; Naddafi and Gholami, 2014). According to Fig. 1, the percentage of dye removal using pistachio ash absorbent at pH 3-5 increased by 8% with increasing pH from 5-11, dye removal efficiency showed about 18% reduction. The percentage of dye removal using palm ash absorbent at pH 3-7 elevated up to about 8% and dye removal efficiency decreased by about 9% with increased pH from 7-11. In a study of Kusvuran *et al*. (2004) that was conducted to compare several advanced oxidation process to remove reactive red 120 dye in aqueous solution, the optimal pH was acidic.

The effect of absorbent dosage in dye removal from textile wastewater in dye concentration of 20 mg L^{-1} and contact time of 60 min and pH 7 are shown in Fig. 2. The optimal dosage of pistachio ash absorbent was 0.04 g L^{-1} and the optimal dosage of palm ash absorbent was 0.05 g L^{-1}. In adsorption studies, determine the appropriate absorbent dosage is one of the most important issues that should be considered. Figure 2 shows the effect of initial absorbent concentration in dye removal by palm and pistachio ashes. According to the figure, the dye removal percentage enhanced with increasing palm ash absorbent dosage so that dye removal was 76% at a concentration of 0.01 g L^{-1} and

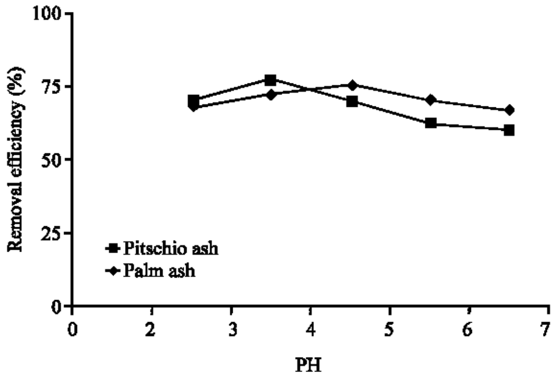

Fig. 1: The effect of PH on the removal of reactive red 120 dye by palm and pistachio ash (initial concentration dye 20 mg L^{-1}, contact time 60 min, adsorbent dosage 0.01 g L^{-1})

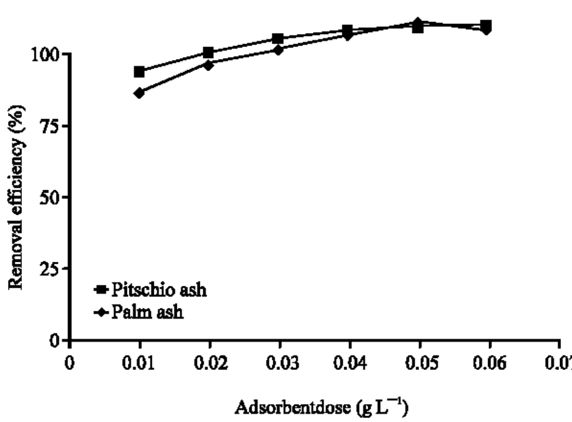

Fig. 2: The effect of adsorbent dose (g L^{-1}) on the removal of reactive red 120 dye by palm and pistachio ash (initial concentration dye 20 mg L^{-1}, contact time 60 min, pH 7)

rose to over 95% at a concentration of 0.04 g L^{-1}. Initial absorbent concentration effect on dye removal by the pistachio ash showed 83% dye removal at the concentration of 0.01 g L^{-1} and over 96% increase at the concentration of 0.05 g L^{-1}. The increase in absorption could be due to great absorbent surface and more accessible to adsorption sites (Khorramfar *et al*., 2009; Ghanizadeh and Asgari, 2009; Nateghi *et al*., 2010). In this study, the optimum concentration of absorbent was 0.05 g L^{-1}. Gholami *et al*. (2013) during a study on the capacity of orange peel ash in direct black 22 dye removal from aqueous environments showed that the removal rate improved from 22-87% with increasing absorbent dosage from 0.5-2 g L^{-1} (Gholami *et al*., 2013).

The levels of dye removal at different times using palm and pistachio ashes with dye concentration of

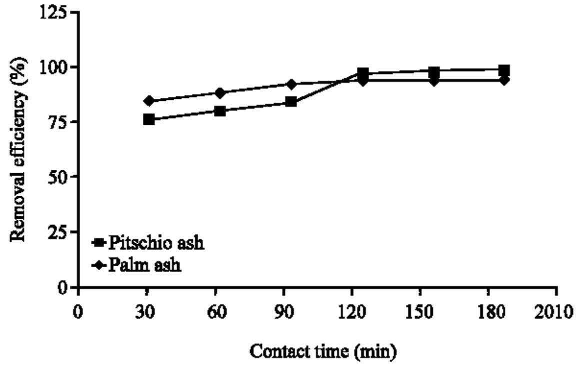

Fig. 3: The effect of contact time (min (on the removal of reactive red 120 dye by palm and pistachio ash (initial concentration dye 20 mg L^{-1}, adsorbent dosage 0.05 g L^{-1}, pH = 7

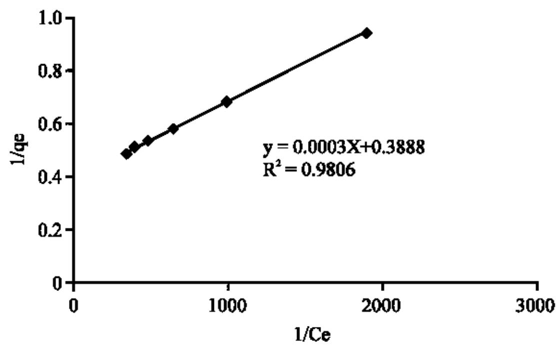

Fig. 4: The palm ash Langmuir isotherms model

20 mg L^{-1}, absorbent dosage of 0.05 g L^{-1} and pH = 7 are shown in Fig. 3. In the present study, over 75% of dye removal by pistachio ashes was done at the first 30 min and 97% dye removal in 120 min. After that, the increase in the removal was very partial to reach a constant value. The results of contact time effect on dye removal by palm ash revealed that over 85% of dye was removed in the first 30 min and 93.5% in 120 min and then came to equilibrium. Comparison of efficacy in these absorbents indicated that both of them reached to equilibrium in 120 min. The pistachio ash removed over 75% of dye in the first 30 min while palm ash removed over 85% of dye. As can be seen, the proper equilibrium time for both types of absorbent was 120 min. By rise of contact time, due to increased collisions between dye and absorbent molecules, adsorption will be greater. The absorption process enhances with the passage of contact time to reach the equilibrium status. According to Fig. 3, contact time is an important variable in the adsorption process. Dye removal efficiency using absorbent has a direct relationship with contact time. During the adsorption process, the absorbent surface is blocked by adsorbate

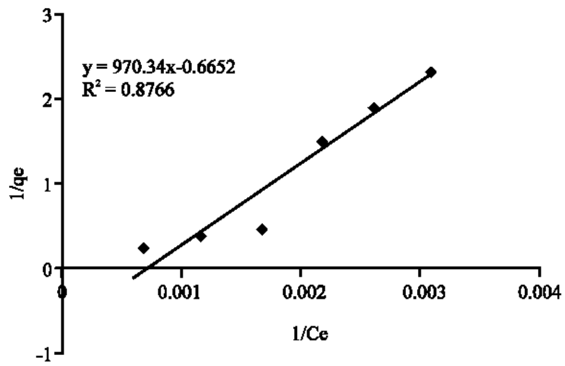

Fig. 5: The pistachio ash Langmuir isotherms model

molecules and can be covered after a period. When this happens, absorbent cannot absorb more dye molecules.

Langmuir isotherms of absorbent concentration effect on dye removal at different concentrations of pistachio and palm ashes are shown in Fig. 4 and 5. Determination of adsorption isotherms of pollutants by different absorbents is an important parameter in the adsorption studies. Adsorption isotherms are adsorption properties and equilibrium data which describe how pollutants to react with absorbent and have key role in optimizing absorbent reagent. In the present study, evaluating the experimental data with the Langmuir and Freundlich Models as well as comparison of their correlation coefficients indicated that dye adsorbed on the palm and pistachio ashes follows the Langmuir isotherm. Due to the higher correlation coefficient in Langmuir Model, dye adsorbed on palm ash had more compliant with the Langmuir Model; accordingly, dye absorption takes place as monolayer on homogeneous surface. Ghaneian *et al.* (2010) used the eggshell as natural absorbent in reactive red 123 dye removal from synthetic textile wastewater and reported that reactive red 123 dye removal follows the Langmuir isotherm. Absalan *et al.* (2011) in reactive red 120 dye removal by Fe_3O_4 magnetic nanoparticles found that dye removal follows the Langmuir Model with correlation coefficient of 0.9946.

CONCLUSION

The present study indicated that the pistachio and palm ashes could effectively remove dye from textile wastewaters. The percentage of dye removal has direct relationship with absorbent dosage and contact time. In this research, the optimal pH was 5 for Pistachio ash and 7 for palm ash. It seems that due to abundance of palm tree wastes in the study area, the use of palm ash requires minimum, affordable low-cost and highly efficient technology.

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