Treatment of Textile Effluent using Tea Waste as Adsorbent
Associate Professor1, Student2,3,4
Department of Civil
Panimalar Engineering College, Poonamallee, Chennai, India

Abstract:
Consumed tea waste produced after the tea is being prepared, were investigated as a potential low-cost adsorbent for the removal of the reactive dyes from textile effluent. Untreated tea waste demonstrated very low removal efficiency (< 7%), while the treated tea waste showed significant increase in adsorption when treated thermally in which the tea waste is heated at 300°C for 1 hour results in removal efficiency ranges from 68.5 to 98.4%. The waste is characterized by FTIR (Fourier Transform Infrared Spectroscopy) and TG/DTA indicates the chemical and structural changes occurred during heating in the components of consumed tea waste.

Keywords: Consumed tea waste, Adsorption, Textile effluent, Textile industry, Wastewater treatment.

1. INTRODUCTION
The contamination of waste water is a major increasing problem throughout the world. Dyes used by textile industries are major pollutant of waste water causing hazardous to environment and pollutes the natural water. During the treatment of dyes, the dye undergoes a hydrolysis reaction and causes loss of hydrolyzed dye in the effluent. During the process, between 60 and 90% of the initial amount of dyes are lost. When these effluents are released to the environment lead toxic effects on plants and animals reduce dissolved oxygen concentration. Due to these, it is considered as a major problem. The effective methods for the removal of dyes from textile effluent is adsorption. Activated carbon is commonly used adsorbent for this removal process, as it has high efficiency and versatility. This carbon adsorption process is expensive. This generated a considerable interest in the search of low-cost alternatives to activated carbon. The adsorbent used for treating textile effluent is abundant in nature which is cost effective or as a byproduct from industries which requires little processing. From this we have estimated the efficiency of consumed tea waste for the removal of dyes from textile effluent.

2. ADSORPTION
Adsorption is a process which is effective and economic it is a good proposition for high strength and low volume of waste water. This is an effective purification technique used by wastewater treatment industries. Adsorption has numerous advantages including simple process, highly efficient, and also it requires low investment. Here we used consumed tea waste as a adsorbent, as it has good capacity for adsorption of various components present in textile effluent.

3. MATERIAL AND METHODS
The sample was collected at the point of discharge from a textile industry outlet in tiruppur during the time from january 2020 to february 2020. For collecting textile effluent plastic cans are used.

4. CONSUMED TEAWASTE PREPARATION
Tea waste was collected from tea shops, hotels, hostels etc. The color from the waste is removed by boiling it with water at 90 °C continued by rinsing it in tap water until the colored components of tea waste are removed, finally the resulting solid was rinsed in distilled water and oven dried at 60 °C for 24 hours atlast it is sieved at <500µm and stored in a container at room temperature. Thermal properties of consumed tea waste was carried out in a muffle furnace by heating it to 300 or 400°C and keeping it at that temperature for 2 hours and finally the treated tea waste is taken for effluent treatment. Fig. 1 and Fig.2 represents the boiling of tea waste and tea waste after treatment respectively.

Figure 1. Boiling of tea waste
the main responsible for the binding of positively charged heavy metal ions to consumed tea waste. In agreement with this hypothesis, very high removal efficiencies were achieved when using consumed tea waste to adsorb dyes, a positively charged cationic dye. Therefore, the limited adsorption of the dyes examined on consumed tea waste can be ascribed to the unfavorable electrostatic interactions with the adsorbent surface. Thermal activation of consumed tea waste resulted in a significant increase in dye adsorption. As apparent from Fig. 2, the observed removal efficiencies with consumed tea waste activated at 300 °C for 1 h reached values close to 99%. Again, the same order of effectiveness was determined. Increasing the activation temperature and/or the duration of heating caused a further improvement in the adsorption capacity of consumed tea waste. However, a parallel reduction in the mass of the adsorbent was observed, the measured weight loss approaching 90% under the most severe treatment conditions (2 h at 400 °C). From these results, it can be concluded that heating consumed tea waste at 300 °C for 1 h could be a good compromise between the adsorbent loss and the enhancement of adsorption capacity. FTIR spectra of untreated and thermally treated consumed tea waste displayed a number of peaks arising from the absorption of different functional groups in this material. The broad band at about 3400 cm⁻¹ can be attributed to bonded _OH groups. The peaks at 2950-2900 cm⁻¹ correspond to aliphatic CH groups. The peak about 1650 cm⁻¹ is due to C=O or C=C groups. While the peak about 1100 cm⁻¹ can be attributed to C-O stretching of ether groups. After subjecting consumed tea waste to the activation treatment, a severe reduction in the intensity of the peaks was observed. This study suggest that heating causes major structural and chemical modification. These changes are probably due to more or less extensive degradation of the cellulose and hemicellulose components of tea leaves. Cellulose degradation starts at about 250–300 °C and proceeds by the cleavage of C–H, C–O and C–C bonds and by dehydration, decarboxylation and decarbonization reactions. Lignin degradation occurs at higher temperatures, typically around 400 °C, and is accompanied by the formation of a variety of low-molecular-weight products. Examination of TG-DTA curves and, particularly, of the derivative weight curve, reveals the presence of three main endothermic peaks, at about 65, 300 and 450 °C (Fig. 4). They can be attributed to the loss of hygroscopic water (65 °C) and to cellulose and lignin degradation (300 and 450 °C, respectively). From these transformations, new adsorption sites with higher affinity for the dyes are likely to be created. During activation treatment there should be an increase in the surface area, contributing to the observed enhancement in dye adsorption. Thus, it can be concluded that thermally treated consumed tea waste could be effectively used as a new adsorbent for the removal of reactive dyes from textile wastewater. Future research should be directed at investigating the mechanisms of consumed tea waste activation and evaluating the optimum process conditions in order to assess the real potential of consumed.

5. CHARACTERISATION OF CTL

MAC 50/1 electronic moisture analyzer (Radwag, Poland) is used to determine the moisture content of the prepared tea waste. FTIR spectra were obtained in the mid-IR region (4000–400 cm⁻¹) using a Bruker Vertex 70 spectrometer equipped with a Platinum ATR sampling module. TG-DTA measurements were carried out between 30 and 900 °C with an SDT Q600 analyzer (TA Instruments, USA).

6. ADSORPTION STUDIES

The experiments were performed in batch mode in 50 mL screw-top flasks for Adsorption. Suitable amounts of consumed tea waste and the effluent solution were charged into thermostated (± 0.1 °C) flasks and magnetically stirred for the required time. Then, the liquid suspension was centrifuged (10,000 × g for 10 min) and the supernatant analyzed for dye content. Measurements were made spectrophotometrically at the λmax value and converted to concentrations by calibration curves obtained from dye standards. The absorption spectra of the dyes. At initially the dye concentration was varied between 50 and 100 mg L⁻¹ and the liquid-to-solid ratio between mL g⁻¹. The dye removal efficiency (E) was calculated as: 

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E = 100 \times \left(1 - \frac{c_f}{c_0}\right)
\]

where 

\(c_0\) and \(c_f\) are the initial and final dye concentrations.

7. RESULTS AND DISCUSSION

Dye adsorption on untreated consumed tea waste was studied at 25 °C by setting the initial dye concentration to 50 mg L⁻¹, the contact time to 1 h and the liquid-to-solid ratio to 50 mL g⁻¹. The results are presented in Fig. 2. As can be seen, the removal efficiencies were < 7% and increases. We also found that the observed E values varied only marginally when increasing the contact time or the adsorbent dose. This indicates that all of the reactive dyes examined had a poor affinity for consumed tea waste. A possible explanation can be offered by the unfavorable electrostatic interactions between the dye molecules and the adsorbent surface. As is known, many negatively charged sites, including the hydroxyl and carboxyl groups of cellulose or those present in proteins and phenolic compounds, are found on the surface of lignocellulosic plant materials. These groups are considered the main responsible for the binding of positively charged heavy metal ions to consumed tea waste. In agreement with this hypothesis, very high removal efficiencies were achieved when using consumed tea waste to adsorb dyes, a positively charged cationic dye. Therefore, the limited adsorption of the dyes examined on consumed tea waste can be ascribed to the unfavorable electrostatic interactions with the adsorbent surface. Thermal activation of consumed tea waste resulted in a significant increase in dye adsorption. As apparent from Fig. 2, the observed removal efficiencies with consumed tea waste activated at 300 °C for 1 h reached values close to 99%. Again, the same order of effectiveness was determined. Increasing the activation temperature and/or the duration of heating caused a further improvement in the adsorption capacity of consumed tea waste. However, a parallel reduction in the mass of the adsorbent was observed, the measured weight loss approaching 90% under the most severe treatment conditions (2 h at 400 °C). From these results, it can be concluded that heating consumed tea waste at 300 °C for 1 h could be a good compromise between the adsorbent loss and the enhancement of adsorption capacity. FTIR spectra of untreated and thermally treated consumed tea waste displayed a number of peaks arising from the absorption of different functional groups in this material. The broad band at about 3400 cm⁻¹ can be attributed to bonded _OH groups. The peaks at 2950-2900 cm⁻¹ correspond to aliphatic CH groups. The peak about 1650 cm⁻¹ is due to C=O or C=C groups. While the peak about 1100 cm⁻¹ can be attributed to C-O stretching of ether groups. After subjecting consumed tea waste to the activation treatment, a severe reduction in the intensity of the peaks was observed. This study suggest that heating causes major structural and chemical modification. These changes are probably due to more or less extensive degradation of the cellulose and hemicellulose components of tea leaves. Cellulose degradation starts at about 250–300 °C and proceeds by the cleavage of C–H, C–O and C–C bonds and by dehydration, decarboxylation and decarbonization reactions. Lignin degradation occurs at higher temperatures, typically around 400 °C, and is accompanied by the formation of a variety of low-molecular-weight products. Examination of TG-DTA curves and, particularly, of the derivative weight curve, reveals the presence of three main endothermic peaks, at about 65, 300 and 450 °C (Fig. 4). They can be attributed to the loss of hygroscopic water (65 °C) and to cellulose and lignin degradation (300 and 450 °C, respectively). From these transformations, new adsorption sites with higher affinity for the dyes are likely to be created. During activation treatment there should be an increase in the surface area, contributing to the observed enhancement in dye adsorption. Thus, it can be concluded that thermally treated consumed tea waste could be effectively used as a new adsorbent for the removal of reactive dyes from textile wastewater. Future research should be directed at investigating the mechanisms of consumed tea waste activation and evaluating the optimum process conditions in order to assess the real potential of consumed.

8. REFERENCES


