Investigation of Greywater Treatment by Adsorption Process Using Polymeric Composites Supported with Activated Carbon

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ABSTRACT

In this study, treatment of greywater from laundry washing was investigated by adsorption process with the use of different waste material derived adsorbents. To synthesize the adsorbents, walnut shell, seed hull, hazelnut shell and rice husk were carbonized and then supported with polyaniline. KIO₃ and K₂S₂O₈ were used as oxidizing agents in the polymerization of aniline monomers. Wastewater treatment efficiencies were evaluated in terms of turbidity, color and MBAS (detergent) parameters. Adsorption experiments were conducted with 100 mL of wastewater and 1 g of adsorbent, for 2 h of reaction time, at room temperature and mixing speed of 150 rpm. As a result of studies with different oxidizing agents; the highest removal efficiencies were calculated for the PAn/RH+KIO₃ adsorbent as 98%, 70% and 96% for color, turbidity and detergent, respectively, while for the PAn/SH+K₂S₂O₈ adsorbent they were 58%, 3% and 95% for the same parameters.

Keywords: Adsorption, Greywater, Oxidizing agents, PAn supported adsorbents.

INTRODUCTION

Household wastewater is classified into two groups, which are greywater and blackwater. It has been indicated that averagely 50-80% of household wastewater consist of greywater, which contains wastewater from baths, wash basins, laundries and dish washing (Tchobanoglous et al., 1991; Rowe and Abdel-Magid, 1995; Ridderstolpe, 2004; Li et al., 2009; Gross et al., 2015). Except these wastewaters in households, the rest of the used waters are called blackwater. According to its chemical pollution content, greywater can be considered as low contaminated (low load) and high contaminated (high load). While low load greywater includes wastewaters from baths and wash basins, high load one involves wastewaters from laundries and dish washing (Karahan, 2011; Boyjoo et al., 2013).

Greywater should be reclaimed as reusable water source. By recycling and reuse of greywater, it has been principally aimed to preserve drinking water sources and decrease the volume of domestic wastewater for reducing operational problems, transport costs and treatment sludge amount so as its removal costs in the wastewater treatment plants. Reuse of greywater is globally accepted as a potential source of water, and there are various studies about its treatment (Li et al., 2009; Ghunmi et al., 2011; Albalawneh et al., 2015).

Membrane bioreactor systems (Ding et al., 2017; Bani-Melhem and Smith, 2012; Li et al., 2009; Lesjean and Gnriss, 2006), biological treatment processes (Mohammadi et al., 2017;
Adsorption process is a relatively easy and practicable method for the treatment of wastewater. One of its advantages is allowing for usage of wastes such as nut shells, seed hulls and rice husks as adsorbents. In this study, the treatment of greywater by adsorption method was investigated, and polymeric composites produced from waste shells with different oxidizing agents were used as adsorbents. Treatment studies were evaluated in terms of color, turbidity and detergent removal.

MATERIAL AND METHODS

Greywater characteristics

The wastewater used for this study was taken from a washing machine and it was in the category of high load greywater. The characterization of greywater was given in Table 1. All analyses of the parameters shown in Table 1 were conducted according to the standard methods (APHA, 2005).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Arithmetic Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>11.63</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>24.00</td>
</tr>
<tr>
<td>Absorbance (331 nm)</td>
<td>3.623</td>
</tr>
<tr>
<td>Color (Pt-Co)- 455 nm</td>
<td>3180</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>176</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>256</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>384</td>
</tr>
<tr>
<td>Surfactant (mg/L)</td>
<td>45.87</td>
</tr>
</tbody>
</table>

Polymerization of active carbons

Waste materials (seed hull, rice husk, walnut and hazelnut shells) used in this study were chemically activated with 50% aqueous solution of H₃PO₄ and then carbonized to obtain activated carbon. By 1 g of each activated carbon (produced from different shells) were taken and added into the continuously mixed on magnetic stirrer solution of 1 g KIO₃/K₂S₂O₈ in 100 mL H₂SO₄ (1 M). 1 mL of aniline monomer was slowly added into this solution while mixing was kept on. After the homogenized mixture had been obtained, polymerization was conducted in ultrasonic bath (Wise Clean WUC-AO6H) for 5 h at ambient temperature. After this procedure, the samples were filtered through creped filter papers and washed with deionized water. Polymerized activated carbons were dried in drying oven for 24 h at 60°C and then cooled in a desiccator. Synthesized polymeric composites were shown in Table 2.
Table 2. Prepared polymeric composites.

<table>
<thead>
<tr>
<th>Substrate of Activated Carbon</th>
<th>Polymer oxidized with KIO$_3$</th>
<th>Polymer oxidized with K$_2$S$_2$O$_8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walnut Shell (WS)</td>
<td>PAn/ WS + KIO$_3$</td>
<td>PAn/ WS + K$_2$S$_2$O$_8$</td>
</tr>
<tr>
<td>Seed Hull (SH)</td>
<td>PAn/ SH + KIO$_3$</td>
<td>PAn/ SH + K$_2$S$_2$O$_8$</td>
</tr>
<tr>
<td>Hazelnut Shell (HS)</td>
<td>PAn/ HS + KIO$_3$</td>
<td>PAn/ HS + K$_2$S$_2$O$_8$</td>
</tr>
<tr>
<td>Rice Husk (RH)</td>
<td>PAn/ RH + KIO$_3$</td>
<td>PAn/ RH + K$_2$S$_2$O$_8$</td>
</tr>
</tbody>
</table>

Experimental Procedure

100 mL of wastewater sample were taken into a 250 mL Erlenmeyer flask and 1 g of adsorbent was added onto the sample. Samples were shaken in the water bath shaker for 120 minutes at room temperature (23°C) and stirring rate of 150 rpm. The samples, which were taken at the end of the agitation, were separated from the adsorbents by filtration. The effectiveness of the applied adsorption process was evaluated via color, turbidity and surfactant parameters. HACH-LANGE Dr 5000 spectrophotometer was used to determine the color, turbidity and surfactant in the experimental study. Color results were determined according to the wavelength of 455 nm in the spectrophotometer. The turbidity was measured by using the nephelometric method. The maximum absorbance was observed at 288 nm for the turbidity analysis. Concentration of surfactant was measured by using the methylene blue anionic surfactant (MBAS) analysis. All analyses were carried on according to the standard methods for the water and wastewater examination (APHA, 2005).

RESULTS AND DISCUSSION

The treatment of generated after laundry greywater by adsorption process with the usage of adsorbents from different waste shells was investigated in this study. The efficiencies of the adsorbents (PAn/WS+KIO$_3$, PAn/SH+ KIO$_3$, PAn/HS+ KIO$_3$, PAn/ RH+ KIO$_3$, PAn/WS+K$_2$S$_2$O$_8$, PAn/SH+K$_2$S$_2$O$_8$, PAn/HS+ K$_2$S$_2$O$_8$ and PAn/ RH+ K$_2$S$_2$O$_8$) for the adsorption experiments at the original pH value of greywater (11.63) and for 120 min duration were investigated in terms of color removal (Figure 1).
As can be seen, in Figure 1 the highest color removal efficiencies for the greywater treatment were achieved with the adsorbents produced with KIO$_3$ oxidation, namely, PAn/SH+KIO$_3$ and PAn/RH+KIO$_3$ with the results of 97% and 98%, respectively. For the adsorbents produced with K$_2$S$_2$O$_8$ oxidation, the highest color removal efficiency was obtained for PAn/SH+K$_2$S$_2$O$_8$ with the result of 58%.

The efficiencies of adsorbents for the greywater treatment were also investigated with the same experimental conditions for the turbidity removal (Figure 2).

According to the Figure 2, the highest turbidity removal efficiencies were achieved for the PAn/SH+KIO$_3$ and PAn/RH+KIO$_3$ adsorbents produced with KIO$_3$ oxidation, with the results of 46% and 70%, respectively. For the adsorbents produced with K$_2$S$_2$O$_8$ oxidation, all turbidity removal efficiencies were obtained as 3%.

And at last, efficiencies of all synthesized adsorbents in the greywater treatment were
investigated in terms of detergent (surfactant) removal (Figure 3).

![Graph showing surfactant removal efficiency for different adsorbents.]

**Figure 3.** The effect of adsorbent on the surfactant removal efficiency (Grey water= 100 mL, adsorbent amount= 1g, reaction time= 120 min, reaction rate= 150 rpm).

As seen from Figure 3, the highest detergent removal efficiencies in the greywater treatment were achieved for the adsorbents produced with KIO₃ oxidation, which were PAN/SH+KIO₃ and PAN/RH+KIO₃ with the efficiencies of 95% and 96%, respectively. For the adsorbents produced with K₂S₂O₈ oxidation, the highest detergent removal efficiencies were determined for PAN/ RH+ K₂S₂O₈ and PAN/SH+K₂S₂O₈ with the results of 97% and 95%, respectively. In general, the detergent removal efficiencies were found above 50% for all adsorbents used in experiments.

**CONCLUSION**

In this study, the treatability of generated from laundry greywater by adsorption with polymeric composites prepared from waste materials and different oxidants was investigated in terms of color, turbidity and detergent parameters. The color removal efficiencies for KIO₃ oxidant used composites can be sorted in the descending order and correspond to the series of adsorbents taken as PAN/RH+KIO₃ > PAN/SH+KIO₃ > PAN/HS+KIO₃ > PAN/WS+KIO₃ for the adsorption studies conducted during 120 min at the original pH value of greywater. For K₂S₂O₈, the adsorbent efficiencies ranged from the highest to the lowest give the series PAN/SH+K₂S₂O₈ > PAN/WS+K₂S₂O₈ > PAN/HS+K₂S₂O₈ > PAN/ RH+K₂S₂O₈.

In respect to the turbidity removal efficiencies, the descending order of the adsorbents corresponds to the series PAN/RH+KIO₃ > PAN/SH+KIO₃ > PAN/WS+KIO₃ = PAN/HS+KIO₃ = PAN/WS+K₂S₂O₈ = PAN/SH+K₂S₂O₈ = PAN/HS+K₂S₂O₈ = PAN/RH+K₂S₂O₈.

According to the detergent removal efficiencies and the same sorting order, the used composites were represented as an array of PAN/RH+KIO₃ > PAN/SH+KIO₃ > PAN/HS+KIO₃ > PAN/WS+KIO₃ in the case of KIO₃ oxidant, while for the K₂S₂O₈ oxidant, the arrangement of the composites was PAN/RH+ K₂S₂O₈ > PAN/SH+K₂S₂O₈ > PAN/HS+ K₂S₂O₈ > PAN/WS+K₂S₂O₈.
It has been determined that the usage of KIO₃ ve K₂S₂O₈ oxidants in the synthesis of polymeric composite adsorbents has positive effect on the adsorption processes, especially, for the removal of surfactant.

ACKNOWLEDGMENTS

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