Eurasian Journal of Environmental Research
Volume 2 Issue 2

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

Sevil Veli[1], Ayla Arslan[1], Eylem Topkaya[*1], Hatice Kurtkulak[1], Şehriban Zeybek[1,] Çisil Gülümser[1] and Anatoli Dimoglo[2]

[1] Kocaeli University,Department of Environmental Engineering, 41380 Kocaeli, TURKEY.
[2] Düzce University, Department of Environmental Engineering, 81620 Düzce, TURKEY.
(Corresponding Author's E-mail: eylem.topkaya@kocaeli.edu.tr)

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. KIO_3 and $K_2S_2O_8$ 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+KIO_3 adsorbent as 98%, 70% and 96% for color, turbidity and detergent, respectively, while for the PAn/SH+$K_2S_2O_8$ 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 Gnirss, 2006), biological treatment processes (Mohammadi et al., 2017;

Hernandez Leal et al., 2011; Ghunmi et al., 2010; Lamine et al., 2007), filtration system (Katukiza et al., 2014) and photocatalytic oxidation (Sanchez et al., 2010) are primary studies in literature about greywater treatment.

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 1. Characteristics of greywater used in the study.

Parameters	Arithmetic Mean
pH	11.63
Temperature (ºC)	24.00
Absorbance (331 nm)	3.623
Color (Pt-Co)- 455 nm	3180
Turbudity (NTU)	176
TSS (mg/L)	256
COD (mg/L)	384
Surfactant (mg/L)	45.87

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 H_3PO_4 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 $KIO_3/K_2S_2O_8$ in 100 mL H_2SO_4 (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 60ºC and then cooled in a desiccator. Synthesized polymeric composites were shown in Table 2.

Table 2. Prepared polymeric composites.

Substrate of Activated Carbon	**Polymer oxidized with KIO_3**	**Polymer oxidized with $K_2S_2O_8$**
Walnut Shell (WS)	PAn/ WS+ KIO_3	PAn/ WS+ $K_2S_2O_8$
Seed Hull (SH)	PAn/ SH+ KIO_3	PAn/ SH+ $K_2S_2O_8$
Hazelnut Shell (HS)	PAn/ HS+ KIO_3	PAn/ HS+ $K_2S_2O_8$
Rice Husk (RH)	PAn/ RH+ KIO_3	PAn/ RH+ $K_2S_2O_8$

Experimental Procedure

100 mL of wastewater sample were taken into a 250 mL Erlenmeyer flask and 1g of adsorbent was added onto the sample. Samples were shaken in the water bath shaker for 120 minutes at room temperature (23ºC) 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+$K_2S_2O_8$, PAn/SH+$K_2S_2O_8$, PAn/HS+ $K_2S_2O_8$ and PAn/ RH+ $K_2S_2O_8$) 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).

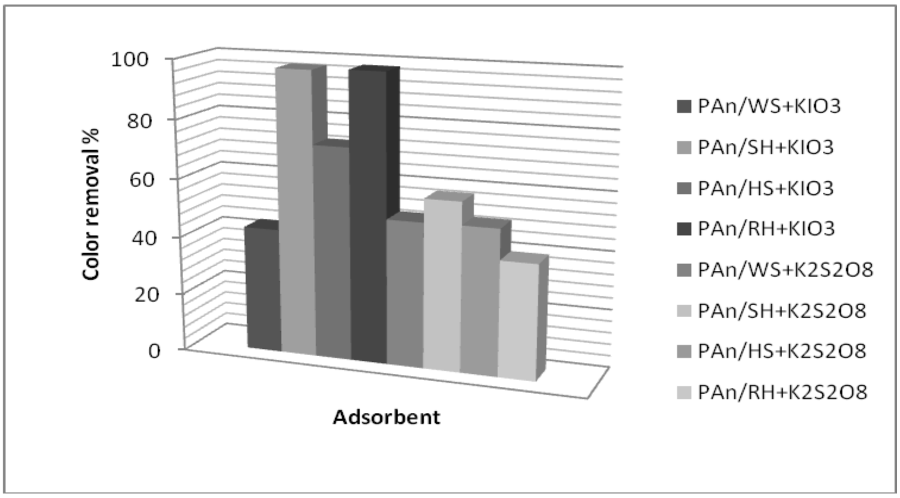

Figure 1. Effect of adsorbent on color removal efficiency (Grey water= 100 mL, adsorbent amount= 1g, reaction time= 120 min, reaction rate=150 rpm).

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 $K_2S_2O_8$ oxidation, the highest color removal efficiency was obtained for PAn/SH+$K_2S_2O_8$ 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).

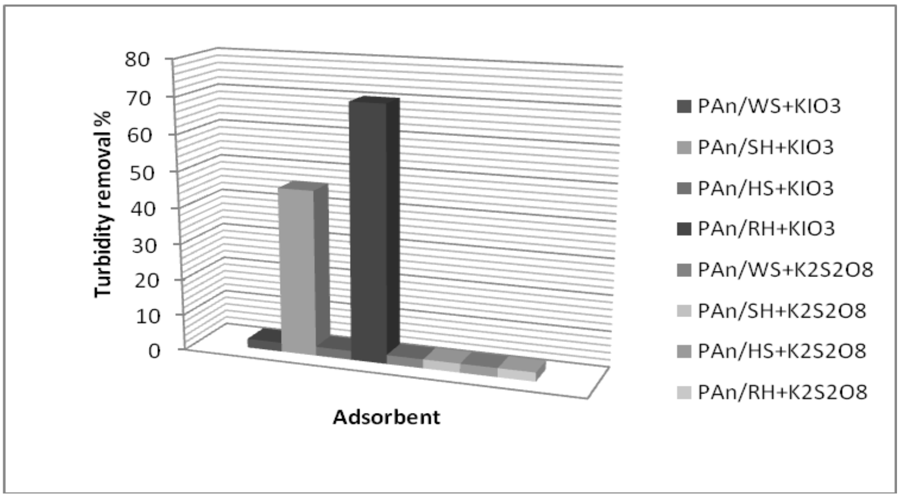

Figure 2. Effect of adsorbent on the turbidity removal efficiency (Grey water= 100 mL, adsorbent amount= 1g, reaction time= 120 min, reaction rate=150 rpm).

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 $K_2S_2O_8$ 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).

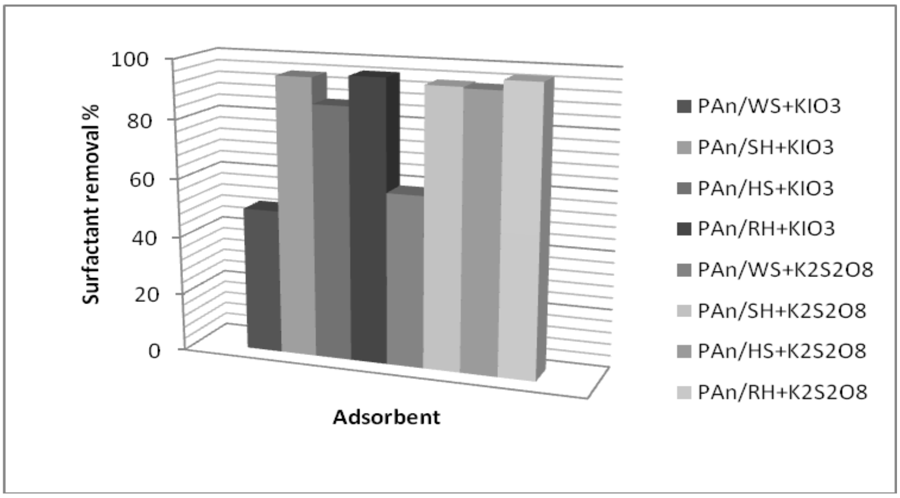

Figure 3. The effect of adsorbent on the surfactant removal efficiency (Grey water= 100 mL, adsorbent amount= 1g, reaction time= 120 min, reaction rate=150 rpm).

As seen from Figure 3, the highest detergent removal efficiencies in the greywater treatment were achieved for the adsorbents produced with KIO_3 oxidation, which were PAn/SH+KIO_3 and PAn/RH+KIO_3 with the efficiencies of 95% and 96%, respectively. For the adsorbents produced with $K_2S_2O_8$ oxidation, the highest detergent removal efficiencies were determined for PAn/ RH+ $K_2S_2O_8$ and PAn/SH+$K_2S_2O_8$ 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 KIO_3 oxidant used composites can be sorted in the descending order and correspond to the series of adsorbents taken as PAn/RH+KIO_3 > PAn/SH+KIO_3 > PAn/HS+KIO_3 > PAn/WS+KIO_3 for the adsorption studies conducted during 120 min at the original pH value of greywater. For $K_2S_2O_8$, the adsorbent efficiencies ranged from the highest to the lowest give the series PAn/SH+$K_2S_2O_8$ > PAn/WS+$K_2S_2O_8$ > PAn/HS+$K_2S_2O_8$ > PAn/ RH+$K_2S_2O_8$.
In respect to the turbidity removal efficiencies, the descending order of the adsorbents corresponds to the series PAn/RH+KIO_3 > PAn/SH+KIO_3 > PAn/WS+KIO_3 = PAn/HS+KIO_3 = PAn/WS+$K_2S_2O_8$ = PAn/SH+$K_2S_2O_8$ = PAn/HS+$K_2S_2O_8$ = PAn/RH+$K_2S_2O_8$.

According to the detergent removal efficiencies and the same sorting order, the used composites were represented as an array of PAn/RH+KIO_3 > PAn/SH+KIO_3 > PAn/HS+KIO_3 > PAn/WS+KIO_3 in the case of KIO_3 oxidant, while for the $K_2S_2O_8$ oxidant, the arrangement of the composites was PAn/RH+ $K_2S_2O_8$ > PAn/SH+$K_2S_2O_8$ > PAn/HS+ $K_2S_2O_8$ > PAn/WS+$K_2S_2O_8$.

It has been determined that the usage of KIO_3 ve $K_2S_2O_8$ oxidants in the synthesis of polymeric composite adsorbents has positive effect on the adsorption processes, especially, for the removal of surfactant.

ACKNOWLEDGMENTS

The authors thank TUBITAK Research and Development Program with Priority Fields (1003) for their financial support to the main Project 115Y797 and sub-Project 115Y820.

REFERENCES

APHA, Standard Methods for the Examination of Water and Wastewater, 2005 21st edn, American Public Health Association, Washington DC, USA.

Albalawneh, A. and Chang, T. 2015. Review of the greywater and proposed greywater recycling scheme for agricultural irrigation reuses. *International Journal of Research*, 3(12), 16-35.

Bani-Melhem, K. and Smith, E. 2012. Grey water treatment by a continuous process of an electrocoagulation unit and a submerged membrane bioreactor system. *Chemical Engineering Journal*, 198–199, 201–210.

Boyjoo, Y., Pareek, V. K. and Ang, M. 2013. A review of greywater characteristics and treatment processes. *Water Science & Technology*, 67(7), 1403–1424.

Ding, A., Liang, H., Li, G., Szivak, I., Traber, J., Pronk, W. 2017. A low energy gravity-driven membrane bioreactor system for grey water treatment: Permeability and removal performance of organics. *Journal of Membrane Science*, 542, 408–417.

Gross , A., Maimon, A., Alfiya, Y. and Friedler, E. 2015. Greywater reuse, Boca Raton, London and New York, CRC Press, 283 pp.

Ghunmi, L.A., Zeeman, G., Fayyad, M., Lier, J.B. 2011. Grey water treatment systems: A review. *Critical Reviews in Environmental Science and Technology*, 41(7), 657- 698.

Ghunmi, L. A., Zeeman, G., Fayyad, M., B. van Lier, J. 2010. Grey water treatment in a series anaerobic – Aerobic system for irrigation. *Bioresource Technology*, 101, 41–50.

Hernández Leal, L., Temmink, H., Zeeman, G. and Buisman, C.J.N. 2011. Characterization and anaerobic biodegradability of grey water. *Desalination*, 270, 111–115.

Karahan, A. 2011. *Gri Suyun Değerlendirilmesi. IX. Ulusal Tesisat Mühendisliği Kongresi,* 1155-1164.

Katukiza, A.Y., Ronteltap, M., Niwagaba, C.B., Kansiime, F. and Lens, P.N.L. 2014. Grey water treatment in urban slums by a filtration system: Optimisation of the filtration medium. *Journal of Environmental Management*, 146, 131-141.

Lamine, M., Bousselmi, L. and Ghrabi, A. 2007. Biological treatment of grey water using sequencing batch reactor. *Desalination*, 215, 127–132.

Lesjean, B. and Gnirss, R. 2006. Grey water treatment with a membrane bioreactor operated at low SRT and low HRT. *Desalination*, 199, 432–434.

Li, F., Witchmann, K., Otterpohl, R. 2009. Review of the technological approaches for grey water treatment and reuses. *Science of the Total Environment*, 407, 3439– 3449.

Mohammadi, M. J., Takdastan, A., Jorfi, S., Neisi, A., Farhadi, M., Yari, A. R., Dobaradaran, S., Khaniabadi, Y. O. 2017. Electrocoagulation process to Chemical and Biological Oxygen Demand treatment from carwash grey water in Ahvaz megacity, Iran. *Data in Brief*, 11, 634–639.

Ridderstolpe, P. 2004. *Introduction to Greywater Management, Stockholm Environment Institute,* Stockholm, Sweden.

Rowe, D.R. and Abdel-Magid, I.M. 1995. *Handbook of Wastewater Reclamation and Reuse*. CRC Press, Boca Raton, Florida.

Sanchez, M., Rivero, M.J. and Ortiz, I. 2010. Photocatalytic oxidation of grey water over titanium dioxide suspensions. *Desalination*, 262, 141–146.

Tchobanoglous, G., Burton, F.L., Stensel, H. D. 1991. *Wastewater Engineering: Treatment and Reuse*, 4th Edition, Mc Graw Hill.