RESEARCH ARTICLE

•Arch Hyg Sci 2017;6(1): 66-74
•Journal Homepage: http://jhygiene.muq.ac.ir

Electrocoagulation Process for Treatment of Detergent and Phosphate

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A-R-T-I-C-L-EI-N-F-O

Article Notes:
Received: Aug. 20, 2016
Received in revised form: Nov. 20, 2016
Accepted: Dec. 19, 2016
Available Online: Jan 1, 2017

Keywords:
Car Wash Wastewater
Electrocoagulation
Detergent
phosphate
Iran.

A-B-S-T-R-A-C-T

Background & Aims of the Study: Detergent and phosphate are one of the main and vital threats (eutrophication phenomenon and production of synthetic foam) for the source of drinking water, agriculture and industrial uses in the Ahvaz, Iran that threaten human health. The aim of this study is the evaluation of the efficiency of the electrocoagulation (EC) process in the removal of detergent and phosphate from car wash effluent.

Materials & Methods: In this experimental study, we used a glass tank with a volume of 2-4 liters (effective volume of 2 liters) containing 4 electrode-plate iron and aluminum (AL-AL, AL-Fe, Fe-Fe). Bipolar method was used to convert alternative electricity to direct; electrodes were connected to a power supply. Daily samples were collected from different car washes sewage. Initial PHs of samples was from 7 to 9. At first, different tests were performed on primary samples. Reaction times were set for 90, 60 and 30 minutes with middle intervals of 2 cm.

Results: According to the result of this study, percentage of phosphate removal in the EC with Al-Fe electrode, with an optimum pH = 7, has been from 34 % (in the 10 Volt) to 78% (in the 30 Volt). Percentage of detergent removal in the EC with AL electrode, with an optimum pH = 7, has been from 68 % (in the 10 Volt) to 94% (in the 30 Volt).

Conclusions: Altogether, it was found that this method can be used as a confident and convenient method for treating car wash effluent and according to the highest removal efficiency of the process, effluent can be discharged safely into the environment.

Please cite this article as: Takdastan A, Farhadi M, Salari J, Kayedi N, Hashemzadeh B, Mohammadi MJ, et al. Electrocoagulation Process for treatment of Detergent and Phosphate. Arch Hyg Sci 2017;6(1):66-74.

Background

The irregular detergent entry into groundwater and surface water resources is causing serious environmental problems, including the eutrophication phenomenon and production of synthetic foam (1-3). Household cleaning products and detergents in sewage are major sources of phosphorus (4-8). In order to remove phosphorus detergent compounds in the treatment basin, the use of different and expensive units such as complex systems, aeration, pumping, treatment and disposal of the resulting sludge will require (9). Most detergents are slow biodegradable and there is no fast break in conventional treatment (10,11). Because of the availability conditions, especially in the pond aeration and mixing, foam is produced which disturbs the treatment process because of the high volume and also creates many risks for the refinery workers (12,13). Therefore, treatment is particularly important for detergents and phosphorus wastewater to prevent environmental pollution, prevent degradation of groundwater, surface water resources and improve the performance treatment plants of municipal sewage (13-15). A wide range of water and wastewater treatment processes, including physical operations, biological, physical-chemical and chemical processes (such as chemical precipitation) have been identified to remove contaminants (16-19). In recent years due to environmental compatibility and the possibility of purification of liquids, gases and solids, the use of direct electricity in the water and wastewater treatment plants is developed; also, it is known as an attractive method for coagulation or sedimentation as an electrocoagulation/electrochemical method (10, 20-25). This method can be used widely for wastewater treatment containing BOD, COD, proteins, oils, detergents, paints and solutions containing heavy metals (13,17,21,26-27). Electrocoagulation is a process that consists of creating a drainage metal hydroxide fluke electrical due to dissolution of soluble anodes which are usually iron or aluminum. This was met with limited success in the twentieth century; this method is accepted recently due to environmental restrictions on output wastewater (17,21,26). Studies on the use of EC in wastewater treatment have increased during recent decades about the kind of consumer electrodes and the effective factors which have been used. In a similar work, Mansoorian et al. studied the removal of lead and zinc from battery industry wastewater, using electrocoagulation process; the effect of direct and alternating current, using iron and stainless steel rod electrodes (25). Malakootian et al in their study had shown the relationship between electrocoagulation process, using iron-rod electrodes and removing hardness from drinking water (10). Jay et al. offered a new bipolar electrocoagulation and electro-flotation process for wastewater laundry treatment. The electrocoagulation and electro-flotation processes were performed in a single reactor simultaneously. Performance parameters such as primary pH, hydraulic retention time (HRT) and flow intensity were examined (23). Irdimz et al. used the Taguchi method to determine the optimum conditions, phosphate removal from wastewater by EC with flat aluminum electrodes. Removal efficiency and a laboratory of phosphate from wastewater by electrocoagulation and flat aluminum electrodes are 99.9 and 100%, respectively (27). Önder et al. studied the possibility of removal of the surface-active agents (surfactants) from the solution model and polluted water sample with EC method by Fe^{2+} ions. In these tests, the efficiency of surface-active substances removal with a concentration of surfactant of 10 mg/L was reached to 100 % (26). In order to remove the COD, phosphate, fat and turbidity from sewage treatment in the presence of hydrogen peroxide (H_2O_2) and poly aluminum chloride (PAC) as a coagulant aid method, Un et al. used an electrochemical method with soluble aluminum or iron electrodes. COD removal efficiency was in the range of 62% to 86%, while the removal rates of oil, fat and turbidity was reached up to 100% (28). Sengil et al. studied the removal of COD, phosphate and fats from dairy wastewater by EC with direct current (DC). The removal efficiency of COD and grease was 98 and 98%, respectively (29). Mahvi et al. studied the usability of the electrocoagulation process, using aluminum electrodes to remove heavy metal chromium in aquatic environments. The test results showed that the highest removal efficiency of chromium ions is at pH=3, and a potential difference of 40 v (20). Bani-Melhem et al. studied the efficiency of submerged membrane bioreactor system on the real grey water treatment. (21).

Aims of the study: In the present study, we investigate the influence of type of electrodes with different arrangements, voltage, PH and retention time in removal of detergent and phosphate from car wash wastewater.

Materials & Methods

Laboratory materials

In this experimental study that conducted in a pilot project in the chemical laboratory, pH, voltage, retention time and the effects of variables of electrode type were measured. Potassium dichromate ($K_2Cr_2O_7$), Potassium permanganate ($KMnO_4$), potassium hydroxide (KOH), potassium hydrogen phthalate ($C_8H_5KO_4$), silver sulfate (Ag_2SO_4), mercury sulfate ($HgSO_4$), sulfuric acid (H_2SO_4), 3-methyl-2-benzothiazoline hydrazine and Formaldehyde (HCHO) used in this study. Equipment that used in this study were photo spectrophotometric meter DR/5000, the AC power supply Tracking Dual JPS-302D, glass reactor electro coagulation, iron and aluminum plate electrodes, oven and magnetic mixer.

Sampling

Samples of wastewater were collected from different car washes in the city and transferred to the laboratory. Tests of phosphate and detergent were done on initial samples, and initial concentration was determined. To adjust the primary pH of the solution, the sulfuric acid and one-tenth normal sodium hydroxide were used. Table 1 shows the factors which were affect the electrocoagulation process including characteristics of the raw carwash wastewater, voltage, primary pH and retention time (Table 1).

Experimental apparatus

A lab-scale reactor with diameters of 15cm×15cm×15cm was used for doing this experiment. This reactor was made of glass with a thickness of 10mm with iron and aluminum electrodes with dimensions 12cm×10cm×2mm that were upright and a distance of 2cm from together that the end of each was connected to the DC power supply. Sewage mixing was done, using a magnetic stirrer with a constant speed of 100rpm. Hydrochloric acid, with a weight of 15%, was used to clean the electrodes before starting the procedure. The test was assessed in the voltage range of 10, 20, 30 and arrangements of AL-AL, AL-Fe, Fe-Fe in the pH domains of 3, 7 and 11 with 2 cm intervals and the contact time of 30, 60 and 90 min for each set of pairs of electrodes. In these tests due to the transmission voltage, flow rates were varied between 0.5 to 2 amps. In each set of experiments, samples were taken from the liquid inside of the reactor at specified times; and after filtration, according to the DR5000 UV- Vis HACH spectrophotometer, the samples were prepared for testing the parameters; then, their values were determined, using wavelengths specified by the device.

Table 1) Parameters measured and their range

Parameter	Range	Unit	Raw wastewater Mean ± S.D
pH	3,7,11	---	7.08±0.03
Steering time	30,60,90	Minutes	-
Voltage	10,20,30	Volt	-
Electrode Type	Al-AlFe-Fe،AL-Fe	---	-
Conductivity	-	(mS/cm)	7.6±2.4
Detergent	-	(mgL^{-1})	23±8.3
Phosphate	-	(mgL^{-1})	17±8.8

Results

In this study, voltage (10, 20, 30 V), contact time (30, 60, 90 minutes), type of electrode (AL-AL, AL-Fe, Fe-Fe), pH (11, 7, 3), turbidity and organic matter has evaluation. The results of various arrangements under optimal conditions is shown in Figures 1 to 6.

Changes in phosphate due to variations in input voltage during EC:

Figure 1 shows that increase in the removal of phosphate in the EC with an optimum pH=7 with aluminum electrode have been from 73% phosphate removal (in the 10 voltage) to 100% phosphate removal (in the 30 voltage), respectively.

According to Figure 2, phosphate removal in the EC with aluminum-iron electrode with an optimum pH=7 has been from 34% (in the 10 voltage) to 78% (in the 30 voltage), respectively.

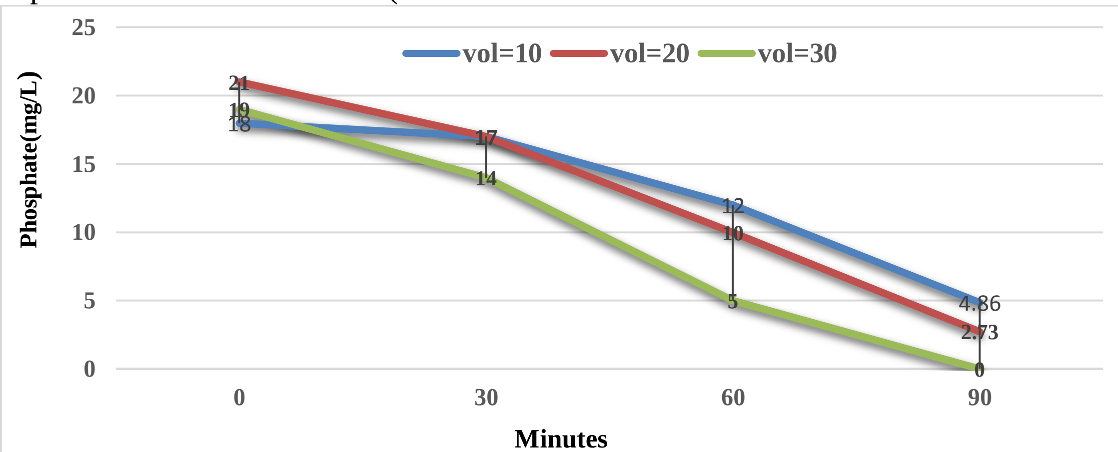

Figure 1) Phosphate changes in the EC with aluminum electrodes in the optimum pH =7

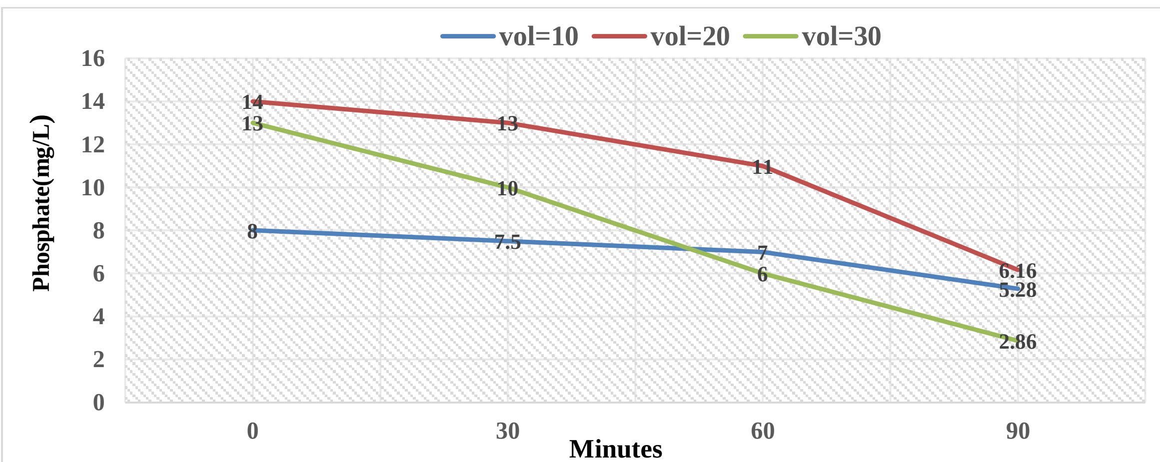

Figure 2) Changes in phosphate in the EC with electrodes made of aluminum – iron at the optimum pH=7

According to Figure 3, the removal of phosphate in the EC with aluminum-iron electrode with an optimum pH=7 has been from 34% (in the 10 voltage) to 63% (in the 30 voltage), respectively. According to Figure 4, percentage of detergent removal in the EC with aluminum electrode with an optimum pH=7 has been from 51% (in the 10 voltage) to 80% (in the 30 voltage), respectively. According to Figure 4, percentage of detergent removal in the EC with aluminum-iron electrode with an optimum pH=7 has been from 68% (in the 10 voltage) to 94% (in the 30 voltage), respectively.

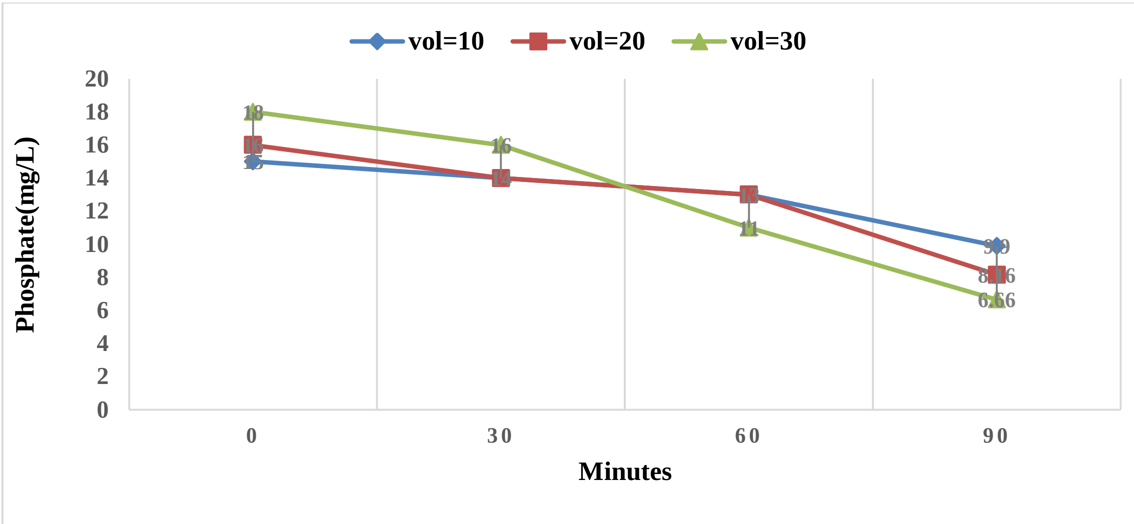

Figure 3) Changes in phosphate in the EC with iron electrodes in the optimum pH=7

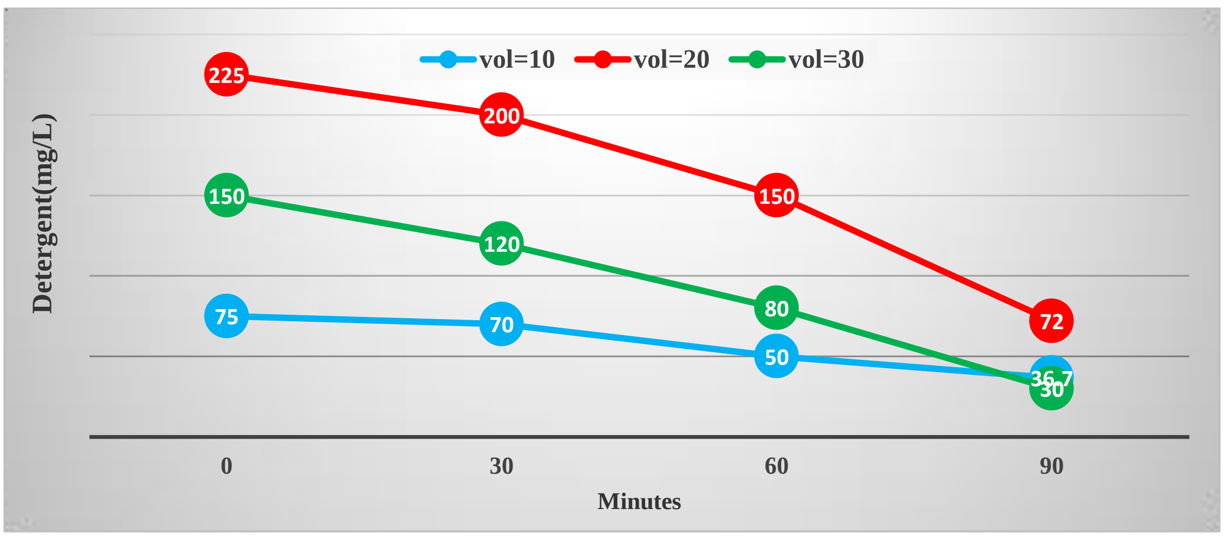

Figure 4) concentration of detergent in the EC with aluminum electrodes in the optimum pH=7

According to Figure 5, percentage of detergent removal in the EC with aluminum-iron electrode with an optimum pH=7 has been from 41% (in the 10 voltage) to 72% (in the 30 voltage), respectively. According to Figure 6, percentage of detergent removal in the EC with aluminum-iron electrode with an optimum pH=7 has been from 68% (in the 10 voltage) to 94% (in the 30 voltage), respectively.

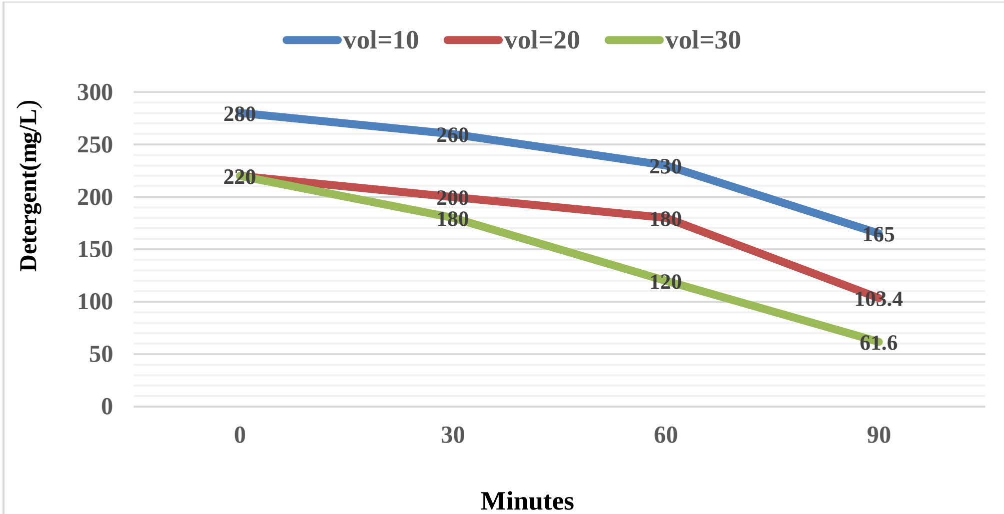

Figure 5) Changes in detergent concentration in the EC with aluminum-iron at the optimum pH electrode=7

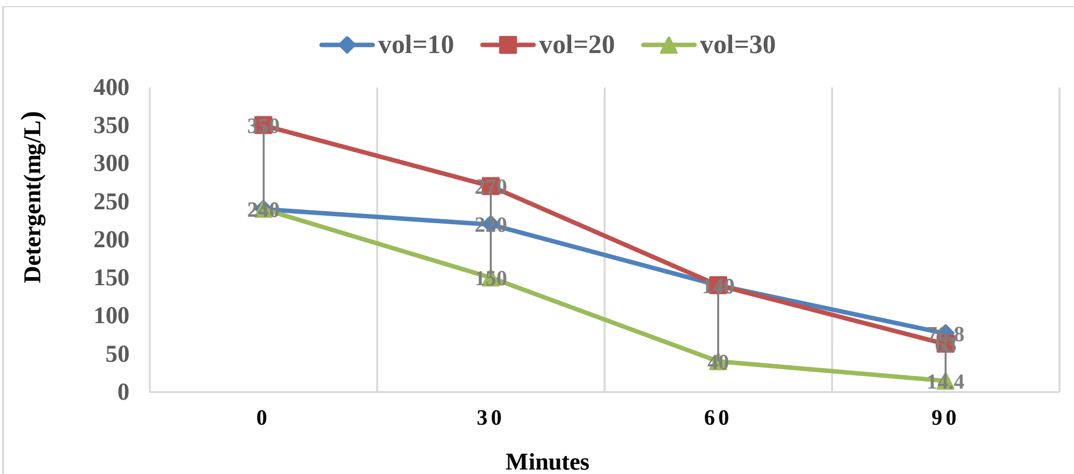

Figure 6) Changes in detergent concentration in the EC iron electrodes in the optimum pH=7

Discussion

Effect of electrode and array

The results of this experiment showed that use of the iron electrodes was appropriate for achieving the highest detergent removal. In the studies conducted by Singil et al. the removal percentage of detergent by iron electrode was 98% (30). By aluminum electrode, Nafa et al. attained a detergent removal efficiency of 76% (31). By iron electrode, Cobarty et al. obtained a detergent removal efficiency of 54% which is in consistent with the results of this study. Önder et al. in their study showed that the removal efficiency in surfactants from water contaminated with iron electrodes was 100% (26).

The effect of voltage

According to the result of our study, increasing the intensity of the current and voltage was affecting the treatment efficiency of detergent. Removal efficiency of detergent at natural pH for the iron electrode pair during 90 minutes at a voltage of 30 was nearly 93 %. By increasing the voltage potential, the response is increasing. Some of organic compounds and suspended solids are taken from the molecule 3 (OH) Fe or 3 (OH) AL; then, they formed fluke by settling or flotation mechanisms and are separated by

2H taken in cathode (20-22). This behavior that filtration efficiency is influenced by voltage is proven by some researchers. Drouche et al. observed that the Al^{+3} amount is increased by increasing the voltage, thereby fluoride ions are eliminated effectively (32). As well as in studies conducted by Rahmani and Samarghandi on the effectiveness of electro-coagulation in removing the detergent from wastewater, they concluded that the percentage of detergent removal is increased due to increasing of voltage (33).

The effect of retention time

Based on the result of this study, increasing the retention time cause the increased removal efficiency. Removal efficiency directly depends on the concentration of ions which were produced in the electrodes. With increasing the time of electrolysis, the concentration of ions which were produced increases, thereby the hydroxide clots increase (16,21,27).

Effect of primary PH

According to the results, apart from the detergent and phosphate that had the greatest efficiency removal at acidic pH, detergent had the greatest efficiency removal at neutral PH. The experiments were performed at pH of 11, 7 and 3. In the course of the electrolysis, when the electrodes of iron or aluminum are used, ions, iron and aluminum are produced at the anode and hydroxyl ion at the cathode, respectively. In a study conducted by Bayramoghlu on poultry slaughterhouse wastewater with aluminum electrode, the removal efficiency of 93% was obtained for 25 minutes and the current density of 150 mA per cubic meter in the initial pH=3 (34). Also, in studies conducted by Kubaya on MCFsW, phosphate removal at pH of 5 was 86% with aluminum electrodes and the removal of detergent was 78% at pH of 5 with electrodes made of aluminum (34). In Adhoum et al. study, an optimum pH was 6-4, which in this range, the olive oil wastewater without mill can be treated during the 25 minutes without the need to adjust the pH with COD and detergent removal efficiency of 76%, polyphenols removal efficiency of 91% and color removal efficiency of 95% (31).

Conclusion

In this study, we evaluate the efficiency of electrocoagulation (EC) process in the removal of detergent and phosphate from car wash effluent. According to the obtained results, the average removal of detergent and phosphate were 93% and 78%, respectively. Reaction rate is used to express a reduction in the concentration of reactants and to an increase in the concentration.

Footnotes

Acknowledgments:

The authors would like to thank student research committee, Ahvaz Jundishapur university of medical sciences for providing financial supported by grant: (95s45) of this research.

Funding/Support

This work was financially supported by grant: (95s45) from Vice- Chancellor for research Affairs of Ahvaz Jundishapur university of medical sciences.

Conflict of Interest:

The authors declared no conflict of interest.

References

1. Hassani G BA, Takdastan A, Shirmardi M, Yousefian F, Mohammadi MJ. Occurrence and fate of 17β-estradiol in water resources and wastewater in Ahvaz, Iran. Global Nest J 2016;18(4):855-66.
2. Kazemi Noredinvand B, Takdastan A, Jalilzadeh Yengejeh R. Removal of organic matter from drinking water by single and dual media filtration: a comparative pilot study. Desalin Water Treat 2016;57(44):20792-9.
3. Orooji N, Takdastan A, Eslami A, Kargari A, Raeesi G. Study of the chitosan performance in conjunction with polyaluminum chloride in removing turbidity from Ahvaz water treatment plant. Desalin Water Treat 2016;57(43):20332-9.

4. Ahmadi M, Mohammadi M-J, Ahmadi-Angaly K, Babaei A-A. Failures analysis of water distribution network during 2006-2008 in Ahvaz, Iran. J Adv Environ Health Rese 2014;1(2):129-37.
5. Alavi N, Zaree E, Hassani M, Babaei AA, Goudarzi G, Yari AR, et al. Water quality assessment and zoning analysis of Dez eastern aquifer by Schuler and Wilcox diagrams and GIS. Desalin Water Treat 2016;57(50):1-12.
6. Sobhanardakani S, Zandi Pak R, Mohammadi M J. Removal of Ni(II) and Zn(II) from Aqueous Solutions Using Chitosan. Arch Hyg Sci. 2016;5(1):47-55
7. Jafari Mansoorian H, Ansari M, Ahmadi E, Majidi G. Assessment of a Continuous Electrocoagulation on Turbidity Removal from Spent Filter Backwash Water. Arch Hyg Sci 2016;5(2):102-110
8. Mahvi A, Mansoorian H, Rajabizadeh A. Performance evaluation of electrocoagulation process for removal of sulphate from aqueous environments using plate aluminum electrodes. World Appl Sci J 2009;7(12):1526-33.
9. Hosseini Panah E, Takdastan A. Feasibility of Total Petroleum Hydrocarbon Removal from Drill Cutting with Digested Sludge Using Earth Worm. J Mazandaran Univ Med Sci 2016;25(133):319-24. (Full Text in Persian)
10. Malakootian M, Mansoorian H, Moosazadeh M. Performance evaluation of electrocoagulation process using iron-rod electrodes for removing hardness from drinking water. Desalination 2010;255(1-3):67-71.
11. Baraee I, Mehdi Borghei S, Takdastan A, Hasani AH, Javid AH. Performance of biofilters in GAC-sand and anthracite-sand dual-media filters in a water treatment plant in Abadan, Iran. Desalin Water Treat 2016;57(42):19655-64.
12. Yari AR, Alizadeh M, Hashemi S, Biglari H. Efficiency of Electrocoagulation for Removal of Reactive Yellow 14 from Aqueous Environments. Arch Hyg Sci. 2013;2(1):7-15
13. Shahmansouri M. Evaluation of Wastewater Treatment of Detergent Industry Using Coagulation Procession Pilot Scale. J Shahid Sadoughi Univ Medical Sci 2005;13(1):62-5. (Full Text in Persian)
14. Rostami A. Study of wastewater containing surfactant treatment and recycling search. [MSc Thesis]. Tehran: Department of Chemistry, Sharif University of Technology; 2000. (Persian)
15. Niri MV, Mahvi AH, Alimohammadi M, Shirmardi M, Golastanifar H, Mohammadi MJ, et al. Removal of natural organic matter (NOM) from an aqueous solution by NaCl and surfactant-modified clinoptilolite. J Water Health 2015;13(2):394-405.
16. Keramati H, Mahvi A, Abdulnezhad L. The survey of physical and chemical quality of Gonabad drinking water in spring and summer of 2007. Horizon Med Sci 2007;13(3):25-32. (Full Text in Persian)
17. Irdemez S, Yildiz Y, Tosunoglu s. Optimization of phosphate removal from wastewater by electrocoagulation with aluminum plate electrodes. Sep Purif Technol 2006;52(2):394-401.
18. Holt P, Barton G, Mitchell C. The future for electrocoagulation as a localised water treatment technology. Chemosphere 2005;59(3):355-67.
19. Jorfi S, Barzegar G, Ahmadi M, Darvishi Cheshmeh Soltani R, Alah Jafarzadeh Haghighifard N; Takdastan A, et al. Enhanced coagulation-photocatalytic treatment of Acid red 73 dye and real textile wastewater using UV_A/synthesized MgO nanoparticles. J Environ Manage 2016;177:111-8.
20. Mahvi A, Bazrafshan E, Mesdaghinia AR, Naseri S, Vaezi F. Chromium (Cr^{+6}) removal from aqueous environments by electrocoagulation process using aluminum electrodes. J Water Wastewater 2007;18(2):28-36. (Full Text in Persian)
21. K. Bani-Melhem, Z. Al-Qodah, M. Al-Shannag, A. Qasaimeh, M.R. Qtaishat, M. Alkasrawi, On the performance of real grey water treatment using a submerged membrane bioreactor system, J. Memb. Sci., 476 (2015) 40-49.
22. Rahmani A, Samarghandi MR. Electrochemical Removal of COD from Effluents. J Water Wastewater 2007,18(4):9-15. (Full Text in Persian)
23. Ge J, Qu J, Lei P, Liu H. New bipolar electrocoagulation-electroflotation process for the treatment of laundry wastewater. Sep Purif Technol 2004;36(1):33-9.
24. Feng C, Sugiura N, Shimada S, Maekawa T. Development of a high performance electrochemical wastewater treatment system. J Hazard Mater 2003;103(1-2):65-78.
25. Mansoorian HJ, Mahvi AH, Jonidi Jafari A. Removal of lead and zinc from battery industry wastewater using electrocoagulation process: Influence of direct and alternating current by using iron and stainless steel rod electrodes. Sep Purif Technol 2014;135:165-75.
26. Onder E, Koparal AS, Ogutveren UB. An alternative method for the removal of surfactants from water. electrochemical coagulation. Sep Purif Technol 2007;52(3):527-32.
27. Irdemez S, Demiricioglu N, Yildiz YS, Bingul Z. The effect of current density and pHospHate concentration on phosphate removal from wastewater by electrocoagulation using aluminum and iron plate electrodes. Sep Purif Technol 2006;52(2):218-23.
28. Un U, Ugur S, Koparal A, Ogutveren U. Elecrocoagulation of olive mill wastewaters. Sep Purif Technol 2006;52(1):114-36.

29. Sengil IA, Ozacar M. Treatment of dairy wastewater by electrocoagulation using mild steel electrodes. J Hazard Mater 2006;137(2):1197-205.
30. Şengil İ. Treatment of dairy wastewaters by electrocoagulation using mild steel electrodes. J Hazard Materials 2006;137(2):1197-205.
31. Adhoum N, Monser L, Bellakhal N, Belgaied JE. Treatment of electroplating wastewater containing Cu^{2+}, Zn^{2+} and Cr (VI) by electrocoagulation. J Hazard Mater 2004:207-13.
32. Drouiche N, Aoudj S, Hecini M, Ghaffour N, Lounici H, Mameri N. Study on the treatment of photovoltaic wastewater using electrocoagulation: Fluoride removal with aluminium electrodes—Characteristics of products. J Hazard Mater 2009;169(1-3):65-9.
33. Rahmani A. Efficiency of electrocoagulation for removal of Ario Chrome Black T color from wastewater. J of Water and Wastewater. 2009:52-8.
34. Bayramoglu M, Kobya M, Eyvaz M, Senturk E. Technical and economical analysis of electrocoagulation for the trea tment of poultry slaughterhouse wastewater. Sep Purif Technol 200651(3):401-8.