

flÿ Ł

.(-)

"fl . Ł

() (ÿmgNO₃-N/l)

.fl . . Ł
(S°)

.fl Ł

.()

(Thiobacillus denitrificans)

(Thiomicrospira denitrificans)

.(- i)

i

.()

.(i)

"fl! . ! Ł

.()

$\bar{n} /$

.()

.() $\bar{y}_{min} \bar{y}^{\circ}C$

.... i i i

i)

.(

/ L

:

)

$\bar{y}^{\pm} \text{ }^{\circ}C$

.(

- mm

(i)

$\bar{y} \bar{y}mg \text{ } ^{\circ}NO_3 \text{ } ^{-}N/l$

.()

$g \text{ } iKH_2PO_4 = \bar{y} / g \text{ } iK_2HPO_4 = g$ ()

$mg \bar{y} \text{ } ^{\circ}Na_2HPO_4 = / g \text{ } iMgSO_4 = \bar{y} / g \text{ } iNH_4Cl = \bar{y} /$

mg/L () $mg/L \text{ } ^{\circ}FeCl_3 =$

$iMnCl_2 \text{ } 1 \text{ } \bar{y} mg/L \text{ } iCaCl_2 = mg/L \text{ } iZnSO_4 = \bar{y}$

$= mg/L \bar{y} \text{ } iCuSO_4 = \bar{y} mg/L \text{ } i(NH_4)_6Mo_7O_{24} = \bar{y}$

.() $EDTA = \bar{y} \bar{y}mg/L \text{ } CoCl_2$

$\bar{n} \bar{y}$

i

i $\bar{y}mL$

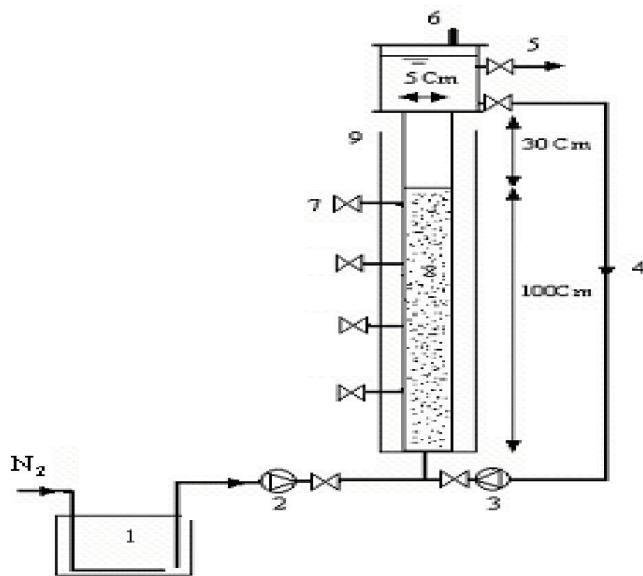
$\bar{y} \bar{y}rpm$

$\bar{y}min$

$\bar{y} \bar{y} - \bar{y} / mL$

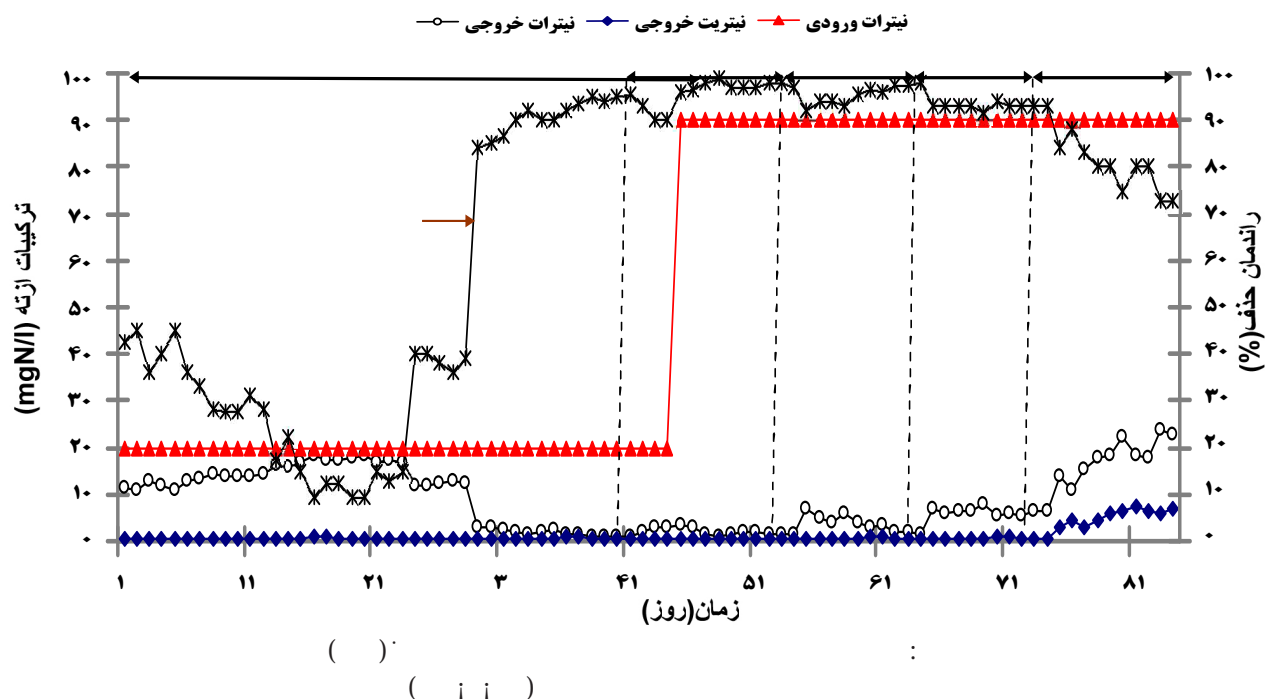
i - $\bar{y}u$

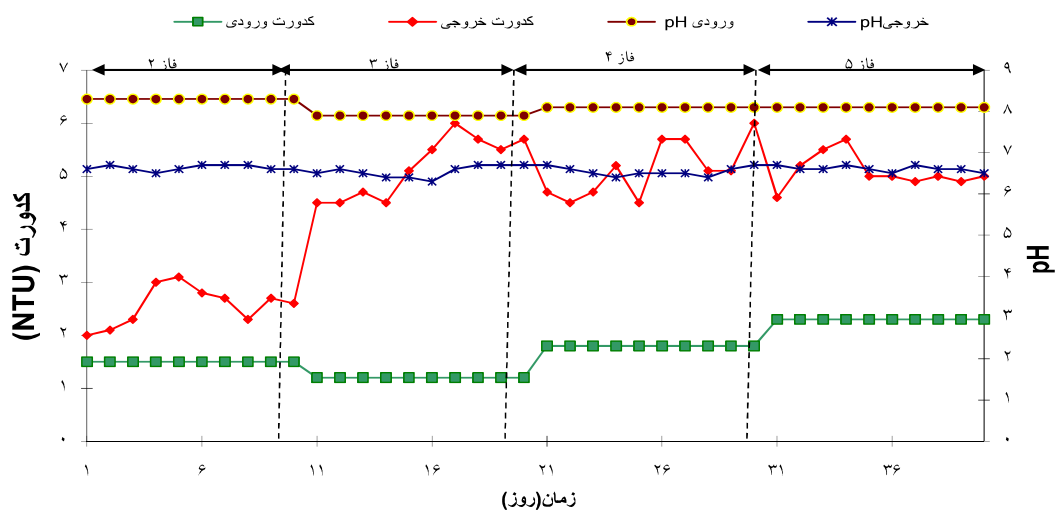
$\pm \dot{y}$ pH
 N
 $\dot{y} \text{ min}^{-1}$ cm $\dot{y} \text{ cm}$ / L
 $\dot{n} /$ $\dot{y} \text{ cm}$
 .
 $\dot{y} \text{ cm}$
 .
 $\dot{n} \dot{y}$ $\dot{y} \text{ cm}$
 $\dot{n} \dot{y}$
 $\dot{y} \text{ d}^{-1}$ mg/L
 $\dot{y} \dot{y} \text{ mg/L}^{-1}$
 .
 .
 $\dot{y} \text{ L}^{-1}$
 $\dot{n} \dot{y}$ $\dot{y} \dot{y} \text{ mg/L}$
 / - / h \dot{y} ()
 ($\dot{y} \text{ mg/L}$) $\dot{y} \dot{y} \text{ mg/L}$ $\text{NH}_4\text{Cl} = \text{mg}$ $\text{K}_2\text{HPO}_4 = \text{mg}$
 $\text{FeCl}_3 = \text{mg/L}$ $\text{MgSO}_4 = \text{mg/L}$
 . () mg/L



fl fl fl fl fl
 fl fl fl fl fl

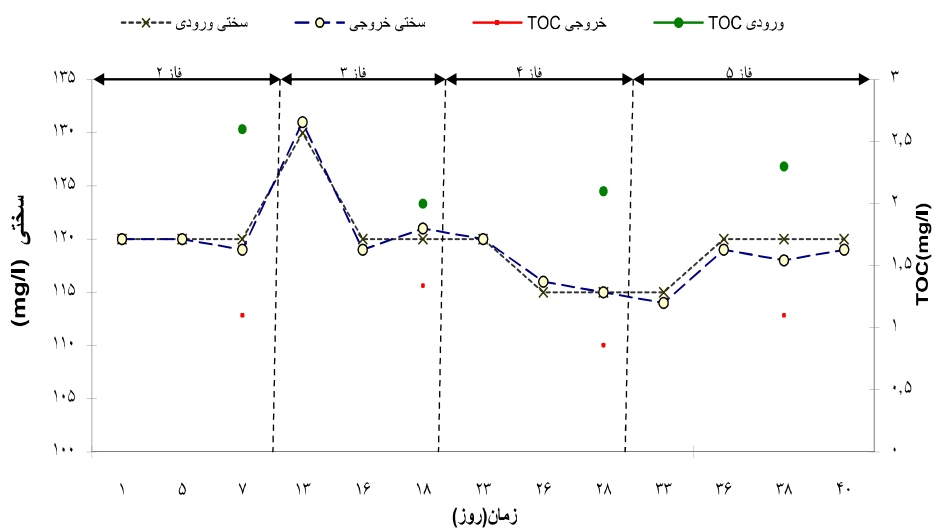
HACH (DR, 5000) UV
 NitriVer3
 pH
 TOC- Shimatzu V_{csH}
 AIS2100 Seron SEM-EDX



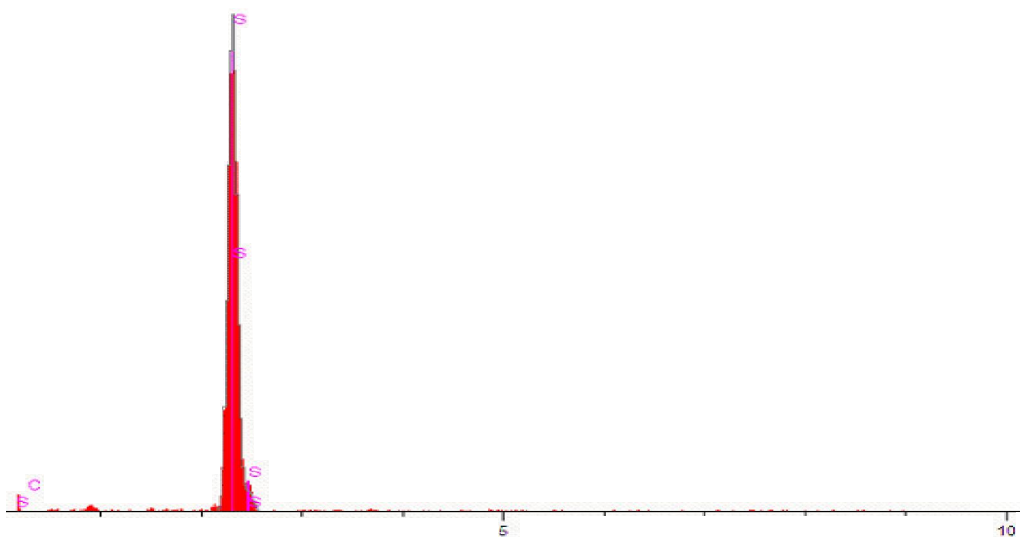


(۱۱)

.....
 / h^۳ £
 / kgN/m³.d^۳
 mg/L ÿ mg/L
 / h^۳ " fh £
 " mg/L d^۳



(۱۱)



EDX :

pH

pH

mg/L

/ /

/ / i / i / h

/ - / NTU

EDX

- NTU

i

/ h

EDX

pH

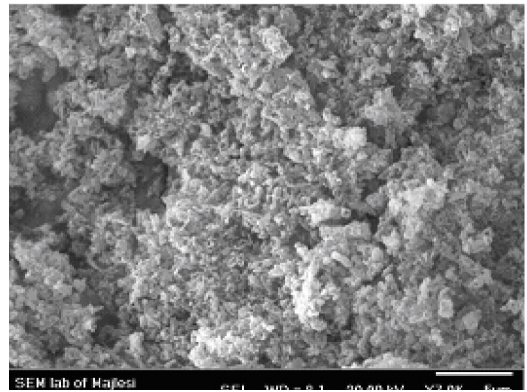
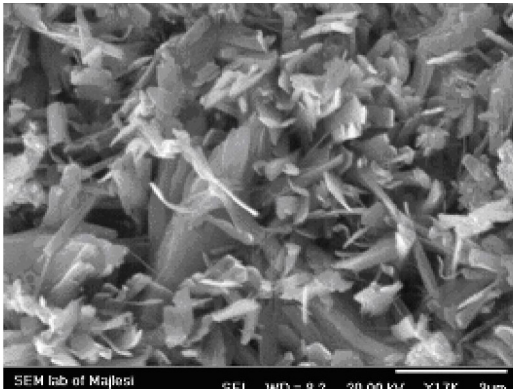
n /

/y± /

()

pH

/ / i / i / h



() : ()

ñ ÿ d

i i

.()

()

i

i

()

d

.()

Ma

Ma

/ h

pH

mg/L

/

mg/L

()

/ - /

Soares

Soares

()

pH

()

pH

Kim

Kim

pH

()

()

/ - /

()

i

pH

()

/ h

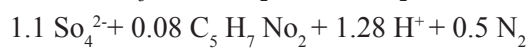
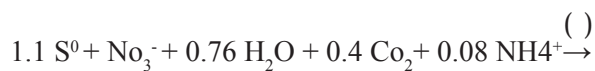
/ - /

()

/ / i /

pH

(Sloughing)



pH

()

pH

pH i

()

/ ± /

/ /

pH

()

TOC

mg/L

()

() mg/L

TOC

TOC

mg/L

mg/L

i

:

i

/ h

"

i

1. Zhang TC, Lamp DG. Sulfur: limestone autotrophic denitrification processes for treatment of nitrate contaminated water: batch experiment. *Water Res.* 1999; 33(3):599-608.
2. Sierra-Alvarez R, Beristain-Cardoso R, Salazar M, Gomez J, Razo-Flores E, Field JA. Chemolithotrophic denitrification with elemental sulfur for groundwater treatment. *Water Res.* 2007;41 : 1253–62.
3. Kimura K, Nakamura M, Watanabe Y. Nitrate removal by a combination of elemental sulfur-based denitrification and membrane filtration. *Water Res.* 2002; 36: 1758–66.
4. WHO. Guidelines for drinking-water quality. [electronic resource]: 3rd ed. Geneva, Switzerland. Vol. 1: Recommendations. World Health Organization; 2006.
5. Pekdemir T, Kacmazoglu EM, Keskinler B, Algur OF. Drinking Water Denitrification in a Fixed Bed Packed Biofilm Reactor. *Tr. J. of Engineering and Environmental Sciences.* 1998; 22: 39-45.
6. Wang Q, Feng C, Zhao Y, Hao C. Denitrification of nitrate contaminated groundwater with a fiber-based biofilm reactor. *Bioresour Technol.* 2009; 100: 2223–7.
7. Godini H, Rezaee A, Beranvand F. Hydrogenotrophic Denitrification of Water Using Zero Valent Iron Nano Particles. *Iran. J. Health & Environ.* 2010; 3(2): 143-152
8. Weisenburger DD. Potential health consequences of groundwater contamination by nitrate in Nebraska. In: Bogardi I, Kuzelka RD, editors. Nitrate contamination, NATO ASI Ser., vol. G30. Germany: Springer, 1991.
9. Bitton G. *Wastewater Microbiology* 3ed. Florida: John Wiley & Sons Inc Publication; 2005.
10. Wang H, Qu J. Combined bioelectrochemical and sulfur autotrophic denitrification for drinking water treatment. *Water Res.* 2003; 37:3767–75.
11. Wan D, Liu H, Qu J, Lei P, Xiao S, Hou Y. Using the combined bioelectrochemical and sulfur autotrophic denitrification system for groundwater denitrification. *Bioresour Technol.* 2009; 100: 142–8.
12. Kim HR, Lee LS, Bae JH. Performance of a sulphur-utilizing fluidized bed reactor for post-denitrification. *Process Biochem.* 2004; 39(11): 1591-7.
13. Zhang Z, Lei Z, He X, Zhang Z, Yang Y, Sugiura N. Nitrate removal by Thiobacillus denitrificans immobilized on poly (vinyl alcohol) carriers. *J Hazard Mater.* 2009; 163: 1090–5.
14. Liu LH, Koenig A. Use of limestone for pH control in autotrophic denitrification: continuous flow experiments in pilot-scale packed bed reactors. *J Biotechnology.* 2002; 99: 161-171.
15. Zeng H, Zhang TC. Evaluation of kinetic parameters of a sulfur–limestone autotrophic denitrification biofilm process. *Water Res.* 2005; 39: 4941-52.
16. Soares MIM. Denitrification of groundwater with elemental sulfur. *Water Res.* 2002; 36:1392–5.
17. Ma LU, Yang BL, Zhao JL. Removal of H₂S by Thiobacillus denitrificans immobilized on different matrices. *Bioresour Technol.* 2006; 97: 2041- 6.
18. Liu W, Vidic RD, Brown TD. Optimization of high temperature sulfur impregnation on activated carbon for permanent sequestration of elemental mercury vapors. *Environ. Sci. Technol.* 2009; 34(3):483-8.
19. Vidic RD, Liu W, Brown TD. Development of novel activated carbon-based adsorbents for control of mercury emissions from coal-fired power plants. *Proceedings of the Advanced Coal-Based Power and Environmental Systems Conference; 1997 July 22-24; Pittsburgh, Pennsylvania.*
20. APHA, AWWA, WPCF. *Standard Methods for the Examination of Water and Wastewater.* 18th ed. Washington DC: APHA; 1992.
21. Rittmann BE, McCarty PL. *Environmental Biotechnology: Principles and Applications.* Boston: McGraw Hill; 2001.
22. USEPA. *Guidelines for Drinking Water Quality.* United State Environmental Protection Agency. 1999.
23. Liu H, Jiang W, Wan D, Qu J. Study of a combined heterotrophic and sulfur autotrophic denitrification technology for removal of nitrate in water. *J Hazard Mater.* 2009; 169(3):23-8.

Drinking Water Denitrification using Autotrophic Denitrifying Bacteria in a Fluidized Bed Bioreactor

Abdolmotaleb Seid-mohammadi¹, Hossein Movahedian Attar², *Mahnaz Nikaeen²

¹Department of Environmental Health, Faculty of Health, Hamadan University of Medical Sciences, Hamadan, Iran

²Department of Environmental Health, Environment Research Center, Isfahan University of Medical Sciences, Isfahan, Iran

Received: 23 April 2011 ; Accepted: 23 July 2011

ABSTRACT

Background and Objectives: Contamination of drinking water sources with nitrate may cause adverse effects on human health. Due to operational and maintenance problems of physicochemical nitrate removal processes, using biological denitrification processes have been performed. The aim of this study is to evaluate nitrate removal efficiency from drinking water using autotrophic denitrifying bacteria immobilized on sulfur impregnated activated carbon in a fluidized bed bioreactor.

Materials and Methods: After impregnating activated carbon by sulfur as a microorganism carriers and enrichment and inoculation of denitrifying bacteria, a laboratory-scale fluidized bed bioreactor was operated. Nitrate removal efficiency, nitrite, turbidity, hardness and TOC in the effluent were examined during the whole experiment under various conditions including constant influent nitrate concentration as 90 mg NO₃--N/l corresponding to different HRT ranging from 5.53 to 1.5 hr.

Results: We found that the denitrification rates was depended on the hydraulic retention time and the nitrate removal efficiency was up to 98% and nitrite concentration was lower than 1mg/l at optimum HRT=2.4 hr respectively. Moreover, there was no difference in hardness between influent and effluent due to supplying sodium bicarbonate as carbon source for denitrifying bacteria. However pH, TOC, hardness, and turbidity of the effluent met the W.H.O guidelines for drinking water.

Conclusion: This study demonstrated that an innovative carrier as sulfur impregnated activated carbon could be used as both the biofilm carrier and energy source for treating nitrate contaminated drinking water in the lab-scale fluidized bed bioreactor.

Keywords: Denitrification, Impregnated activated carbon, Autotrophic bacteria, Fluidized bed bioreactor

*Corresponding Author: nikaeen@hlth.mui.ac.ir

Tel: +98 311 7922660 , Fax: +98 311 6682509