Original Article

Survey on removal efficiency of linear alkylbenzene sulfonate in Yazd stabilization pond

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ABSTRACT

Aims: In this study, removal efficiency of linear alkylbenzene sulfonate (LAS) in Stabilization pond plant was investigated.
Materials and Methods: In this study, 64 samples were taken for 1-year in stabilization pond plant of Yazd city, central of Iran, in 2010. The samples were analyzed according to the standard methods. Methylene blue active substances were used to determine the amount of anionic surfactants.
Results: The most removal efficiency of anionic surfactants occurred in secondary facultative stabilization pond in summer and the least removal efficiency of anionic surfactant in anaerobic stabilization pond in the autumn was obtained.
Conclusion: According to the environmental standards for discharge of treated wastewater to the surface water, agricultural water usage and discharge to absorbent wells with $P < 0.5$ have significant difference values are more than standards.

Key words: Facultative pond, linear alkyl benzene sulfonate, stabilization pond, Yazd city

INTRODUCTION

Wastewater stabilization pond is a simple, cost-effective and easy maintenance for urban wastewater treatment, even in tropical areas. It generally consists of a series of anaerobic, facultative and maturation ponds. In this system, the pollutants are removed from wastewater streams through sedimentation or conversion in biological and chemical processes.[1] Schematic of Yazd wastewater stabilization pond is shown in Figure 1 and its specifications are presented in Table 1. Wastewater is one of the main sources of water pollution in developing countries. Detergents used in household and industrial has enhanced these compounds in urban and industrial wastewater.[2] surfactants have a high solubility in water. That can cause foam formation in wastewater treatment plants and receive water.[3,4] Biodegradation capabilities of surfactants are relatively low, and they are often highly toxic. Major concern surfactants are lower the surface tension of water, also reduce the amount of oxygen transfer.[5,6] These compounds can cause taste and odor changes. Growth of aquatic plants and algae consume the oxygen

Access this article online	
Quick Response Code:	Website: www.ijehe.org
	DOI: 10.4103/2277-9183.153995

This article may be cited as:
Ebrahimi A, Ehrampoosh MH, Samaei MR, Shahsavani E, Hosseini E, Hashemi H, *et al*. Survey on removal efficiency of linear alkylbenzene sulfonate in Yazd stabilization pond. Int J Env Health Eng 2015;4:10.

dissolved in the water and leads to fish death. Degradation and destruction of ecosystems, eutrophication phenomenon due to phosphates increase, lack of appropriate degradation and causing physiological reactions in consumers of contaminated water are other negative effects of surfactants. Detergents in destroying viruses and bacteria affect the metabolism of stopping. Detergents cause microorganisms' membrane rupture and enzyme loss; also, they slow and disrupt enzymes activity affecting the bacteria respiration.[7] Linear alkylbenzene sulfonate (LAS) is the largest anionic surfactant group, which can be decomposed about 90-97% by bacteria and its amount in domestic wastewater is 3-21 mg/L. LAS structural formula is shown in Figure 2.[8] The data indicate very similar toxicity levels of LAS to fish, with LC_{50} values range from about 3 to 6 mg/L. data on the toxicity for algae, with EC_{50} value in a range from 29 to 170 mg/L. Several aspects of mammalian toxicity are evaluated. Acute testing provides information on gross effects, such as mortality, from exposure to high doses. The data indicate minimal to moderate toxicity, with LD_{50} values ranging from 500 to 2000 mg/kg body weight.[9] Ebrahimi *et al*. studies showed that aeration tanks with fixed beds and conventional activated sludge system achieved LAS removal efficiencies of 96% and 94% for an influent LAS concentration of 5 mg/L. At LAS concentrations higher than 5 mg/L the conventional activated sludge system did not have the required efficiency and its effluent did not meet the environmental discharge standards. In contrast, aeration tanks with fixed bed achieved a removal efficiency of 97% at higher concentrations (15 and 20 mg/L) and were capable of reducing the amount of effluent LAS concentration.[10]

Environmental Protection Agency, in 1989 recommended maximum secondary concentration of foaming agents to be 0.5 mg/L and in 1984 WHO indicated that no foaming agents should exist in raw water. The maximum amount of surfactant in drinking water is mentioned 0.2 mg/L. LAS over other detergents are manufactured, approximately 18% of all surfactants. In 1996, The Institute of Standards and Industrial Research of Iran determined the maximum permissible detergents in drinking water to be 0.2 mg/L.[11-13] The objective of this study determined removal efficiency of LAS in Yazd stabilization pond.

MATERIALS AND METHODS

The scientific study was experimentally and aimed community is incoming wastewater to stabilization pond in Yazd city.

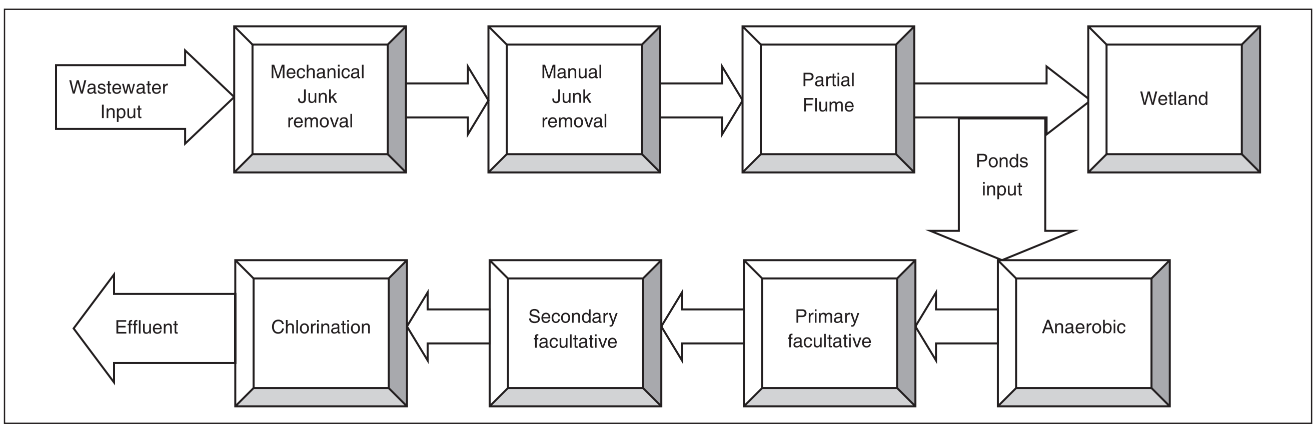

Figure 1: Yazd wastewater stabilization ponds schematic

Table 1: Profile of ponds

Parameter	Value	Parameter	Value
Anaerobic ponds			
Hydraulic retention time in the pools at the end of the project period	5 days	Walls tilt	1-1.5 (vertical to horizontal)
The depth of each pool basin	5 m	Material of pools walls	Concrete
The free height of each pool	0.75 m	Material of pools floor	Asphalt
The upper level dimensions of each pool	239 m × 103 m	Basin size of each pool	107,169 cubic meters
The floor dimensions of each pool	221.75 m × 85.75 m	BOD5 reduction percentage in anaerobic ponds	40%
Sludge discharge period in anaerobic pools	At least once every 10 years	SS reduction percentage in anaerobic ponds	40%
Primary and secondary facultative ponds			
Free height of each pool	0.75 m	Basin size of each pool	107,169 cubic meters
The upper level dimensions of each pool	239 m × 103 m	Material of pools walls	Concrete
The floor dimensions of each pool	85.75 m × 221.75 m	Material of pools floor	Asphalt
The upper level dimensions of each pool	239 m × 103 m	Walls tilt	1-1.5 (vertical to horizontal)

BOD: Biochemical oxygen demand, SS: Sewage sludge

Composite sampling was done. Samples were taken during four consecutive seasons. Sampling locations included:
(1) Treatment plant input,
(2) Anaerobic output,
(3) Primary facultative output, and
(4) secondary facultative output.

Parameters of pH, dissolved oxygen (DO), electrical conductivity (EC), and temperature were measured at the site and then samples were transported to the laboratory of Department of Health in University of Medical Sciences of Yazd adjacent to ice container. Methylene blue active substances were used to determine the amount of anionic surfactants by spectrophotometer in 605 nm wavelength. All sampling and testing conditions conducted based on guidelines in the standard methods book.[14] A *t*-test statistical test was conducted to compare the results with standard values using SPSS software version 11.5.

RESULTS

Average results of tests on 1-year period of 16 samples from each pond are presented in Table 2. These data suggest that, ambient temperature was in the range of 20-26°C and DO concentration at the plant input and anaerobic output was zero and its value increased at primary facultative output to 4.8 mg/L and at secondary facultative output to 6.52 mg/L. EC increased in effluent compared to input wastewater, and its value was equal to 2396 μs/cm and the pH parameter was equal to 8-8.5. The annual average of LAS concentration at the plant input was 8.21 mg/L and reached 3.61 mg/L at secondary facultative pond output. Concentration fluctuations of surfactant at different sampling locations at four consecutive seasons are shown in Figure 3. The highest concentration of anionic surfactants is dedicated to winter and lowest in the mentioned areas except the secondary facultative output to autumn. The maximum concentration of anionic surfactant at input equals to 10.85 mg/L in winter and at output equals to 3.02 mg/L in summer. Anionic surfactant concentration changes in different sampling locations show an early uptrend in its value and then a downtrend. As observed in Figure 4, in all seasons, the surfactant concentration increased in anaerobic pond output and then reduced in the output of primary and secondary facultative ponds. Average increase percentage in anaerobic pond output was 9.7% the maximum of which was 14 % in winter, and the minimum was 5.2% in autumn. As shown in Table 3, the anionic surfactant removal efficiency in spring, summer, autumn, and winter, was 60.9, 67, 27, and 35.5, respectively. Maximum anionic surfactants removal efficiency in these ponds was in the summer and the minimum in autumn. Annual average removal percentage equals to 50%. Comparison of LAS average in different seasons with the environmental standards of Iran is presented in Figure 4. The results show that the output amount of anionic surfactants, in spring, summer and autumn are about twice the amount authorized for discharge to surface water and about 6 times the amount authorized for agricultural use and discharge into adsorbent wells. In the winter, the output value reached more than double that of other seasons and with the same ratio it

Table 2: Average LAS, specifications and characteristics of wastewater samples during 1-year

Place of sampling	Parameters			
	Temperature (°C)	Dissolved oxygen (mg/L)	pH	LAS (mg/L)
Input plant	25.27	0	8.12	7.5
Anaerobic output	23.63	0	8.50	8.18
Primary facultative output	22.07	4.80	8.86	7.30
Secondary facultative output	19.91	6.52	8.70	3.61

LAS: Linear alkylbenzene sulfonate

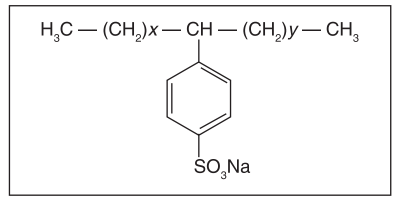

Figure 2: Structural formula of linear alkyl benzene sulfonate

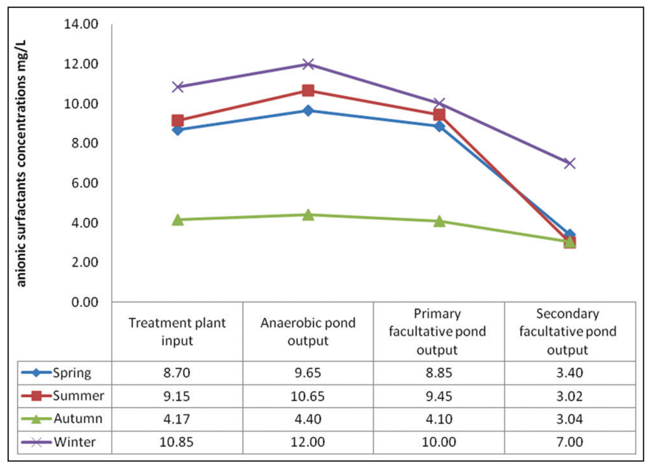

Figure 3: Seasonal variation of anionic surfactants in different sampling locations

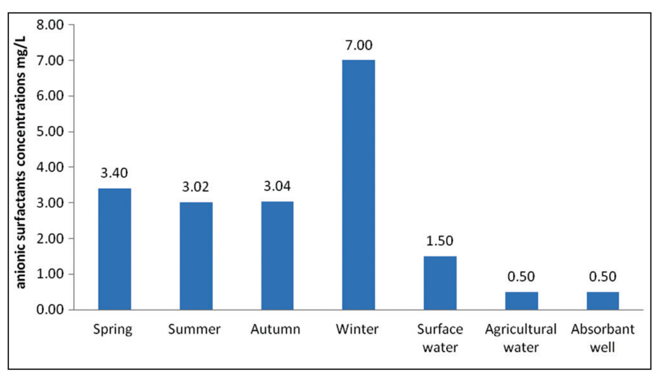

Figure 4: Comparison of linear alkyl benzene sulfonate in seasons with environmental standards of Iran

Table 3: Comparison of LAS average concentration at input wastewater and effluent and removal efficiency in different seasons in mg/L

Sampling season	LAS (mg/L)		Removal efficiency (%)
	Wastewater input	Effluent	
Spring	8.7	3.40	60.9
Summer	9.15	3.02	67
Autumn	4.17	3.04	27
Winter	10.85	7	35.5
Annual average	8.21	4.11	50

LAS: Linear alkylbenzene sulfonate

exceeded the standard level. The results of the statistical tests of the present study show that there are significant differences between the average anionic surfactant in the effluent from stabilization ponds in Yazd and environmental standards for discharge to surface water (1.5 mg/L), agricultural irrigation (0.5 mg/L) and discharge into adsorbent wells (0.5 mg/L) ($P < 0.05$).

DISCUSSION

Linear alkyl benzene sulfonate concentrations at ponds input different in seasons. In the winter, it reaches its maximum and in autumn it is at minimum. Factors such as weather conditions changes, customs and traditions of the people, industrial wastewater discharges, LAS biodegradation in the transmission path to wastewater treatment plant, and wastewater flow fluctuations are the most important factors influencing concentration variations of wastewater entering stabilization ponds. The results show that the amount of anionic surfactant in all seasons in anaerobic ponds output is more than in wastewater input, and this increase in winter is higher than other seasons. As number of sunny days and temperature are important parameters affecting the removal efficiency in stabilization ponds, they can be stated as the reason for low efficiency in winter, on the other hand, the activity of microorganisms and decomposition and conversion of substances because of enzymes interference will lead to the production of organic and nonorganic acids and CO_2 that eventually will reduce the pH. pH reduction affects dissolving and release of LAS.[15,16] Results from Peng *et al*. study on phosphorus removal by stabilization ponds show that the pH of ponds' content is effective on the phosphorus amount so that in pH of 7-8, the highest rate of phosphorus removal occurs.[17] The results indicate that EC in effluent is enhanced because the wastewater entering the ponds spends a long time to leave them, and high evaporation rate in the city of Yazd leads to water evaporation and salts retention, as a result, the EC increases. Comparison of DO and anionic surfactants in Table 1 shows an inverse relation between the amount of anionic surfactants and DO in aerobic conditions in primary and secondary facultative ponds. Hence that the more anionic surfactants in the ponds, the less DO will be, because these substances can remain on water surface and prevent oxygen exchange between ponds and atmosphere, and the more surfactants are removed from ponds, the more amount of DO increase. Martin and Johannes studies showed that the surfactant can reduce aerate rate to <55% and oxygen transfer rate to <20%.[18] Ebrahimi *et al*. studies showed that when LAS increase 1 mg/L the concentration of chemical oxygen demand 2.5 mg/L is higher.[17] Comparing seasonal analysis of the results with national environmental standards shows that anionic surfactant concentration in stabilization Ponds' effluent is higher than environmental standards of Iran and it is recommended to take special considerations in reuse or discharge of the effluent.[10]

CONCLUSION

Surfactant concentration in the wastewater entering the treatment plant varies in different seasons. The concentration of LAS in anaerobic ponds system output increases compared to its input, and in winter this increase will be more than other seasons. The EC increases due to high evaporation in the system output compared with its input; moreover surfactant concentration and DO are inversely related.

ACKNOWLEDGMENTS

The authors want to appreciate cooperation of Mr. Akrami and Salehi from Water and Sewage Company of Yazd, also would like to give special thanks to Ms. Talebi, Head of Chemistry Laboratory of Yazd Health Department.

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Source of Support: Nil, **Conflict of Interest:** None declared.