RESEARCH ARTICLE

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Efficiency of Horizontal Roughing Filter in Removing Suspended Solids from Effluent of Waste Stabilization Ponds in 2013

Seyed Mostafa Khezri[a], Hossein Jafari Mansoorian[b,c], Gharib Majidi[d], Farideh Atabi[e], Taha Tohidi Moghaddam[f], Narges Khanjani[g], Nahid Rashtchi[h*]

[a]Department of Environmental Engineering, School of Environment and Energy, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[b]Young Researchers and Elite Club, Hamedan Branch, Islamic Azad University, Hamedan, Iran.
[c]Environmental Health Engineering Research Center, Department of Environmental Health, Kerman University of Medical Sciences, Kerman, Iran.
[d]Research Center for Environmental Pollutants, Qom University of Medical Sciences, Qom, Iran.
[e]Department of Environmental Engineering, School of Environment and Energy, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[f]Department of Environmental Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[g]Environmental Health Engineering Research Center, Kerman University of Medical Sciences, Kerman, Iran.
[h]Department of Environmental Engineering Water and Wastewater, Islamic Azad University, Western Tehran Branch, Tehran, Iran.

***Correspondence** should be addressed to Ms. Nahid Rashtchi, **Email:** nahidrashtchi1392@gmail.com

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Background & Aims of the Study: The Horizontal roughing filters (HRF) are generally formed with three layers. The size of the course at the beginning of the flow path is large and at the end is small. This kind of layering increases absorption capacity while the solids entering the bed–depth gradually separate because of the decline in the holes' diameters. This study aimed to examine the efficiency of HRFs in removing total suspended solids (TSS) from effluent of a waste stabilization pond.

Materials & Methods: This experimental study was conducted in 2013. The pilot project was transferred to the Karaj wastewater treatment plant (waste stabilization pond), Alborz province of Iran. Then, the installation, equipping and start-up of the system began, using an effluent treatment plant. Sampling was done from March to August in 3 rates of 0.5, 1 and 1.5 m/h, which was included simultaneous sampling from inlet and outlet HRF to determine the concentrations of TSS.

Results: The results showed that at filtration rates of 0.5, 1, and 1.5 m/h, the average of TSS removal was equaled to 42.46, 56.65 and 33.22%, respectively. The removal efficiency of TSS at the rate of 1m/h was more than 0.5 and 1.5 m/h rate ($p<0.05$). The Outlet value of TSS was lower than the standards which are set by the Environmental Standards Organization (ESO) ($P < 0.05$).

Conclusion: According to the results of this study, the HRF function was approximately adequate in TSS removal and can be a suitable option for improving the quality of stabilization ponds effluent.

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Background

Water is a fundamental need of human life and its importance is understood by man and animals a like (1-3). Water supplies continue to

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decrease because of resource depletion and pollution, whilst demand is also rising fastest. Reuse of wastewater is an appropriate approach for development of water resources and water supply strategies (3-7).

In the effluent of waste stabilization pond, the concentration of suspended particles increases, because of growth of algae. This high concentration of suspended particles may cause trouble in wastewater reuse, especially for underground water; also, in under pressure and drop irrigation where it blocks the nozzles (8-11). Therefore, to make reusing wastewater feasible, an advanced treatment must be conducted on the effluent of biological treatment plants, the dominant process of which is based on separating solid and liquid, like chemical coagulation, focalization, filtration and disinfection (11-13).

Filters, which were used in advance wastewater treatment, are usually dual or multiple media (14). Coarse filters are classified in two groups which are horizontal roughing filter (HRF) and vertical roughing filter (VRF) (15,16). HRFs were used during the second half of the twentieth century as an appropriate pre-treatment for achieving the quality standards of slow sand filters' influent water and in some cases they were used for eliminating Fe^{2+} and Mn^{2+} from underground water (17). HRFs can be used effectively for treating various wastewaters (18).

Horizontal roughing filters (HRFs) are filters with an effective end grain size of larger than 2 mm. The efficiency of horizontal roughing filters in removing solids is higher than the sedimentation tank (19). During the pass of flow through the bed, the suspended substances are gathered. Material size of the bed is about 4 mm to 25 mm. The horizontal roughing filters are generally formed with three layers. The size of the course at the beginning of the flow path is large and at the end is small. This kind of layering increases absorption capacity while the solids entering the bed depth gradually separate because of the decline in the holes' diameters. Horizontal roughing filters are between 5 and 9 meters long, their width is about 2 to 5 meters and their height is about 1.5 meters (20). Advantages of HRFs are include a higher capacity for gathering silt and sediment matters, lack of length limitation, no use of mechanical mobile pieces and simplicity of establishment and utilization (21-23).

Wegelin evaluated the performance of HRF in TSS removal at the filtration rate of l m/h. The results of this study showed that HRF can remove up to 95% of TSS (23). In a study done by Khazaei et al, the efficiency of HRF in TSS removal from the effluent of an aerated lagoon at the filtration rate of 0.5, 1 and 1.5 m/h was between 75 to 97% (24).

Aims of the study:

The present study aimed to evaluate the efficiency of HRF in total suspended solids (TSS) removal from the waste stabilizing ponds in different filtration rates.

Materials & Methods

This experimental study was performed in 2013 and used a HRF. The pilot was designed and developed based on Wegelin criteria approved by World Health Organization (WHO) (23). After its construction, the pilot was transferred to the Karaj wastewater treatment plant. Then, installation, equipping and start-up of the system began, using treated outlet effluent. The wastewater treatment plant of Karaj works on a stabilization pond. The sampling period lasted from March to August. In order to evaluate the influent, effluent and removal efficiency of TSS at different filtration rates, one way ANOVA was used. The removal efficiency of TSS in different filtration rates was compared by Scheffe test, in pairs.

The development and installation of pilot

This pilot was constructed of a sheet of non-galvanized iron 3 mm thick and 2 sheets with dimensions of 1.5 × 2 meters. After rolling, the sheets became incomplete cylinder shaped and were welded along their length. Both ends were covered by two circular sheets, and then

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welding and leakage detection were performed. The quad netted wall made of galvanized sheet was used to separate the bed layers. 4 mm holes in diameter and 4 square cm in density were created in these 4 pieces, using a turnery drill. The walls were welded to the body at a distance of 1.6 m and 1.3 m from the beginning of the filter. The distances between drainage pipes in the first, second and third holes were 20 cm, 30 cm and 40 cm, respectively. On these drain pipes, netted faults with 5 mm holes in diameter and a density of 7 holes per square cm were installed. In the third drainage, each hole of one piezometer was installed to determine the hydrological gradient of flow. The filter's exit was guided by a 1-inch diameter trunk-like pipe into the drainage of the pump room bottom. The filter bed was washed hydrologically. The exit faucet of the filter was closed and the filter holes completely filled with effluent. Then, the arranged drainage pipe faults on the filter floor opened at the same time. As a result of this action, hydraulic cutting force will dislodge sediments from the surface of media and out of the floor drains. The washing strategy of the filter bed was based on the change of pressure head lost. At the beginning of the filter start-up, the effluent level in the entrance area was 10 cm from the bed level. As sediment was gradually gathered in the bed, the height of effluent in the inlet area increased to the same level as the filter bed. At this time, the bed washing process was done.

Sampling and conducting experiments

The sampling period at a filtration rate of 0.5 m/h was 60 days; samples were taken every other day. The sampling period at filtration rates of 1 and 1.5 m/h was 26 days, on a daily basis; sampling performed every day. All experiments were measured based on techniques which are mentioned in the book for standard techniques of water and wastewater experiment (25).

Results

In Table 1, the average amount, standard deviation and the slope of TSS changes for inlet, outlet and removal efficiency are presented according to filtration rates. Figure 1 shows the changes in the efficiency of TSS removal, at the filtration rate of 0.5 m/h. Figure 2 presents the changes in the efficiency of TSS removal, at filtration rate of 1 and 1.5 m/h. The mean removal efficiency of TSS in filtration rates of 0.5, 1 and 1.5 m/h was 42.46, 56.65 and 33.22 percent, respectively.

Table 1) Average quantities of TSS changes according to filtration rate

Zone	Filtration rate	Average	Standard deviation	Minimum	Maximum
Influent (mg/l)	0.5	114.4	28	95	215
	1	141	39.2	98	295
	1.5	129	17.3	98	160
	Total	138.6	29.7	95	295
Effluent (mg/l)	0.5	81.9	36.1	30	183
	1	61.6	22	37	150
	1.5	86.8	15.6	57	120
	Total	77.2	28.3	30	183
Removal Efficiency (%)	0.5	42.4	23.4	7	76
	1	56.6	5.7	43	64
	1.5	33.2	6.5	23	44
	Total	43.9	17.5	7	76

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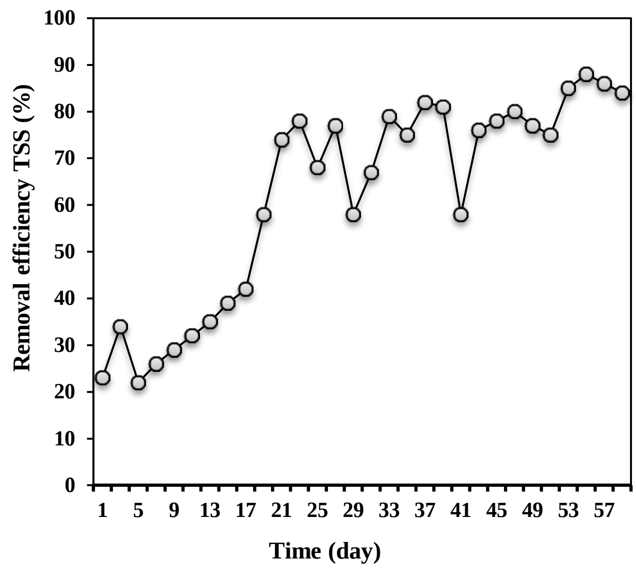

Figure 1) Changes in removal efficiency of TSS in the filtration rate of 0.5 m/h

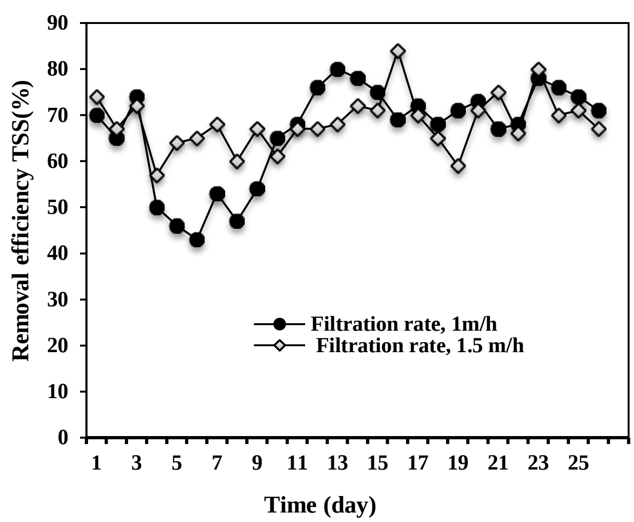

Figure 2) The changes in removal efficiency of TSS in the filtration rate of 1 or1.5 m/h

Discussion

The mean removal efficiency of TSS in filtration rates of 0.5, 1 and 1.5 m/h was 42.46, 56.65 and 33.22 percent, respectively. In order to evaluate the influent, effluent and removal efficiency of TSS at different filtration rates, one way ANOVA was used. There was no significant difference in the amount of influent TSS among three filtration rates (P>0.05). However, there was a significant difference in the effluent TSS and removal efficiency (P<0.05). According to Scheffe test, the removal efficiency of TSS at different filtration rates was compared. The removal efficiency of elimination at the rate of 1m/h was more than 0.5 and 1.5m/h (P<0.05). The percentage of TSS removal was higher at the filtration rate of 1 m/h than at 0.5 and 1.5m/h (P<0.05).

The changes in removal efficiency of TSS are shown in Figures 1 and 2. The removal efficiency of TSS at the filtration rate of 0.5m/h increased until the 23rd day and reached 78%. After day 23, removal efficiency had fluctuations. At the rates of 1 to 1.5 m/h, the removal efficiency of TSS increased a little during the time. The highest TSS removal efficiency (88%) relates to the filtration rate of 0.5 m/h and occurred 55 days after the pilot study began. The least efficiency was 23% on the first day of filter work. This increase over time can be related to the formation of a microbial film in the horizontal roughing filter bed, which led to a reduction in pore diameter, an increase in the substrate contact surface and dominance of chemical and biological processes in removing elements and microbial load (25).

Wegelin evaluated the performance of HRF in removing TSS at the filtration rate of l m/h. The results of this study showed that HRF can remove up to 95% of TSS (23). In 1993, Galvis studied the performance of HRF in suspended solids removal from the wastewater of the soft drink industry, at the filtration rate of 0.7 m/h. The removal rate of TSS was 0.94 (26). In a study done by Mohammadi in 2003, the efficiency of multiple–bed filters in the advance treatment of wastewater; in order to reuse wastewater was evaluated. The removal rate of TSS was reported to be 97.2% (27). In a study done by Khazaei et al, the efficiency of HRF in TSS removal from the effluent of an aerated lagoon at the filtration rate of 0.5, 1 and 1.5 m/h was evaluated. Removal efficiency was between 75 to 97% (24). In 2005, Sarvmeili

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examined the performance of the HRF with the filtration rate 2.5 m/h in improving the effluent quality for urban purposes and obtained value of 37% for TSS removal (28). In the present study, the maximum amount of TSS removal was 94%. This result was in agreement with studies by Khazayi et al, Seyd Mohammadi et al, Galvis et al, and Wegelin et al (23). The results of the present study had no conformity with those of Sarvmeili's study. The reason for low removal efficiency in Sarvmeili's study in comparison to our study was probably the higher filtration rate (28).

The Environmental Protection Organization (EPO) standards for discharge and reuse of wastewater are shown in Table 1 (29). The t test was used to compare the outlet values of TSS with the EPO standards. A significant difference was observed between outlet TSS of HRF and the standard of the EPO for discharge into surface water and irrigation ($P<0.05$). Outlet values of TSS were lower than EPO standards ($P<0.05$).

Table 2) The EPO standard for discharging and reuse of wastewater

Parameter	Discharge into surface waters	Irrigation
BOD	40	100
TSS (mg/l)	6.5-8.5	6-8.5
pH	50	50
Turbidity (NTU)	1000	1000
Total Coliform (MPN)	400	400
Fecal Coliform (MPN)	60	200

*Abbreviations: EPO, Environmental Protection Organization; TSS, total suspended solids.

Conclusion

Filtration efficiency of a horizontal roughing filter was estimated with Pilot constructed and transferred into the wastewater treatment plant. According to the results of this study, HRF performs was well in suspended particles removal. The mean of TSS removal efficiency at the rates of 0.5, 1.0 and 1.5 m/h were 42.46, 56.65 and 33.22 percent, respectively. The removal efficiency of TSS at the rate of 1m/h was higher than the rate of 0.5 and 1.5 m/h ($p<0.05$). Outlet values of TSS were lower than EPO standards ($P<0.05$). According to the results of this study, the HRF function was approximately adequate in TSS removal and can be a suitable option for improving the quality of stabilization ponds effluent.

Footnotes

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Conflict of Interest:
The authors declared no conflict of interest.

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