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TREATMENT OF FRESH LEACHATE FROM MUNICIPAL SOLID WASTE LANDFILL USING HORIZONTAL ROUGHING FILTER

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Abstract

The roughing filters have effective size of the substrate grain which is greater than 2mm. This study aimed at the examination of the efficiency of horizontal roughing filter in nitrate, turbidity and chemical oxygen demand removal (COD), obtained in the fresh leachate from municipal solid waste landfill. This experimental study was conducted in 2014 in Karaj. Sampling was done in 3 rates 0.5m/h, 1m/h and 1.5 m/h, including simultaneous sampling from input and output filtering, to determine the concentration of nitrate, turbidity and COD.

The sampling period lasted from March to August (2015). The average efficiency of COD removal in filtration rates of 0.5 m/h, 1 m/h and 1.5 m/h was equal to 84, 88 and 85 % respectively. The average removal efficiency of nitrate in filtration rates of 0.5 m/h, 1 m/h and 1.5 m/h was equal to 88, 88 and 85 % respectively. The average removal efficiency

of the turbidity in filtration rates of 0.5 m/h, 1 m/h and 1.5 m/h was equal to 72, 86 and 81 % respectively. Output values of COD and nitrate were lower than the environmental organization standard ($P<0.05$).

Based on the results of this study, the nitrate removal with a horizontal roughing filter was better than that obtained with COD and turbidity.

Keywords: Horizontal Roughing Filter, Nitrate, Turbidity, Chemical Oxygen Demand, Karaj.

Introduction

The MSW (Municipal solid waste) leachate is typically rich in organic matters, heavy metals, and other inorganic compounds, posing a major threat to the surrounding environment and human health. In case these materials enter into environment without treatment, their biological persistence leads to reduction of oxygen sources and creation of anaerobic conditions and secretion of shrunk smells [1, 2].Thus the effective treatment of the fresh leachate is becoming a serious challenge. There are many different leachate treatment options that complex and expensive methods from physico-chemical to biological processes for the treatment of high strength organics and inorganics.

Karaj has an area of 2255 sq. km located between latitudes 35º 67′–36º 140 ′ N and longitudes 50º 56′ –51º 42′ E . The annual average temperature and rainfall of Karaj is around 14–15 ºC and 243.63 mm, respectively. Karaj is the second most populated city in Tehran province, with a population about 2,132,275 people according to the census of the year 2011. A closer look at the scenario of municipal solid waste generation indicates that the major generation sources in Karaj are households, markets, restaurants, government offices and hospitals. The total quantity of waste generated in Karaj is 1800 tons/day on average. A qualitative analysis indicated that the solid waste generated in Karaj contains a relatively high percentage of organic matter (70–75% dry weight) [3]. The current situation in the city is that the waste diversion by recycling and composting is about 30% of waste, and the rest of waste is disposed of at the Halghe Darehe site, which was launched since 1993 and covers 30 hectares but lacks the perfect standards for sanitary landfilling [3].

In the present study, roughing filters with end grain larger than 2 mm are employed. Roughing filtration technology is a filtration process through a coarse medium using low filtration rates [4]. The suspended materials are collected when passing through the bed of the roughing filters.

The roughing filters consist of three layers and their particle size is about 4-25 mm. The coarse larger particles are situated at the beginning of flow path and their size reduces towards the end of flow path. Layering of such a nature may increase

the absorption capacity while the solids entering the bed –depth are gradually separated by decreasing diameters of the hole. The length of roughing filters is between 5-9 meters, and width is about 2 to 5 meters and the height is about 1.5 meter [5]. The advantages of the horizontal roughing filters include the higher capacity of silt gathering and sediment matters, lack of length limitation, lack of mechanical mobile pieces, and simplicity of the establishment and utilization [4]. Due to the feasibility, this kind of filter is prone to resistance power up to about 500-1000NTU against suspended solids and turbidity [6]. The aim of this study was to examine the efficiency of horizontal roughing filter in turbidity, nitrate and chemical oxygen demand (COD) removal from landfill site in karaj.

Materials and Methods

This experimental study was done in 2014. Pilot was used from horizontal roughing filter. This pilot plant was designed and developed based on Wegelin criteria approved by world health organization (WHO) [7]. After its construction, pilot was transferred to landfill site in karaj, and the processes of installation and start up the system began by using output refinery effluent. The sampling period lasted from March to August Month (2015). Table 1 gives the composition of the leachate. Analysis was performed using SPSS Release 22.0 version.

Table-1: Composition of leachate.

Parameters	Range of Values(mg/L)
BOD_5	8753
COD	21531
pH	6.2
Turbidity	2230
TS	51200
TSS	18523
NO_3	593

The development and installation of Pilot:

The pilot plant was constructed using 3mm thickness non-galvanized iron two pieces of sheet with 1.5×2 meter dimension. Both sides were closed by two welded pieces of circular sheets, and leakage detection was connected on it. The quad netted wall made of galvanized sheet used for separating the layers of bed. Holes with 4mm diameter and 4 square cm density pores created in these four pieces using turnery drill. These walls were welded to the body by 1.6 and 1.3 distances from the beginning of the filter. The distance of drainage pipes in the first, second and third holes were 20,

30, 40 cm, respectively. On these drain pipes, netted faults with holes of 5mm diameter and 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 exit side of the filter was by a one inch diameter trunk-like pipe to the drainage of pump room bottom. Washing the filter bed was done by hydrological way. The exit faucet of filter was closed and filter holes completely filled with effluent. Then, the arranged drainage pipe faults on filter floor opened at the same time. As a result of this action, the hydrological cut power took off the sediments on bed surface and run them out of floor drain pipes. The washing strategy of filter bed was based on changing the pressure shortage. At the beginning of filter start-up, the effluent level in entrance area was 10 cm distance far from bed level. When the level of the sediment gradually accumulates in the bed, the height of effluent in the area of the entrance increased to the same level as the filter bed. At this point in time, the bed washing process was done.

Sampling and conducting experiments:

The sampling period in filtration rate 0.5 m/h, lasted for 72 days, and sampling was done alternatively. The sampling period in filtration rate of 1 m/h and 1.5 m/h, lasted for 26 days, and sampling was conducted during the day. The number of samples in filtration rate of 0.5 m/h is equal to 30 samples whereas in the filtration rate of 1m/h and 1.5 m/h is equal to 26 samples. All experiments were measured in accordance with Standard Methods for the Examination of Water and Wastewater [8].

Results and Discussion: The average amount and slope of COD, nitrate and turbidity for input, output and removal efficiency range were shown in tables 2, 3 and 4.

Table-2: Performance of Roughing Filter for COD.

	Filtration Rate	Number of Samples	Average	Minimum	Maximum
Input (mg/l)	0.5 m/h	30	25710±883	12640	32520
	1 m/h	26	24783± 982	15430	36700
	1.5 m/h	27	22868±856	14251	34121
	Total	83	23651±943	13132	33151
Output (mg/l)	0.5 m/h	30	4112±54	2778.1	3571.3
	1 m/h	26	2971±29	2314.7	2206.1
	1.5 m/h	27	3451±56	2990.7	3068.9
	Total	83	3791±61	2754.3	3311.4

Removal Efficiency (%)	0.5 m/h	30	84.2±9.3	78.2	89.7
	1 m/h	26	88.1±8.6	84.8	93.8
	1.5 m/h	27	85.3±5.6	79.3	91.2
	Total	83	86.8±8.7	78.8	90.8

Table-3: Performance of Roughing Filter for nitrate.

	Filtration Rate	Number of Samples	Average	Minimum	Maximum
Input (mg/l)	0.5 m/h	30	452±59	288	617
	1 m/h	26	525±76	317	710
	1.5 m/h	27	531±93	351	652
	Total	83	480±82	2.30	647
Output (mg/l)	0.5 m/h	30	54.3±3.0	43.2	49.2
	1 m/h	26	63.1±4.9	53.2	49.7
	1.5 m/h	27	79.1±3.8	62.1	77.1
	Total	83	62.8±4.5	51.7	51.3
Removal Efficiency (%)	0.5 m/h	30	88.3±3.7	85.1	92.1
	1 m/h	26	88.2±4.1	83.7	93.7
	1.5 m/h	27	85.1±3.2	82.6	88.1
	Total	83	87.8±2.8	84.2	91.8

Table-4: Performance of Roughing Filter for turbidity.

	Filtration Rate	Number of Samples	Average	Minimum	Maximum
Input (mg/l)	0.5 m/h	30	2150±420	1810	3215
	1 m/h	26	2710± 233	2172	3520
	1.5 m/h	27	2456±321	1757	3159
	Total	83	71.33±34.7	1781	3198
Output (mg/l)	0.5 m/h	30	601±52	541.2	385.6
	1 m/h	26	381±47	543.2	457.1
	1.5 m/h	27	470±63	614.2	505.1
	Total	83	512±72	541.7	442.7
Removal Efficiency (%)	0.5 m/h	30	72.20±22.1	69.3	88.1
	1 m/h	26	86.57±10.8	75.1	87.2
	1.5 m/h	27	81.40±5.9	65.7	84.0
	Total	83	79.61±3.1	71.3	87.2

According to Tables, the performance of horizontal roughing filter on the removal of nitrate, turbidity and COD in filtration rate of 0.5 m/h, 1 m/h and 1.5 m/h were examined in the present study. The average efficiency of COD removal in filtration rates of 0.5 m/h, 1 m/h and 1.5 m/h was equal to 84, 88 and 85 % respectively. The average removal

efficiency of nitrate in filtration rates of 0.5 m/h, 1 m/h and 1.5 m/h was equal to 88, 88, and 85 % respectively. The average removal efficiency of the turbidity in filtration rates of 0.5 m/h, 1 m/h and 1.5 m/h was equal to 72, 86, and 81 % respectively. The average removal efficiency of COD, nitrate and turbidity of the three filtration rates was equal to 87, 89 and 80 % respectively.

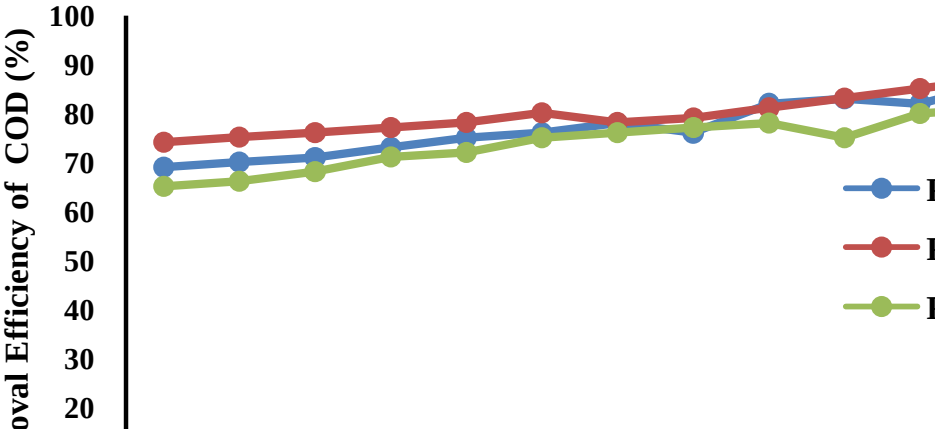

Fig. 1: Efficiency changes of COD removal in three filtration rates.

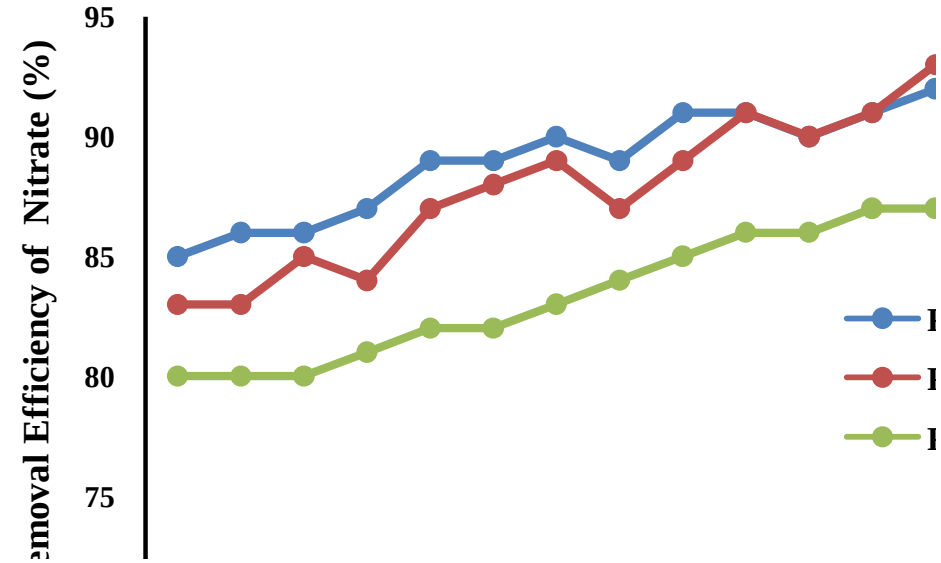

Fig. 2: Efficiency changes of nitrate removal in three filtration rates.

The removal efficiency of nitrate and phosphate in different filtration rates were compared by using Scheffe Test. The percent of nitrate removal with 1.5 m/h was higher than with 0.5 m/h (P>0.05). Considering that the data of removal percentage of COD were not normal, the Mann–Whitney non-parameter test was used to compare the rates as two – to – two. The difference in the removal rate of COD in three filtration rate was insignificant (P>0.05).

Ehteshami *et al.* [9] conducted a study on the reduction of COD from wastewater treatment plant of Yasooj city using horizontal roughing filter. The average removal of COD with filtration rates of 0.5, 1 and 1.5 meter per hour, showed equaled to 60, 51, 38 percent, respectively. In the present study, the COD removal efficiency in three filtration rates did not show significant difference. The results of present study do not correlate with the findings of the study by Ehteshami *et al.* [9]. The removal efficiencies of nitrate, turbidity, and COD are shown in (Figs. 1-3). The highest removal efficiency of nitrate (94%) occurred at the filtration rate of 1 m/h which occurred after 27 days of the operation of the pilot plant. The removal efficiency of nitrate in each three rates increased until the 14th day without showing any fluctuation. The lowest efficiency was 80 % occurred within the first day of operation/experiment. The highest removal efficiency of turbidity (89%) occurred at filtration rate of 0.5 and which occurred after 31 days of the operation of the pilot plant. The lowest efficiency was 64% which occurred on the 2th day of filter operation. The highest removal efficiency of COD (94%) occurred at the filtration rate of 0.5 m/h and took place after 32 days of the pilot plant's operation. The lowest efficiency was 62% at the beginning of filter operation. The removal efficiency of COD of 63% at filtration rate 0.5 m/h occurred within 3 days. Increasing removal efficiency over time is attributed to the formation of microbial film in roughing filter bed. This phenomenon lead to the reduction of the pore diameter, thus increasing the substrate contact surface and dominance of chemical and biological processes in removal of elements and microbial load [10].

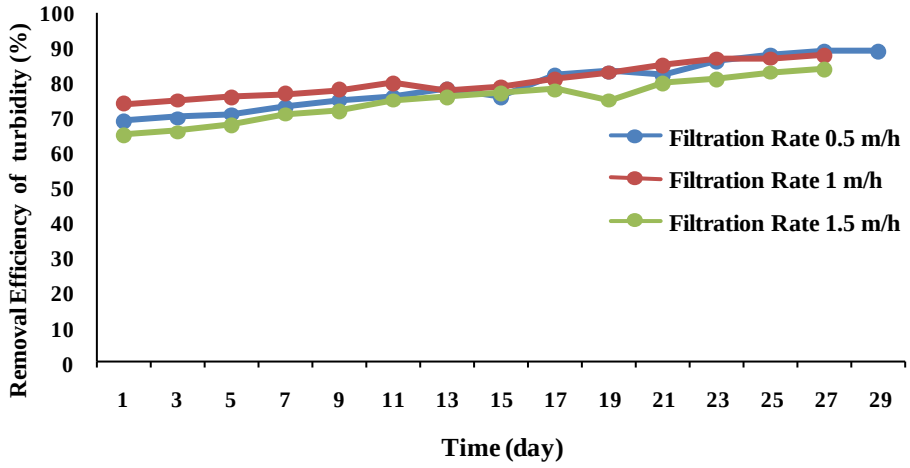

Fig. 3: Efficiency changes of turbidity removal in three filtration rates.

Conclusions

In this study, the average removal efficiency of COD, nitrate and turbidity of the three filtration rates was equal to 87, 89 and 80 % respectively. Reducing filtration rate and increasing contact time simultaneously reduced adsorption and hence removal efficiency.

The Horizontal up flow roughing filter can be used for treatment or polishing of leachate before further biological treatment.

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