Organic matter removal from landfill leachate in shallow waste stabilization ponds

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Abstract This paper describes the organic matter removal from leachate treated in shallow waste stabilization ponds series, with ponds depths varying from 0.45 to 0.60 m and dispersion number of 0.18 in all the ponds. Experimental system was built in Estação Experimental de Tratamentos Biológicos de Esgotos Sanitários – EXTRABES in Campina Grande, northeast Brazil. The leachate used in the study was periodically obtained in the landfill in João Pessoa, 130 km away from Campina Grande and was stored in PVC tanks for a maximum of 30 days. After characterization, the leachate was applied to the series of ponds with total HRT of 50 days. Results have shown that the system was efficient in the removal of COD (66%) for an applied organic load of 5,276 kgCOD/ha.d.
Keywords Urban solid wastes; waste stabilization ponds; leachate

INTRODUCTION

About 240 thousand tons of urban solid wastes are collected in Brazil, of which most is disposed off in open dumps and only 13% is properly disposed off in landfills. Most of the urban solid wastes content is organic matter and its decomposition originates sub products that must be adequately treated. Among these sub products, the leachate and the biogas must be given emphasis because of their hazardous effects to the environment. According to Henry *et al*, (2000), leachate can be defined as the liquid generated from the solid wastes mass, which percolates through the soil. The amount of leachate produced in a landfill depends on the local hydrological regime, on the contents of the solids wastes and on the operational factors in the landfill. With regards to leachate the physic-chemical composition the high COD, volatile acids and nitrogen content are cited in the literature (Leite *et al*, 2002) as shown in table 1.

Tabela 1. Leachate content variation with stabilization period

Time (days)	pH	Total alkalinity ($mgCaCO_3.\ L^{-1}$)	Volatile fat acids ($mgHAc.\ L^{-1}$)	COD ($mg.\ L^{-1}$)	TKN ($mg.\ L^{-1}$)	VTS ($mg.\ L^{-1}$)
30	4.2	2,875	13,500	36,169	829	34,892
90	4.2	2,000	16,500	37,382	941	41,134
150	4.0	0	14,040	47,995	1,155	32,730
210	4.3	2,408	17,570	47,692	2,038	22,152
270	4.7	5,500	10,650	31,621	1,994	30,108
330	4.6	3,625	7,138	34,090	1,557	12,892

Analysing data from table 1, it can be noticed that the leachate generated in the decomposition of organic solid wastes presents acid characteristics and high organic content. This pattern can be

explained by the content of the organic wastes that differently from the urban wastes, does not contains significant amount of mineral constituents. Considering that the wastes used in the paper reported by Leite *et al* (2002) were based on organic wastes, still after 330 days of stabilization, the pH of the leachate were acid (4.6).
The treatment of leachate can be done using different techniques that are generally classified into three groups: *in situ* treatment, that consists of units and equipments that can be used in the area of the landfill; combined treatment of wastewater and leachate, physic-chemical treatment followed by biological treatment; or the combination of several technologies (Shilton, 2005).

MATERIAL E METHODS

The research was conducted in Estação Experimental de Tratamentos Biológicos de Esgotos Sanitários – EXTRABES, in the city of Campina Grande, northeast Brazil (7º13'11'' south; 35º52'31'' east; 550 m above mean sea level). The experimental system comprised four shallow ponds in series, as show in figure 1. Table 2 shows the physical and operational features of the pond system. The Yanez (1993) method was used for the dispersion number determination because it take into account only the dimensions of the pond.

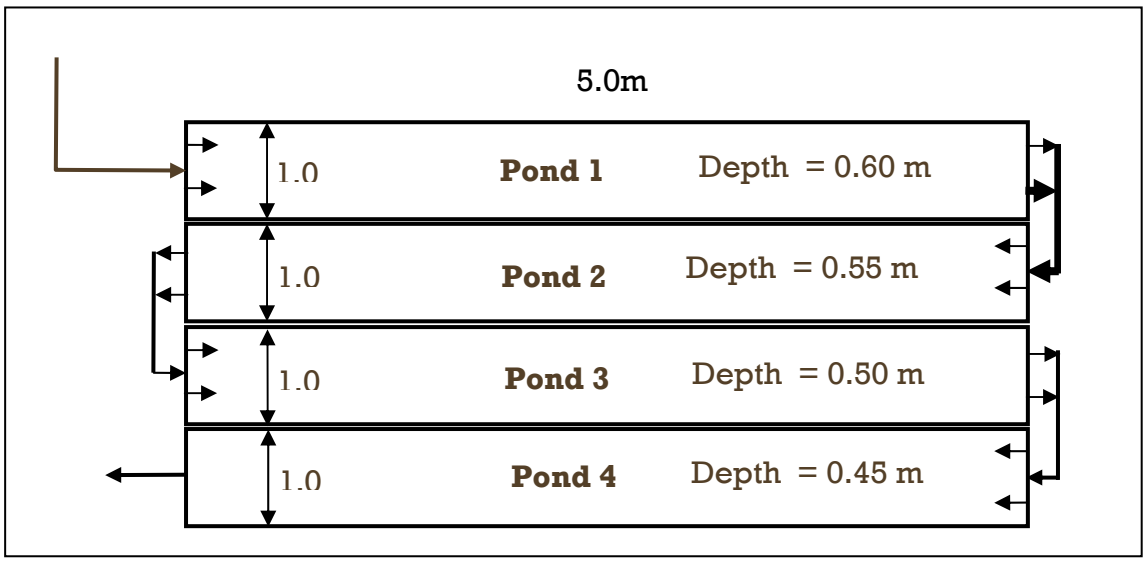

Figure 1: Scheme of the experimental waste stabilization ponds.

Table 2. physical and operational features of the pond system.

	Length (m)	*width (m)*	*depth (m)*	*Volume (m^3)*	*HRT (days)*	d
Pond 1	5	1	0.60	3.00	14.3	0.18
Pond 2	5	1	0.55	2.75	13.1	0.18
Pond 3	5	1	0.50	2.50	12.1	0.18
Pond 4	5	1	0.45	2.25	10.5	0.18

d: theoretical dispersion number

The leachate used in the study was periodically obtained in the landfill in João Pessoa, 130 km away from Campina Grande. The leachate was collected in three different cells of the landfill and was stored in PVC tanks for a maximum of 30 days. After leachate characterization of each cell, the content o the three tank were mixed and fed the ponds. The following parameters were analysed

according to APHA et al (1998): pH, total alkalinity, volatile fat acids, solids, COD and dissolved oxygen. Chlorophyll *a* was determined according to Jones (1979).

RESULTS

Table 3 shows the results obtained for the leachate characterization, while figures 1 – 5 shows the fluctuations on the effluent concentration along the series of ponds.

Table 3: Leachate characterization for cell 1, cell 2 and cell 3

Parameters	Cell 1	Cell 2	Cell 3
pH	8.2	8.5	7.6
Total alkalinity (mg $CaCO_3$/L)	10,500	10,710	12,558
Volatile fat acids (mg/L)	422	576	8140
COD (mg/L)	3,244	3,920	26,373
Soluble COD (mg/L)	3,189	3,818	16,619
Sulphide (mg/L)	44.8	11.2	100.8
Total phosphorus (mg/L)	22.2	25.8	32.2
Soluble phosphorus (mg/L)	12.5	13.8	3.5
TKN (mg/L)	2,490	2,340	2,520
Ammonia (mg/L)	2,250	2,290	2,282
Total solids (mg/L)	11,852	13,734	28,682
Fixed total solids (mg/L)	1,484	1,626	10,806
Volatile total solids (mg/L)	10,368	12,108	17,876
Suspended solids (mg/L)	254	378	4,620
Volatile suspended solids (mg/L)	132	190	2,928

Figure 2 shows the total COD concentration in the influent substrate (mixture of the content of the three cells) and in the effluent of each pond. Analyzing data from figure 2, it can be noticed that the total COD concentration in the substrate varied from 6,382 to 10,405 mg/L, while in the final effluent this concentration varied from 1,148 to 3,889 mg/L and the resulting removal efficiency was 66.3%, which is lower than the common removal efficiency for COD in WSP in series.

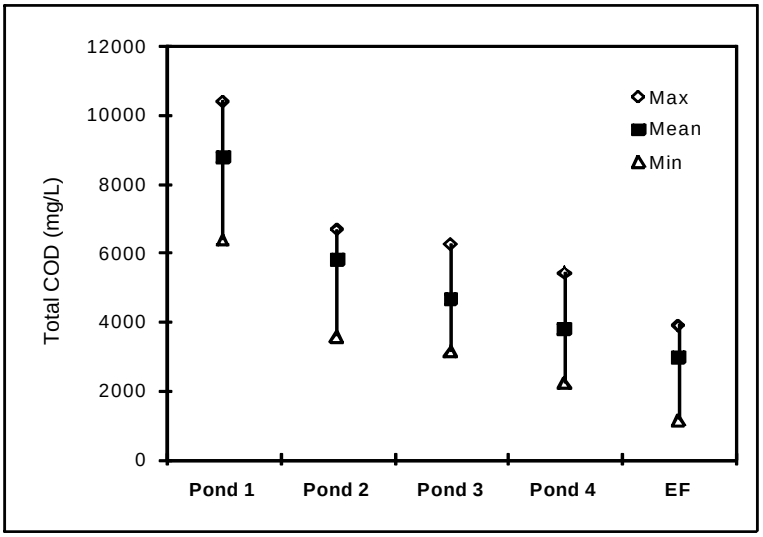

Figure 2: Variation of Total COD along the ponds.

The maximum and minimum Figure 3 shows the soluble COD concentration in the influent substrate (mixture of the content of the three cells) and in the effluent of each pond. The soluble BOD in the influent substrate varied from 2,972 to 6,720 mg/L, with mean value of 4,843 mg/L. The removal efficiency was 52%. From the total COD in the leachate, about 55% was in the soluble fraction. On the other hand, in the final effluent the ratio (soluble COD/total COD) was 0.77.

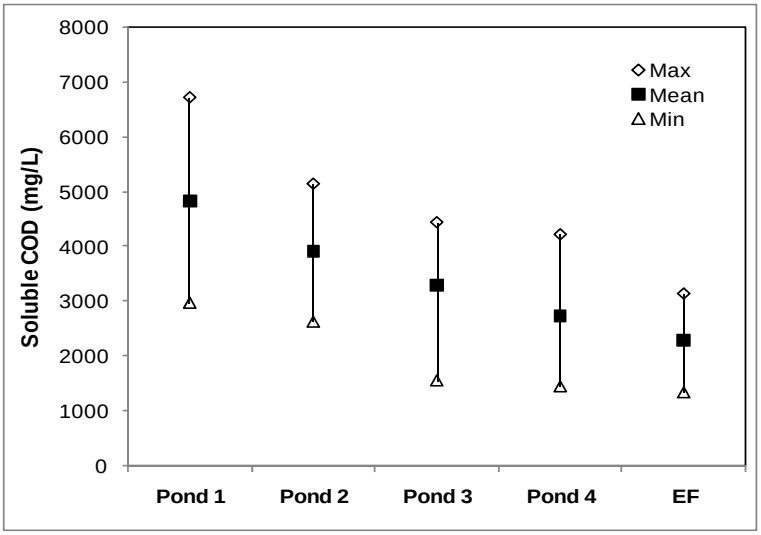

Figure 3: Variation of Soluble COD along the ponds.

Figure 4 shows the suspended solids concentration in the influent substrate (mixture of the content of the three cells) and in the effluent of each pond. The suspended solids in the influent substrate varied from 221 to 370 mg/L and a significant increase in this content was observed, possibly associated with the algae growth. In the final effluent the suspended solids varied from 132 to 448 mg/L.

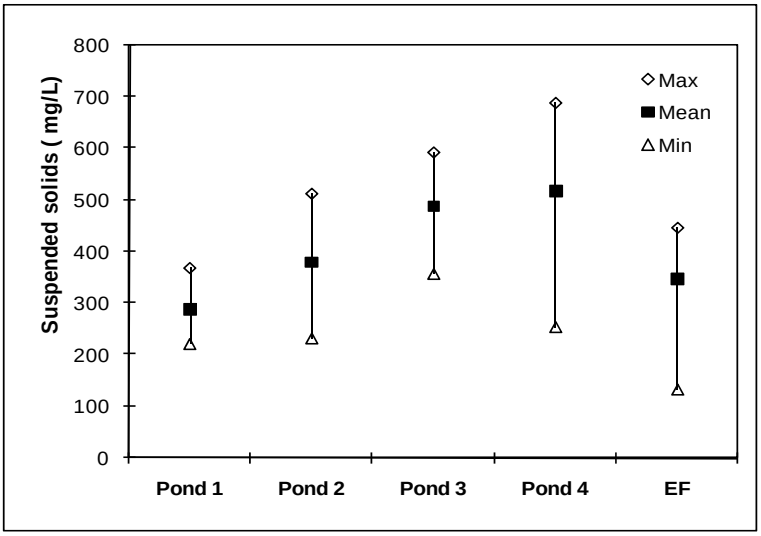

Figure 4. Variation of Suspended solids along the ponds.

Figure 5 shows the volatile suspended solids concentration in the influent substrate (mixture of the content of the three cells) and in the effluent of each pond. The volatile suspended solids in the influent substrate varied from 178 to 282 mg/L. In the ponds effluent the volatile suspended solids varied from 200 to 514 mg/L. In the final effluent the volatile suspended solids varied from 78 to 346 mg/L. Similarly to what happened with suspended solids, the variation in the volatile suspended solids seems to be associated with algae growth.

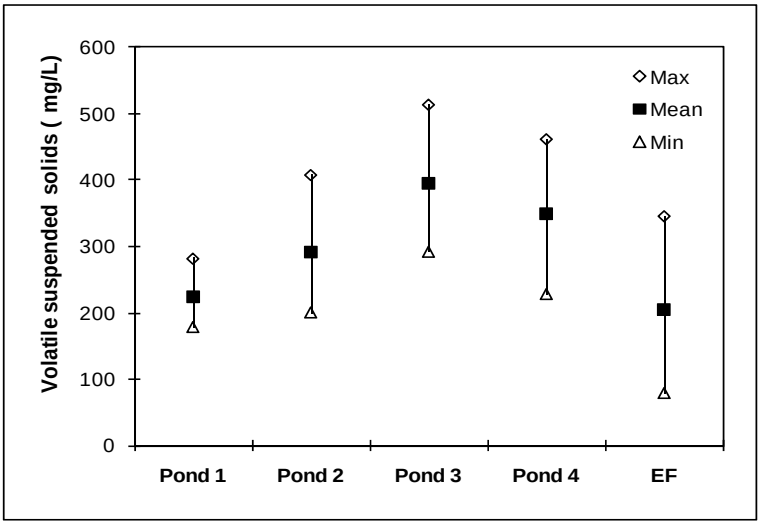

Figure 5: Variation of Volatile suspended solids along the ponds.

CONCLUSION

Shallow waste stabilization ponds, fed with landfill leachate in a plug flow regime removed 66% and 52% of total and soluble COD. Given the high carbonaceous and nitrogenous loading applied to the ponds, the growth of algal biomass and these good removal efficiencies, the shallow ponds can became an important alternative for landfill leachate treatment in northeast Brazil.

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