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Simulation of solid waste landfill leachate treatment

[1]Elena E. Manea, [1]Lăcrămioara D. Robescu, [2]Tiberiu Apostol

[1] University "Politehnica" of Bucharest, Department of Hydraulics, Hydraulical Machinery and Environmental Engineering, Bucharest, Romania; [2] University "Politehnica" of Bucharest, Department of Producing and Using Energy, Bucharest, Romania. Corresponding author: L. D. Robescu, diarobescu@yahoo.com

Abstract. Solid waste disposal to landfills is an important technique in waste management, but the treatment of the leachate that is collected represents one of the major problems. This paper presents a simulation study on the leachate treatment that was conducted using STOAT, a dynamic sewage treatment works modelling package. Two biological nutrient removal treatment schemes were evaluated: nitrogen removal only (AO scheme) and the Bardenpho process (nitrogen and phosphate removal). The results have shown that AO scheme works better than Bardenpho, because the landfill leachate contains little phosphorus and the treatment process should be focused on removing BOD and ammoniacal nitrogen.
Key Words: leachate treatment, landfill, simulation, disposal.

Introduction. Leachate treatment and disposal is one of the major problems for solid waste landfill management. The landfill leachate usually results from the rainwater that percolates through the landfill and absorbs chemical and biological compounds and from the liquid resulted from the decomposition of the wastes. Thus, the leachate is highly loaded with many organic compounds, some of them not readily biodegradable and toxic heavy metal compounds. The composition of the leachate varies greatly depending on the age of landfill. Furthermore the flow value changes with the weather. As a result of the variability in leachate characteristics, the design of a leachate treatment system is a complicated process. There are currently in use biological, physico-chemical and advanced methods to treat leachate. Renout et al (2008), presented a review of leachate treatment technologies with their advantages and drawbacks and pointed the major criteria to select a suitable treatment strategy. Madu (n.d.), searched for and compared leachate treatment methods in terms of efficiency in the treatment of young, medium and old leachate as well as in term of space utilization, skilled personnel requirement, installation and operational cost. He found twenty different principle techniques for treatment of landfill leachate.

Anaerobic biological leachate treatment is not a successful technology because of the high required COD levels and the inability of ammoniacal-N removal. Aerobic biological treatment of leachate is widely used, most of the leachate contaminants being removed, but the remaining values of COD and AOX are still relatively high (Stegmann et al 2005). This was the reason to develop physical-chemical treatment steps as an alternative or as additional treatment methods. From these biological treatment systems of leachate, good results were obtained using Sequencing Batch Reactor (SBR) technology (Carville & Robinson 2005; www.gov.uk), that is well suited to the higher organic strength and concentrations of ammoniacal-N in landfill leachates. This technology is applied tank based or lagoon based. Also MBR and attached growth systems have proved good results in removing contaminants from leachate.

Coban et al (2012) present a method for the removal of organic material using aerobic/anoxic MBR system followed by a nanofiltration process. They have shown that nitrogen removal by nitrification/denitrification process is hard, but integrated membrane process greatly enhances treatment efficiency and removes organic and nitrogenous matter from landfill leachate.

In some cases, landfill leachate can be added into incoming wastewater stream at a sewage works, where it is biologically, physically, and/or chemically treated (Stegmann et al 2005; www.dwaf.gov.za). This is not always a good option because of the fact that contaminants from leachate can disturb the operation of wastewater treatment processes. Usually, in order to meet the limiting concentrations for the effluent, the treatment of leachate consist of several of the treatment methods.

Simulation study. In this paper a leachate treatment system was considered for an hourly flowrate Q = 1.7 [m^3/h] that processes the leachate from a medium aged landfill, with a summary composition presented in Table 1. The following notations were made: BOD – biological oxygen demand [mg/L]; COD – chemical oxygen demand [mg/L]; TSS – total suspended solids [mg/L]; N_T – total nitrogen [mg/L]; P_T – total phosphorus [mg/L].

Table 1

Leachate composition

Parameter	*Value*
BOD [mg/L]	1250
COD [mg/L]	7340
TSS [mg/L]	311
N_T [mg/L]	1720
P_T [mg/L]	17.1
NH_4^+ [mg/L]	1300

A simulation study was conducted using STOAT, a dynamic sewage treatment works modelling package. Two biological nutrient removal treatment schemes were proposed: nitrogen removal only (AO scheme) (Figure 1), and Bardenpho process (nitrogen and phosphate removal) (Figure 2), with a total volume of biological reactor of 122 m^3.

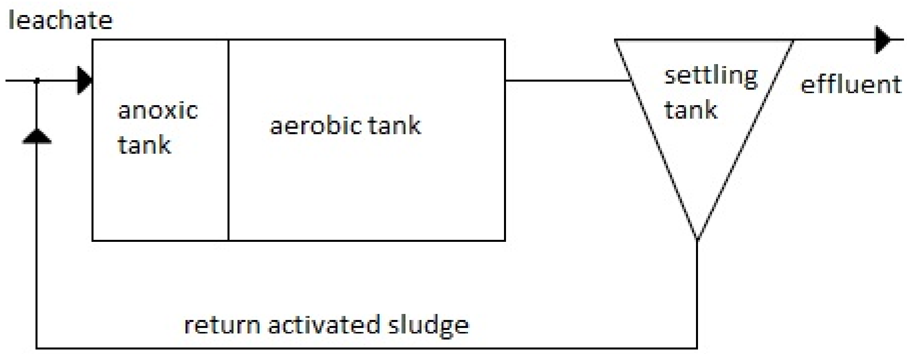

Figure 1. AO (anoxic-oxic) scheme for nutrient removal.

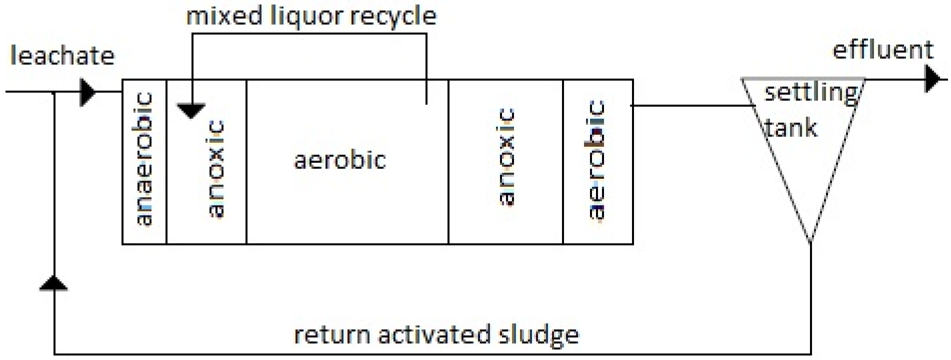

Figure 2. Bardenpho scheme for nutrient removal.

A single model for both nutrient removal schemes was built in STOAT, using available library for processes (Figure 3). The appropriate scheme can be defined before running the simulation, when processes dimensions have to be set.

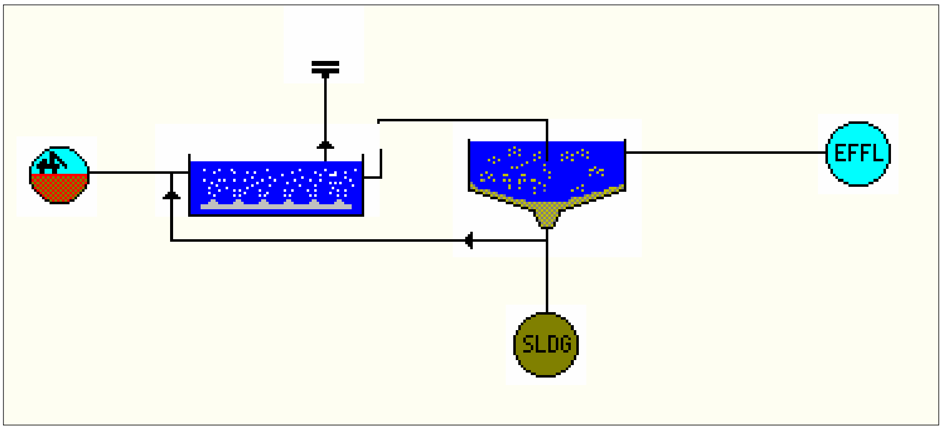

Figure 3. STOAT model for nutrient removal schemes.

First, the nutrients removal efficiency is evaluated by using the AO scheme. The results of the simulation for the main parameters are presented in Table 2 and Figure 4.

Table 2

Results for total suspended solids, BOD and ammonia removal using AO scheme

	Flow (m^3/h)	*Total SS (mg/L)*	*Total BOD (mg/L)*	*Ammonia (mg/L)*
Mean	1.47	2.94	1.54	14.69
Minimum	0.00	0.00	0.00	0.00
Maximum	1.50	3.78	5.05	40.00
Standard deviation	0.22	1.13	1.37	12.28
Total mass (kg)		0.211	0.111	1.058
Peak load (g/s)		0.002	0.002	0.017

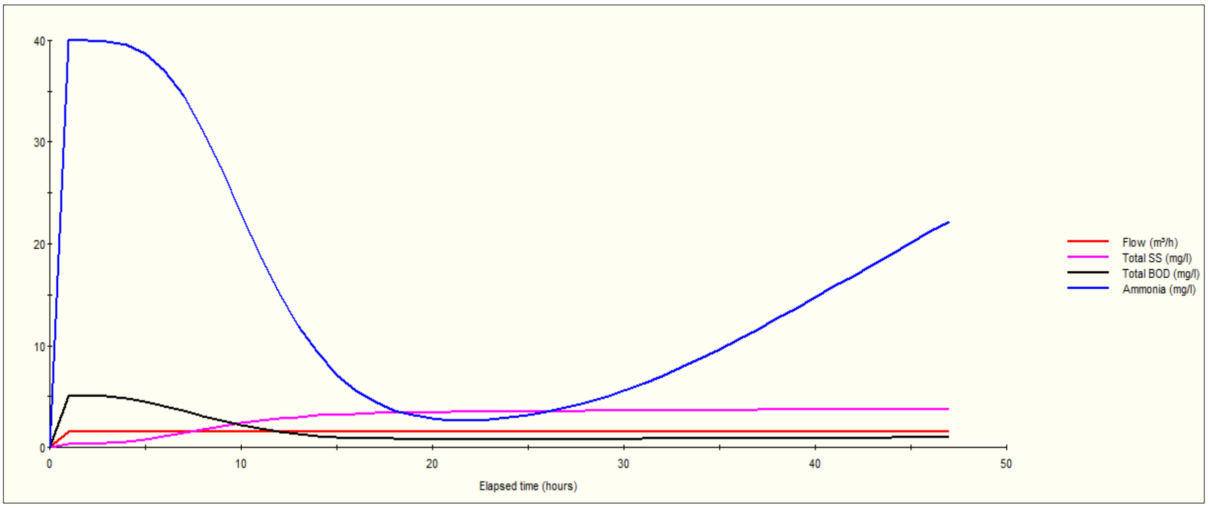

Figure 4. Results for total suspended solids, BOD and ammonia removal using AO scheme.

The simulation time was considered of 2 days, but as can be seen, after retention time of 10 h the effluent values for total suspended solids, BOD and ammonia are in the limits indicated in the Romanian legislation for treated wastewater discharge. After a longer retention time it can be observed that nitrates concentration raises (Figure 5).

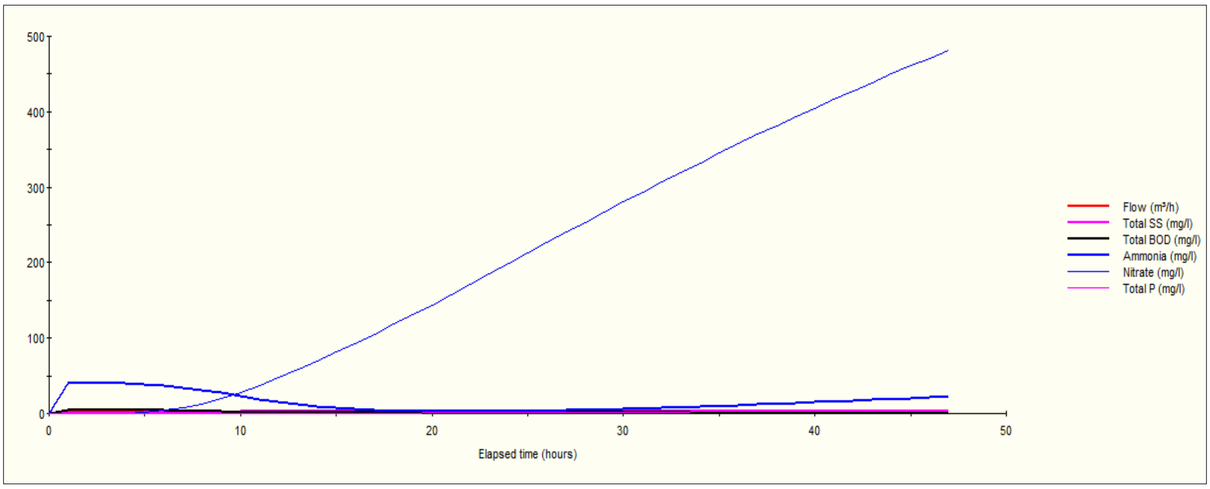

Figure 5. Results for total suspended solids, BOD, ammonia, phosphorus and nitrates removal using AO scheme.

Secondly, the biological nutrient removal was evaluated using Bardenpho process and the simulation results, as can be seen in Table 3 and Figure 6 are worse than the AO process, especially for BOD, ammonia and nitrates removal. The pollutants concentration are high above the standards values.

Table 3

Results for total suspended solids, BOD and ammonia removal using AO scheme

	Flow (m^3/h)	*Total SS (mg/L)*	*Total BOD (mg/L)*	*Ammonia (mg/L)*	*Nitrate (mg/L)*
Mean	1.47	2.70	182.80	724.14	62.26
Minimum	0.00	0.00	0.00	0.00	0.00
Maximum	1.50	4.58	449.56	1122.29	269.12
Standard deviation	0.22	1.68	158.07	415.58	84.13
Total mass (kg)		0.194	13.162	52.138	4.482
Peak load (g/s)		0.002	0.187	0.468	0.112

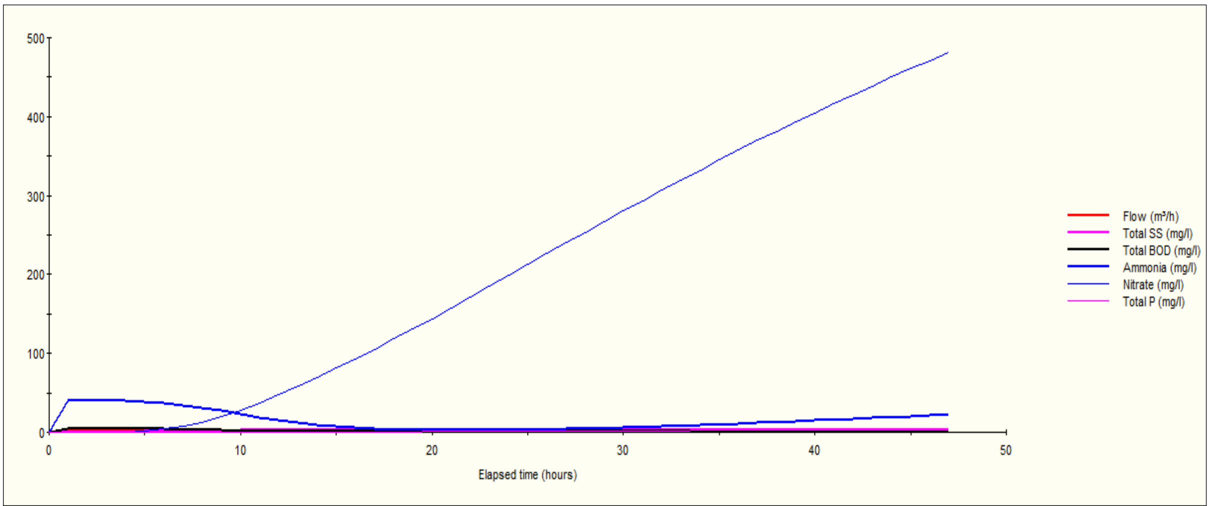

Figure 6. Results for total suspended solids, BOD, ammonia, phosphorus and nitrates removal using Bardenpho scheme.

Conclusions. Leachates from domestic landfills are rich in organic compounds and ammoniacal nitrogen, but usually contain little phosphorus. It is necessary to remove the ammoniacal nitrogen as a primary treatment or to denitrify after the nitrification step. It can be said as a conclusion that the biological nitrification/denitrification treatment can lead to good results depending on the chosen scheme. After that biological step, polishing treatment can be added to provide treated leachate quality matched to site-specific discharge requirements.

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Authors:
Elena Elisabeta Manea, University "Politehnica" of Bucharest, Department of Hydraulics, Hydraulical Machinery and Environmental Engineering, Splaiul Independentei, 313, 060042 Bucharest, Romania
Lăcrămioara Diana Robescu, University "Politehnica" of Bucharest, Department of Hydraulics, Hydraulical Machinery and Environmental Engineering, Splaiul Independentei, 313, 060042 Bucharest, Romania, e-mail: diarobescu@yahoo.com
Tiberiu Apostol, University "Politehnica" of Bucharest, Department of Producing and Using Energy, Splaiul Independentei, 313, 060042 Bucharest, Romania
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