Full scale performance of biological leachate treatment at low temperature

Pelkonen Markku [1] , Kotro Mikko [2], Wang Zengzhang [1]

1) Helsinki University of Technology, Laboratory of Environmental Engineering
PO BOX 6100, FIN-02015 HUT (Espoo) Finland, markku.pelkonen@hut.fi
fax: +358-9-451 3856

2) Helsinki University Development Services, Helsinki, Finland

The aim and background

The aim of the study was to examine the performance of a new full scale biological leachate treatment plant in demanding Nordic winter conditions and to study factors affecting the process, especially nitrogen removal, and its feasibility including economical aspects.

The treatment unit consisted of an activated sludge process with pre-denitrification and nitrification stages. The process configuration and design values were based on the pilot scale results found earlier (Pelkonen et al.1999). The construction of full-scale plant started in summer 1999 and was taken in operation at the end of November 1999. The water taken into the process consisted mainly of leachate from a 2.5 ha landfill (age 7 years) and from an approx. 1 ha windrow composting area. The water was led to a balancing tank, from where it was pumped to the treatment process. During the winter and spring period the water temperature was around 2-4 °C, the hydraulic retention time 1.5-3.8 days and the sludge age over 30 days. Phosphorus was added to the process to maintain the nutrient balance.

Results and discussion

The loading of the process was increased stepwise during the first two months after the start of the process to allow the adaptation of the biomass. Results after this period representing winter and spring conditions with snow melting period (length approx. 3 months) are shown in table 1.

Table 1. Treatment efficiency during the winter and spring period

	Influent					Effluent					Removal efficiency
	Unit	Avg	std	Min	Max	Avg	std	min	max	N	avg *
CODtot	Mg/l	619	101	540	820	189	23.8	154	224	7	69.4
BOD_7	Mg/l	227	48.3	170	290	11.2	3.5	6	15	5	95.0
Ntot	Mg/l	84	11.4	66.4	97.6	38.3	9.1	32.2	56	6	54.4
NH_4-N	Mg/l	77	8.7	61.7	90.8	1.2	2.5	0.1	7.4	8	98.5
NO_2+NO_3-N	Mg/l					25.0	10.8	16	50.7	8	
Temperature	°C					6.6	2.3	4.7	11.4	8	
	*unit %										

Avg = average, std = standard deviation, min = minimum, max = maximum, N = number of observations

The results show a nearly complete nitrification, the ammonia removal was in average over 98 %. A reasonable denitrification was found; in average the total nitrogen removal was approx. 55 %. The lowest monthly process temperature was 4.5-5 °C, which can be characterised extremely low. It is obviously first time, when a full and stable nitrification has been reported in a leachate treatment process in this temperature range in full scale.

Removal of BOD_7 was in average 95 % and of COD approx. 70 % indicating efficient degradation of biodegradable organic matter. The residual COD was in average 190 mg/l. The COD- and BOD_7- concentrations in the influent were lower than during the previous pilot tests mainly due to obvious increase in gas production in the landfill and decrease of organics in the water phase.

The specific nitrification rate was 0.009-0.02 g NH_4-N (g VSS) $^{-1}$. This did not differ considerably from the pilot tests, in which the temperature range was approx. 7-11 °C. These results support to extend the feasible temperature range for nitrogen removal down to 4.5-5 °C. An important factor to take into consideration is the possible inhibition of nitrification due to heavy metals or other toxic compounds, which can have a synergetic effect with the decreasing temperature. These results (and other test results not shown here) indicate that at least in this case this phenomenon did not have a remarkable role.

Of importance is, in spite of carbon and nitrogen removal, the solids separation efficiency, because excess solids deteriorate the effluent quality. Results in table 1 and other test results (not shown here) confirm a reasonable bioflocculation and that the solid particles can also be removed without serious problems in an activated sludge process in these temperature conditions.

The operation and investment costs were estimated in the pilot study and the real data from this full-scale plant confirms that the costs of local biological treatment per m^3 and per kg nitrogen removed are competitive. An important factor was that no extra heating was used and the energy consumption was low. The good treatment results at low temperatures aid also the process economy.

Conclusions

A biological process was applied successfully to treat cold leachate in winter conditions in full scale. A complete ammonia nitrogen oxidation was maintained, obviously first time in full scale at process temperature 4.5 – 5 °C in combination with a reasonable denitrification efficiency.

The process was not considerably affected by inhibition due to heavy metals and toxic compounds in these extreme conditions. In addition, the solids removal was reasonable.

The treatment results together with economical evaluation show that the application of biological processes in leachate treatment at low temperatures is worth considering and the feasible temperature range can be extended down to 4.5 – 5 °C.

Reference:

Pelkonen M, Kotro M, Rintala J 1999: Biological nitrogen removal from landfill leachate: a pilot scale study. Waste Management & Research 17, 493-7.