ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

1999
Volume 2
Issue 2
Series
ENVIRONMENTAL DEVELOPMENT

BLAZEJEWSKI R., ZYTYNSKI W. 1999. REMOVAL OF NITROGEN FROM PRETREATED WASTEWATER IN SOIL ABSORPTION SYSTEM AND DENITRIFYING TROUGHS **Electronic Journal of Polish Agricultural Universities**, Environmental Development, Volume 2, Issue 2.
Available Online http://www.ejpau.media.pl/

REMOVAL OF NITROGEN FROM PRETREATED WASTEWATER IN SOIL ABSORPTION SYSTEM AND DENITRIFYING TROUGHS

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ABSTRACT

The paper presents results of two year field and laboratory investigations of a denitrifying system below leach lines. More than two days retention time was provided by siphoning of the denitrifying trough located 35 and 60 cm under the leach lines. Due to clogging and capillary suction in medium sand the seepage flow through the denitrifying troughs was limited to less than 10 % of the sewage inflow. Average efficiency of the total nitrogen removal was equal to 55 % after 3-4 days of travel time within the soil. To force wastewater to pass through the anaerobic bed within the trough two lateral vertical impermeable membranes are recommended.

Key words: Denitrification; domestic wastewater; nitrification, nitrogen removal; septic tank

INTRODUCTION

Septic tanks and soil absorption systems are widely used in unsewered areas owing to their simplicity, reliability and relatively low capital and operating costs. They are a proven technology but require specific-site conditions: a low ground water level, good permeability of soil and minimum set-backs. One of the drawbacks of this technology is an insufficient removal (10-40 % only) of nitrogen by the soil (US EPA 1992). Rettinger (1993) showed that it is relatively easy to provide nitrification within the soil under a clogging mat below leach lines.

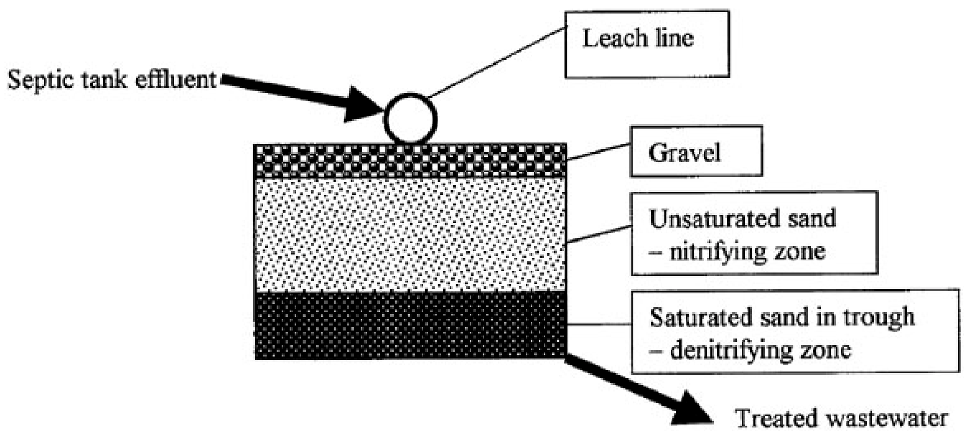
Unfortunately, the produced nitrates are freely transported downward and often pollute ground water resources. To avoid this problem various systems of advanced nitrogen removal have been applied. One of them is a denitrifying trough built under soil absorption system. The idea was probably implemented first by Erickson et al. (1971) for liquid feedlot waste, then by Sikora and Keeney (1976) to denitrify nitrates in domestic sewage using bacteria *Thiobacillus denitrificans.* The last authors showed that at extreme winter temperatures complete denitrification could be obtained in approximately 1.5-2 days residence time in anaerobic conditions. Field performance of their system has probably not been proven or was not efficient as we do not know such systems under operation.

The purpose of this study was to investigate a removal efficiency of nitrogen from septic tank effluent via nitrification and further denitrification within soil. The idea is shown in a concept diagram (Fig. 1). The wastewater passed through both nitrifying and denitrifying zones is collected to examine treatment efficiency.

EXPERIMENTAL MATERIAL AND METHODS

A single house inhabited by 5 persons was selected for this study. It was located in a park area in Poznan, closely to the municipal sewerage system. The septic system was built in September1995 in medium sand with deep (> 8 m) ground water level. A schematic layout of the system is shown in Fig. 2. Two HDPE rectangular septic tanks of volume 2 m^3 each, connected in series, were installed first. After one year of poor

Figure 1. Vertical section trough layers under a leach line



performance they were replaced by one rectangular tank of volume 2 m^3 equipped with a granular outlet filter. The filter significantly improved removal of suspended solids in the septic tank. Two leach lines both 15 m long were constructed at depth 108 cm (Fig. 3). The sand under the leach lines was native, having effective diameter d_{10} = 0,2 mm and mean diameter d_{50} = 0,5 mm. A trough made of LDPE was spread 35 cm below one of the leaching pipes and 60 cm below the other one. The volume of each trough would guarantee more than two days retention time if the whole amount of sewage went through the siphons. This was provided by siphoning of the trough outlet which forced wastewater to pass through the anaerobic zone. Leachate from the troughs were collected in an observation well located between the leach lines.

Figure 2. Layout of the experimental site: ST – septic tank, DB – distribution box, L1, L2 – leach lines, T1, T2 – denitrifying troughs

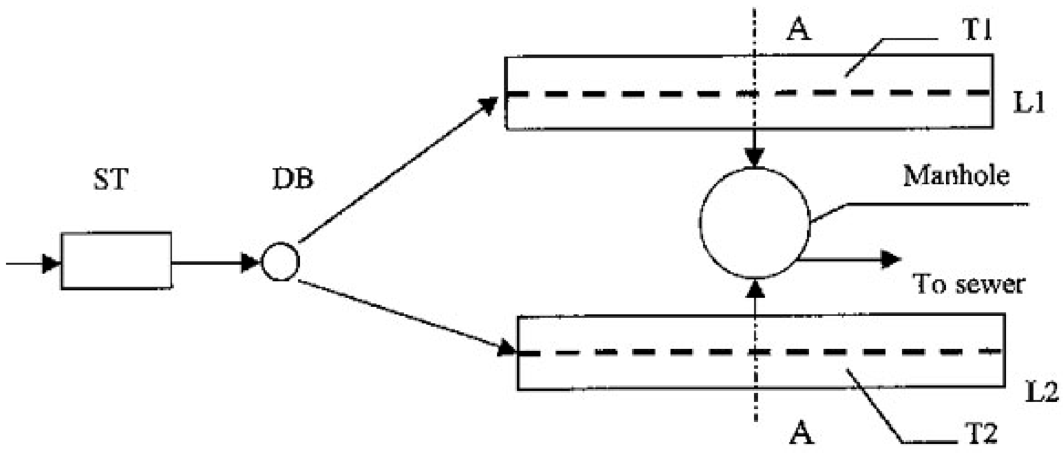
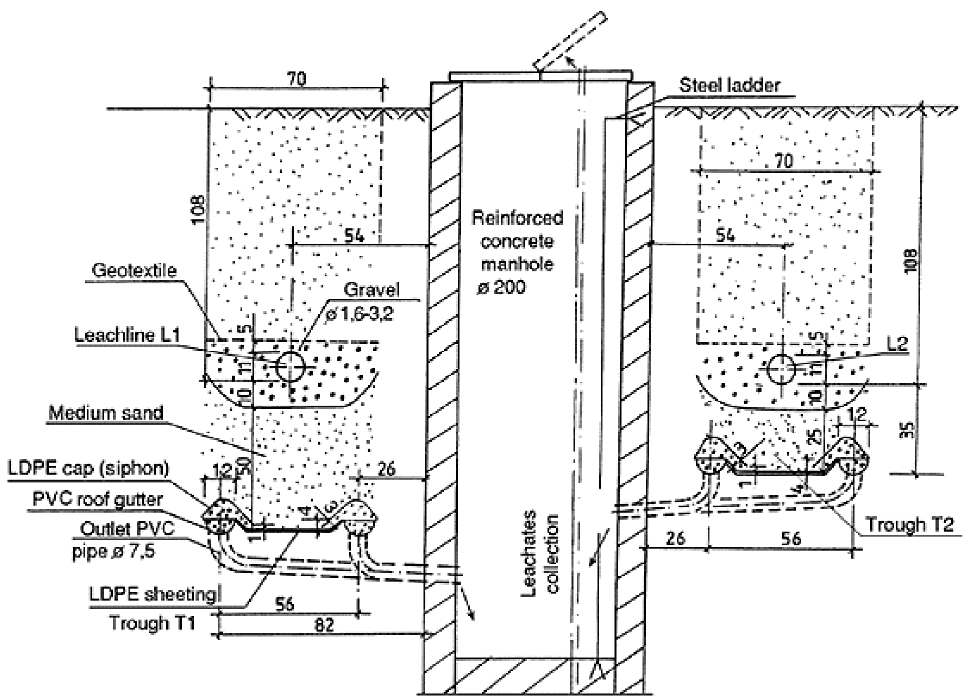


Figure 3. Vertical section A-A (see Fig. 2) of the experimental soil absorption system (dimensions in cm)



Preliminary treated wastewater was sampled at the distribution box where a tipping bucket was installed to measure the effluent quantity. Samples were taken with regard to pollution travel time determined using tracer KBr. The following characteristics of wastewater quality below septic tank and the denitrifying troughs were analysed: COD, BOD_5, total suspended solids, pH, alkalinity, total phosphorus, TKN, ammoniacal nitrogen, nitrites and nitrates.

RESULTS AND DISCUSSION

Detailed results of our preliminary investigations in 1996 were published elsewhere (Blazejewski and Zytynski 1997). They showed a significantly better performance of the shallower denitrifying trough than the deeper one. It was explained by higher availability of organic carbon estimated by BOD and a lower redox potential in the shallower trough (T2). During the study period described here (Feb. 1996 - Dec. 1997) a mean daily outflow of

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wastewater was equal to 0,83 m^3/d and the mean hydraulic load on the infiltration surface was 0,83 m^3/d /(2 x 15,0 m x 0,7 m) = 0,040 m/d, i.e. the leach field was slightly overloaded. Daily volumes of collected leachates were surprisingly low because they did not exceed 10 % of the wastewater inflow to the system. Investigations carried out in laboratory on a 2D physical model confirmed the result. They showed that water was sucking aside due to capillary forces and that permeability of the sand in the denitrifying troughs dropped as a result of clogging by a biomass.

The mean times of travel of a conservative salt (KBr) in both lines were equal to 3-4 days with high dispersion. Results of chemical analyses are shown in Fig. 4 and 5. The trend lines were calculated using moving averages. The mean concentration of total nitrogen in sewage leaving the septic tank equalled 54 mg/dm^3 (n = 16). It consisted of 61 % of N-NH_4 and 39 % of N_{org} (Fig. 5 a). Nitrification in both the shallower and the deeper systems was good (Fig. 5 b). A dramatic decrease in nitrification efficiency was observed in February and March 1997. The mean air temperature at the ground level in that period equalled -1.1°C. Apart from that cold period the nitrification efficiency reached on average 85% in both systems.

Figure 4. Nitrogen concentrations in effluent from septic tank (ST) and troughs (T1 and T2)

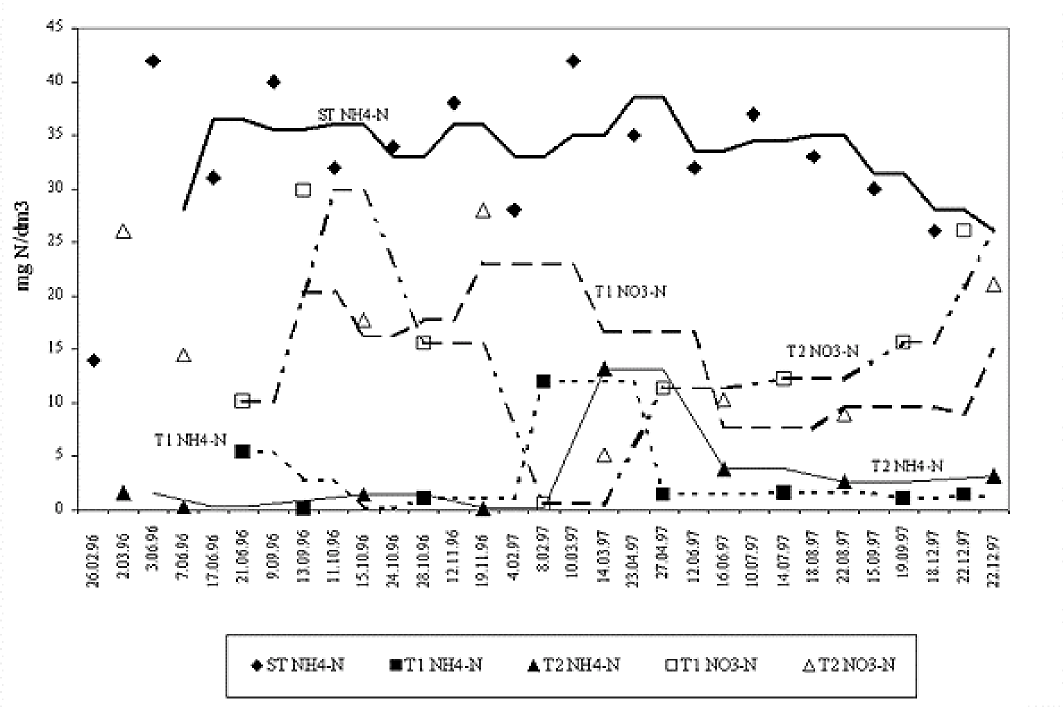
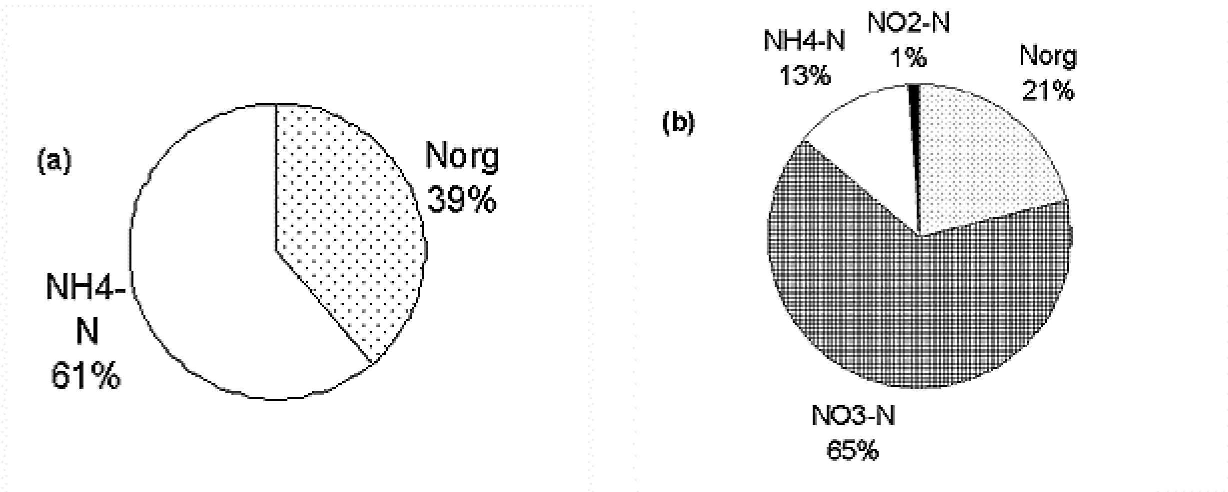


Figure 5. Partition of nitrogen forms in effluent from the septic tank (a) and troughs (b)



Removal of total nitrogen in the shallower system also did not significantly differ from that in the deeper one and was equal to 55 %. The mean concentrations of the total nitrogen in leachates were equal to 24 6 mg/dm^3 (n = 8) and 24 7 mg/dm^3 (n = 9), respectively. These values were lower than the permitted ones for a treated wastewater in Poland (30 mg N/dm^3), but higher than standard limit for drinking water (10 mg N-NO_3/dm^3).

The main disadvantage of the investigated system was the limited seepage through the siphons. It seems that two lateral vertical impermeable barriers are needed to force all the wastewater to flow through the anaerobic (denitrifying) zone. In that case the soil absorption field will work like a partly inundated sand filter. To avoid anaerobic conditions under the clogging mat just below gravel filling, vertical vent tubes connected with the upper inner side of leach lines would be helpful.

CONCLUSIONS

Nitrogen removal in the investigated system was good, however the volume of effluent from the denitrifying troughs did not exceed 10 % of the inflow to the system.

To lead all the wastewater through the denitrifying trough two lateral vertical impermeable membranes are needed. The denitrifying trough should be placed as shallow as possible and filled with gravel to confine the capillary rise from the inundated bottom zone.

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This paper was partly presented as a poster at the IVth IAWQ Specialised Conference on Small Wastewater Treatment Plants in Stratford-upon-Avon – UK (April 1999)

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