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CLOGGING MANAGEMENT AND REMOVAL OF ENTERIC BACTERIA FROM SECONDARY EFFLUENTS BY INFILTRATION PERCOLATION

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ABSTRACT

Infiltration-percolation is an extensive technique used to remove microorganisms from secondary effluents. It consists in intermittently infiltrating wastewater in unsaturated sand beds. Biomass expansion is managed through alternate operation and drying periods. Secondary effluent infiltration tests were performed on sand columns. Operation schedules were 4 days operation and 1 to 5 days drying. Organic matter, faecal coliforms and enterococci were monitored. Drying periods were shown to highly affect the elimination of enteric bacteria. Alternating operation and drying periods commands organic matter availability, biomass development and enteric bacteria removal. It was demonstrated that bacteria elimination was not solely related to water retention times and oxygen availability. Other factors, physical or biological, have also a key role in removal performances.

KEYWORDS

Bacteria removal, enteric bacteria, infiltration percolation, water retention times.

INTRODUCTION

Infiltration percolation is an extensive wastewater treatment technique which has been developed as a tertiary treatment of secondary effluents in several Mediterranean countries. As regulations are being more stringent, infiltration percolation efficiency in the removal of enteric bacteria has to be re-assessed.

Processes involved in the removal of microorganisms include mechanical filtration, adsorption and microbial degradation. Efficiency of bacterial removal has been shown to depend mainly on water retention times in the filter (Ausland *et al*., 2002) which is controlled by the amount, frequency and distribution of the application and particle size of the infiltration media (Stevik *et al*., 1999). Thus, some fair prediction of the performances through simple numerical modelling is allowed. In spite of this, certain variations remained unexplained (Brissaud *et al*., 1999). Most studies of bacteria elimination by infiltration percolation have been either only based on a weekly monitoring of filter performances or conducted regardless of the operation-drying alternation (Brissaud *et al*., 1997).

Infiltration percolation systems are divided into more than one field. This allows alternated use of the individual fields and periodical drying – through the effects of drainage, sun exposure and wind - of fields removed from service for a period of time, typically 2 to 3 days. This drying period allows a periodic elimination of accumulated biomass through endogenous respiration, thus avoiding a possible clogging of the filter. Operation-drying alternation entails a periodic fluctuation of the ecosystem state. The purpose of this work was to study the influence of drying periods on enteric bacteria removal by way of a high sampling frequency.

MATERIALS AND METHODS

Experiments were performed on 1.4 m high, 0.19 m diameter sand columns. Columns were filled with a sorted sand with a d_{10}= 0.17 mm and d_{60}=0.41mm (10% and 60% of the media are smaller than these grain sizes, respectively). During the operation periods, secondary effluents were intermittently applied in 6 doses per day. The daily hydraulic load was 0.4 m. The operation period was 4 days whatever the experiment while the drying period varied from one to five days. Every 4 hours during the operation periods, influent and filter effluent samples were taken and analysed for organic matter, nitrogen, dissolved oxygen, feacal coliform and *Enterococci* contents. Bacteria were enumerated by the membrane filter technique as specified in AFNOR standards. Retention time distributions (RTD) were determined by adding a tracer ($CaCl_2$) to the water of one application dose. The water conductivity and the flow rate were monitored at the column outlet.

RESULTS AND DISCUSSION

Physico-chemical analysis of applied secondary effluent and filtered water showed a total elimination of suspended solids, an 87 % COD reduction and a virtually total nitrification of nitrogen (Table 1). The efficiencies observed in this research are comparable to those reported by Brissaud *et al*. (1999), who noted an 100 % suspended solids elimination, an 83 % COD reduction and that ammonium was completely oxidized to nitrates. These data are evidences of the high oxidation capacity and aerobic state of the system, which were confirmed through dissolved oxygen monitoring at the column outlet.

Table 1.Physico-chemical performances (mean values)

SS (mg/L9		COD (mg/L)		N-NTK (mg/L)		$N-NO_3$ (mg/L)	
Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
29.5	<0.1	120.29	20	40.32	1.68	1.61	40.5

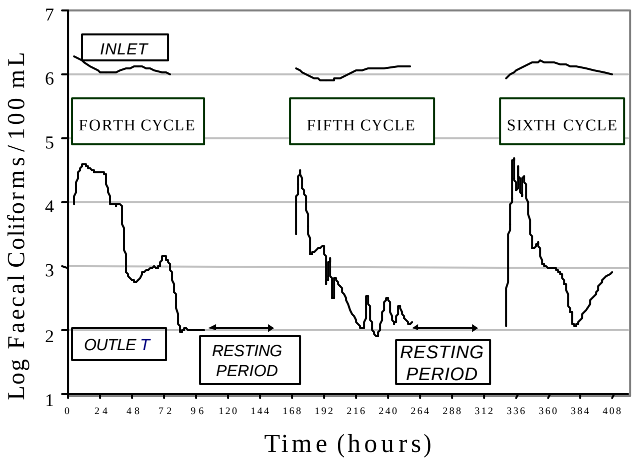


Figure 1. Faecal coliform content in inlet and filtered water.

The removal of faecal coliforms and Enterococci was in a range of 1 to 4.5 and 0.5 to 4.5, respectively. Even if high bacteria reductions could be achieved, there were significant variations of faecal coliform and *Enterecocci* concentrations in the filter effluent. These variations could not be related to the inlet concentrations, which were fairly even all along the experiment (Figure 1).

Bacteria contents in column effluent were always higher the first day of an operation period, after a drying period, than at the end of the previous operation period (Figure 1). Concentration decreased progressively afterwards. These results had been already observed by Bouwer (1974) and Bouwer and Rice (1980) who reported a bacteria peak when a new operation period was started.

Figure 2 compares the bacteria removal as affected by different durations of the drying period. Bacteria removal is defined as $\log_{10}(Ci/Co)$, with Co being the bacterial content in the filtered water and Ci, the bacteria content of applied secondary effluent. In all cases, bacteria removal performances decreased after the filter's drying interval, and the longer the drying period the greater the deterioration. The time needed to recover the highest removal capability, a few hours for one day drying and up to more than 2 days for longer drying periods, increased with the duration of the drying period.

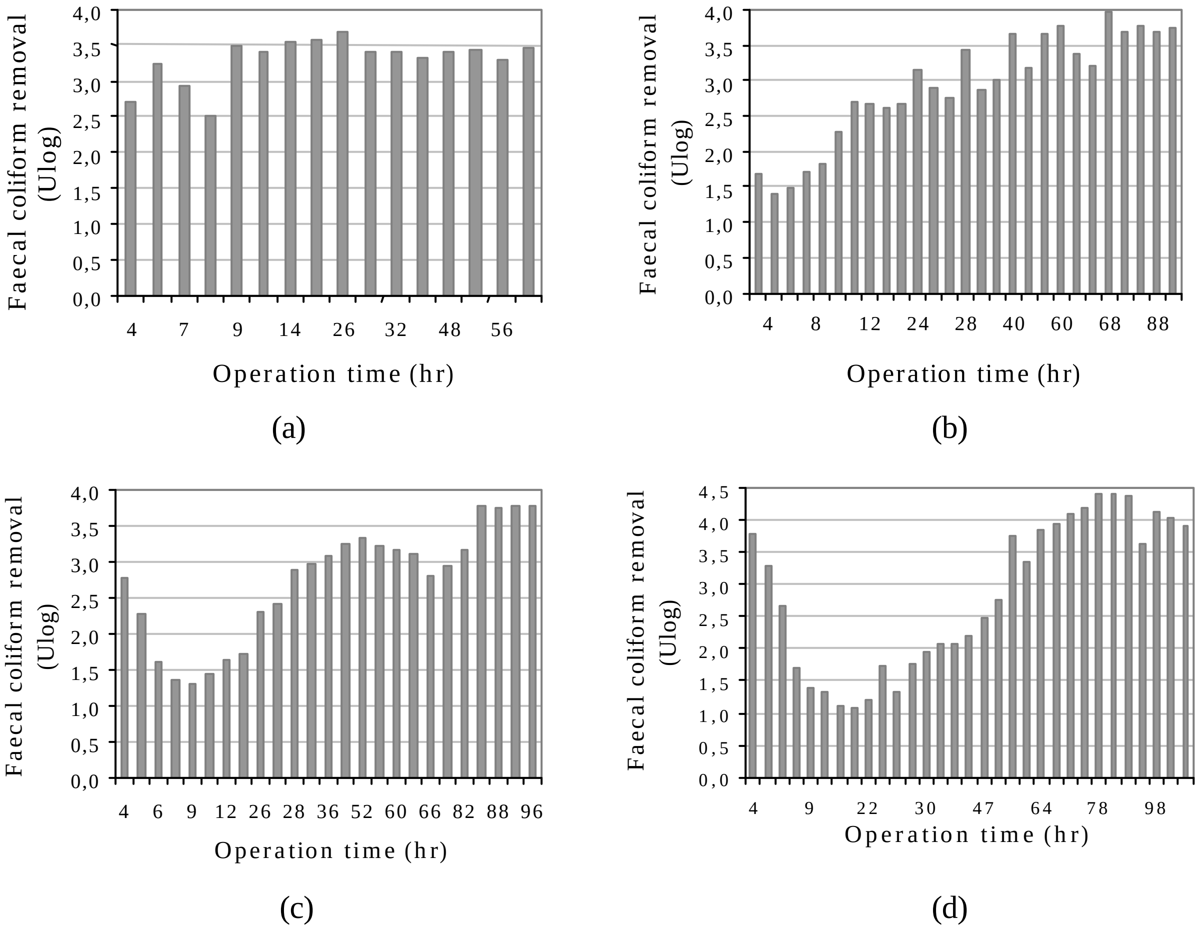
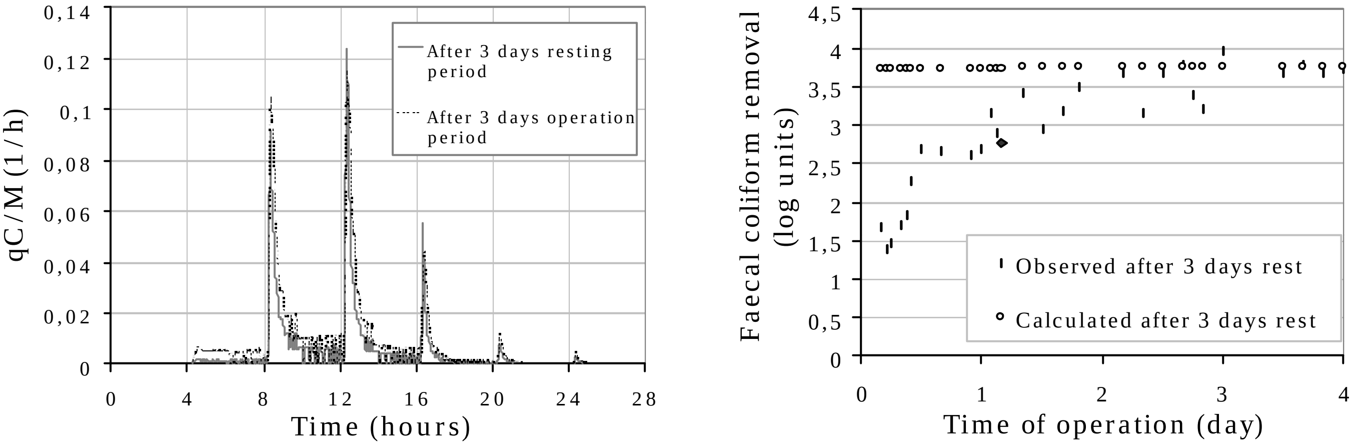


Figure 2. Faecal coliform removal after (a) 1 day drying period, (b) 3 days drying period, (c) 4 days drying period, and (d) 5 days drying period.

A linear relationship between water detention time and faecal coliform removal (Brissaud et al., 1999) was supposed to predict bacterial reduction level (equation 1): where the volume of each analysed sample is considered as made of fractions x_i characterised by different residence times t_i. calculated from the RTD measured from tracer tests (fig. 3a). This relationship allowed a good prediction of the bacterial performances for the latest days of the operation periods but not for the first day (fig. 3b). Though significant, RTD differences before and after a drying period did not allow explaining the observed variations in enteric bacteria content.

$$\Delta CF = -\mathrm{Log}_{10}\left(\sum_{i=1}^{i=n}\left(x_i \cdot 10^{-\mathrm{ati\text{-}b}}\right)\right) \qquad \text{equation 1}$$

The bacterial peak in the filtered water can be attributed to less adsorption of bacteria at the surface of the biofilm after drying. Also, the activity of native soil bacteria and the whole ecosystem at the end of a drying period is lower, producing a less antagonistic environment for the faecal bacteria when operation is resumed. During the last days of the operation periods, optimal conditions for biological activities were established and enteric bacteria borne by secondary effluent were efficiently eliminated.



(a) (b)

Figure 3. a) Detention time distributions after 3 days drying period and after 3 days operation period. b) Faecal coliform removal as a function of the operation time.

CONCLUSION

Our results illustrate first the importance of sampling frequency when investigating the mechanisms of bacteria removal in unsaturated filters. We monitored water quality every four hours. If we had sampled only once or twice a week we could have missed certain major phenomena such as the effect of drying periods on bacteria reduction.

Bacteria removal appeared to be highly sensitive to alternate operation and drying periods. Consequently, to improve the reliability of the infiltration percolation treatment, drying periods must be shorter and daily hydraulic loads reduced in order to avoid clogging.

Although RTD has been found a relevant parameter for predicting bacterial removal in unsaturated filter systems, the biofilm state, which depends on organic substrate availability, appears to be a key factor of removal efficiency. Relationship between adsorption and biofilm dynamics still has to be elucidated.

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