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Reclamation of domestic greywater for agricultural irrigation by intermittent sand filter bioreactor

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Summary

Potential adverse effects to human health, environment and purpose-related infrastructure should be considered when designing systems for treatment and reuse of greywater. Intermittent sand filtration (ISF) bioreactors are efficient systems for treatment of wastewater and are able to produce effluents of high quality. However, ISFs have potential to clog easily under uncontrolled loads of solids and organics. Furthermore, the specifications of its design are varied and generally aim to polish effluents for environmental discharge. This study discusses an approach to extend the lifetime of ISFs by incorporating a pretreatment that aims to control the size of solids loaded to the bioreactor and to design the configuration of an ISF based on standards of quality that are suitable to the agriculture reuse scenario.

In Chapter 1, background and the objectives of this study were described. Greywater reuse potential, drawbacks and potential adverse effects were enumerated. Natural treatment technologies were compared and the suitability of intermittent sand filtration bioreactors for some scenarios is discussed. Challenges for an improved setup of these systems are listed.

In Chapter 2, the capability of geotextile fabric filter for removal of SS from greywater and the effects of this system when used as pretreatment for ISFs were investigated. The efficacy of several polypropylene non-woven geotextiles (apparent opening size from 0.10 to 0.18 mm) used as primary treatment filters to remove suspended particles from domestic greywater and the effects of this pretreatment in the performance of fine and small media size (0.3 and 0.6 mm) ISFs was examined. Results showed geotextile achieved suspended solids (SS) removal rates from 25% to 85% and chemical oxygen demand (COD) from 3% to 30%; although the portion larger than 75 μm was removed at higher rates (55% to 90%), particles smaller than the nominal pore size of the filter were also captured. Geotextile used as pretreatment resulted in improvement of lifetime of the ISFs over an experimental run of 60 days. The vertical profile of volatile organic matter in the ISFs was evaluated at the end of the experiment and it showed a clear reduction in the accumulation of organic material on the top layer of the ISFs, effectively avoiding its early failure by accumulation of solids.

In Chapter 3, the influence of media when using a ISF for treating domestic greywater was investigated. The efficiency of the systems to reclaim effluents to be used in agricultural irrigation was evaluated by comparing the impact of physical parameters: depth (0.2, 0.4 and 0.6 m), media size (0.3, 0.6 and 0.9 mm) and layering in the quality of effluent regarding three potential risks: health safety (E. Coli 0-5 log reduction), damage to irrigation systems (SS < 3mg L^{-1} and COD) and phytotoxicity (LAS < 8 mg L^{-1}) indicators. Six ISF configurations were operated for 250 days without clogging or requiring any other maintenance than changing the geotextile filter used as pretreatment. SS and LAS concentrations were below the limits set in all cases, showing that even

the shallowest ISF is effective. Removal of E Coli ranged from 1.2 to 2.2 log, considered not enough to reach an acceptable level for intensive human handling, but sufficient for usage in conjunction with high-efficiency irrigation systems. Depth and inclusion of fine sand layer showed a marginal improvement in the removal of dissolved organic matter in effluent, which can be an advantage to avoid potential biofilm regrowth in irrigation systems.

In Chapter 4, using the same quality parameters previously described, the effects of hydraulic loading rate (HLR) on a stratified 40-cm depth ISF in the effluent of treated greywater were evaluated. HLRs of 8, 16, 32 and 48 cm d-1 were used. Increasing of the hydraulic daily discharge (i.e. reduction of surface area) reduced the lifetime of ISFs and marginally reduced the quality of effluent in terms of SS and dissolved organic matter. Although higher SS was observed, it was mostly nonsettleable particles, and therefore less likely to cause immediate damage to irrigation systems. In contrast, the total filtering capacity of the systems was higher when greater daily discharges were used. Low removal of E. Coli was observed a maximum of 2 log units under the experimental conditions (8 cm d^{-1}), so additional measures must be considered for safe reuse of LLGW treated by ISF.

In Chapter 5, the efficiency of ISF systems to remove hydrophobic organic micro pollutants was evaluated. Emergent micro pollutants such as UV filters have a potential to bio accumulate in biota or soil due to its hydrophobic characteristics. Four of the most common compounds in the market: p-aminobenzoic acid, benzophenone-3, ethylhexyl methoxycinnamate and octocrylene, were chosen. All of them had different levels of hydrophobicity evaluated by log Kow and the solubility in water. The same six ISFs as in Chapter 3 were used for this experiment. Results showed that ISFs of only 20 cm depth were able to capture the hydrophobic UV filters to concentrations under 0.0005 mg/L (99.95% removal). The form of hydrophobic compounds changed in the greywater phase showed to depend on the solubility of the compound, the nature of the product matrix and the contents of surfactants in greywater. However, hydrophilic UV compounds were removed in lower rates, similar to that of total dissolved organic matter.

In Chapter 6, the results obtained in the previous chapters were applied to designing ISFs for implementation in rural area scenarios. Comparisons were made between different financing scenarios and the cost-effectiveness of the systems was evaluated.

In Chapter 7, the summary of most important findings and conclusions of this research and recommendations for future studies are listed