APPRAISAL OF TECHNICAL OPTIONS FOR GREY WATER TREATMENT PROCESSES

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Abstract

Population increase, migration, industrialization, and climate change contributing to water scarcity is recognized worldwide especially in Mediterranean region. Alternative options to provide innovative water supply is becoming more important. In this respect, grey water may constitute an alternative none-drinkable water resource. Planning and long term monitoring of several GW treatment and reuse technologies, covering the range of very sophisticated to simple, including MBR, SBR, RBC and CWs were investigated under Mediterranean conditions. The assessments were made in terms of technical, operational, environmental, hygienic, and economic concerns. EPA suggested guidelines were used for compliance with reuse criteria. Despite of operational difficulties MBR turned out to be most reliable option. All other alternative options meet the criteria for agricultural reuse of greywater. It was concluded that local conditions and assets along with the type of reuse intended should be taken into consideration for successful applications results.

Introduction

Greywater (GW) is produced from domestic laundry, dishwashing and bathing activities. GW has low content of organic matter, low nutrients and pathogens as compared to composite domestic wastewater (DWW). The concept of reusing GW as an alternative resource to mitigate water stress, due to climate change impacts and to achieve sustainable water management (SWM), is gaining importance in Mediterranean region. GW can be reused for non-drinkable purposes as irrigation and toilet flushing. Research oriented studies were conducted on various GW treatment and reuse technologies (Nolde, 2005; Atasoy *et al*, 2007; Murat Hocaoglu *et al*, 2010; Masi *et al,*2010*;* Kraume *et al,* 2010). There are several benefits of reusing GW over DWW or black water (BW) reuse including low pollutant characteristics of GW, applicability of treatment options for installation and operation to some extent and higher amount of GW generated for reuse. The principal objective of this study is to develop, modify and assess the treatment and reuse technologies including the advances under Mediterranean conditions in terms of environmental, social, economic concerns and usability. In this manner, several GW treatment systems, a MBR (membrane bioreactor), a hybrid SBR (sequential batch reactor), a RBC (rotating biological contactor) and a series of CWs (constructed wetlands), were planned and operated in the long term. The presented study intends to provide information on the appraisal of the grey water treatment options for the points of effluent qualities, removal efficiencies, relevant operational parameters, operational simplicity, reliability and the operational experiences. The

applied GW treatment systems were compared with each other consequently. The results were also appraised in terms of local and international reuse standards. Moreover, the operational conditions of the GW systems under local conditions were closely focused. The data presented covers simultaneous running of the treatment units fed with the identical grey water source. The study was carried out in an technical experiment site constructed in the context of the Zer0-m project located in TUBITAK-MRC, within the activities of the EU funded Zer0-m (www.zer0-m.org) project (Regelsberger *et al,2007)*.

Materials and methods

GW of 28 apartments of the lodging buildings of MRC, including kitchen, laundry and bathing wastewater, was segregated from black water (BW) and collected in a tank. GW was first passed through coarse (6 mm) and fine screens (3mm) and pumped to MBR, SBR, RBC and CW systems at predetermined flow rates. The submerged MBR used was manufactured by BUSSE GmbH Company had a micro-filtration plate and frame module (KUBOTA) with a total filtration area of 5 m^2. The Hybrid SBR was manufactured by PONTOS GmbH., consisted of two serial chambers for biological-reactions and a third tank for storage including UV disinfection. The hybrid SBR had suspended and attached growth biomass in biological reaction chambers, it contained packing materials to provide area for attached growth microorganisms. Both systems had an approximately working effective volume of 600 L. The RBC had discs with radial and concentric passages, rotating at a speed of 2-3 rpm in a 4 serial tank and a settling chamber for clarification of the effluent. The CW systems consisted horizontal submerged flow (HF) and free water systems (FWS). The raw GW was first diverted into the HF-CW by a pump and then in the second step, it flowed to a FWS by gravity flow for disinfection and further polishing. Equivalent amount of GW, 400 L/d, fed to the SBR and RBC. The flow rate for CWs series was 1000 L/d. Whereas, the flow rate was adjusted to be 800 L/d for the MBR. Under these operational conditions the hydraulic retention time (HRT) was about 24 h for the SBR for two reaction chambers and 18 h for the MBR. The hydraulic loading rate (HLR) for the RBC was about 0.03 m^3/m^2d and for the HF + FWS 16 L/m^2-d.

Results and discussion

The raw GW had average concentrations of 250-270 mg/l COD, 50-60 mg/l TSS, 2-3 mg/l NH_4^+-N, and turbidity of 68-70 NTU. Pollutant characteristics were in compliance with the data stated in the literature. The average effluent concentrations for some monitored parameters and the relevant average removal efficiencies of the treatment units are indicated in Figure 1.

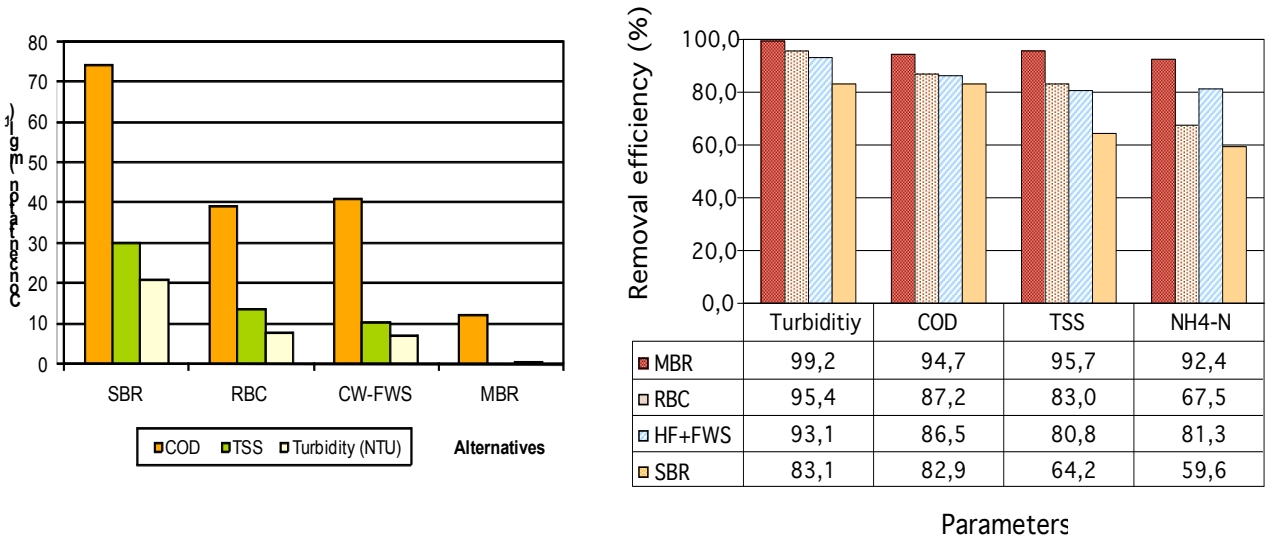

Figure 1. Performance of grey water treatment units (a) effluent pollutant concentrations (b) removal efficiencies

The results indicated that for all cases relatively high removal efficiencies were attained and among these options the best removal performance was obtained with the MBR. However, for all the alternatives at least the criteria for agricultural reuse for food crops commercially processed indicated in the EPA Suggested Guidelines (EPA Guidelines for Water Reuse, 2004) were fulfilled most of the time. Table 1 summarizes the overall results obtained from the study in terms of economic considerations and reusability of treated GW. It should be noted that the cost of the land required is not taken into account for this assessment. For this issue CWs is the most disadvantageous technical option. On the other hand, for the point of net revenue, calculated based on local electricity and water prices, CWs systems are proved to be favorable. However, it should be noted that due to evaporation in summer months the effluent flow rate was considerably reduced. To overcome the deteriorations in the effluent quality of SBR reactors installation of a filtration unit (rapid gravity filtration or pressure filter) is advisable to comply with the reuse criteria continuously. This condition is also valid for the effluent of the RBC, especially, for the large systems operating at high flow rates are concerned. It is also recommended to install a UV disinfection unit for the RBC to satisfy the microbiological criteria for reuse. Furthermore, UV disinfection may also be utilized for the effluents of FWS CWs to mitigate the risks of microbial contamination.

Table 1. Assessment of GW treatment technologies applied in this study

Parameters / GW technology	MBR	SBR	RBC	CWs
Investment cost, €/pe	645	1150	1000	1200
Energy requirement, kWh/ m^3 GW	1,7	3,8	1,2	0,02
Energy req., kWh/kgCOD removed	7,2	17,5	5,7	0,1
Operator technical level	high	high	low	low
Sludge production, L/ m^3GW-d	5	4-5	1-3	-
Area requirement, m^2/m^3 GW treated	1,0	4,0	1,8	63
Disinfection requirement	no	no (inc. UV)	yes	no
Effluent suitability for reuse,	unrestricted reuse	irrigation, with filtration	irrigation with filtration+UV	irrigation
Net revenue, €/pe-year at local conditio	24	17	39	48*

*evaporation was not accounted for CWs

Conclusions

The treatment options tried were efficient, however, optimization of the systems were not exclusively aimed throughout the study. The results, to some extent, represent design criteria and operation under local conditions with the selected equipment and liable to differ for the larger scale implementations favorably. It was experienced that the most qualified staff required technology for operation is MBR. RBC and CWs are quite advantageous for the point of operational ease. Each system designed and operated in this study possesses own advantages, however, local conditions in terms of economic, social, environmental and hygienic concerns play the virtual role for the appraisal of the most suitable technical option.

Keywords: Greywater, Membrane Bioreactor, Sequencing Batch Reactor, Rotating Biological Contactor, Constructed Wetland, Sustainable Water Management, Reuse

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