Optimization of decentralized treatment and sanitation of domestic wastewaters via constructed wetlands: The DOMUS_CW project

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Abstract
Two free surface flow CWs constructed in one Greek and one Cypriot community, were upgraded in order to serve as case studies to be further optimized via modeling. Through the systematic and detailed monitoring of the two CWs their operational efficiency was evaluated, and the response to operational factors that have not been extensively studied yet, such as supply variations and recirculation, were recorded and incorporated into the model. In addition, the effect and fate of xenobiotics, the interactions among plants and microorganisms, the toxic potency of effluents an the cropping frequency were evaluated aiming to the better understanding and thus further improvement of the operation of the systems. An exploitation plan for CW effluents and plant biomass is also proposed investigated, aiming at the recovery of water and nutrients, contributing thus to the European goals for Sustainable Development. The main outcome of the project is the creation of a generic assessment tool, a model platform via which the feasibility of CW technology application in different sites could be evaluated based on minimal initial data.

Keywords: constructed wetlands, modeling, toxic assessment, composting, anaerobic digestion

1. Introduction

A considerable ratio of the total population in Balkan and Mediterranean countries is dispersed in rural areas and organized in small communities that are often spaced apart, and therefore the management of their wastes and wastewaters in a centralized system is not feasible. Indeed, wastewater treatment via typical biological wastewater treatment plants might not be the most appropriate in the case of small communities since it has high manufacturing and maintenance costs and its presence within the community limits, is not acceptable by the residence for fear of odors and safety. On the other hand, constructed Wetlands (CW) constitute a cost efficient and highly effective practice for the treatment of domestic/household wastewaters in rural areas since they do not require complex mechanical and expensive equipment and their maintenance and operation costs are minimal. Moreover, CWs do not contribute to natural environment degradation; on the contrary they can be aesthetically pleasing and they also provide habitat for wildlife and human enjoyment, and thus can be easily accepted by the residence.

In the framework of the DOMUS_CW project two underperforming free surface flow CWs (FSFCWs), in one Greek and one Cypriot community, were modified and upgraded to serve as real scale laboratories. Based on their data a model that has been previously developed by our research group (Galanopoulos et al., 2013; 2014), is expanded taking into account operational factors that have not been extensively studied yet, such as flow rate variations and recirculation.

The ultimate goals of the study are 1. the creation and distribution of a generic assessment tool i.e. a model platform, via which the feasibility of CW technology application in different rural areas could be evaluated based on minimal initial data and 2. Contribution to the sustainability and maintenance of the CWs, by identifying solutions for resources and energy recovery in a cost-and eco-efficient manner

2. Overall approach and goals

2.1. Methodology

The methodology of the DOMUS_CW progect is schematically illustrated in Figure 1. The core of the project is the optimization of CWs performance via modeling. For that reason the FSFCWs of Ploutochori a community of the Municipality of Andrichaina/Krestena of Ilia Prefecture, Greece (CW1, Figure 2a), and at Choletria a community in Paphos Province of Cyprus (CW2, Figure 2a) were upgraded and monitored for a period of 18 months. Monitoring includes the selection of meteorological data (T, rainfall, light intensity) that highly affect CWs performance, and also water quality parameters (DO, conductivity, pH, BOD, SS, metals, chlorophyll, bacteria, bio-toxicity, xenobiotics etc), sediments and biotic parameters (plant activity and symbiotic relationships in the roots, zooplankton etc.) will be monitored weekly, in, out and along profile of CWs. Those data are necessary for understanding the mechanisms that take place along a CW and the way it responds to alterations of operational factors. Thus, factors that have not been extensively studied yet, such as

supply variations and recirculation, will be analyzed and incorporated into the model.

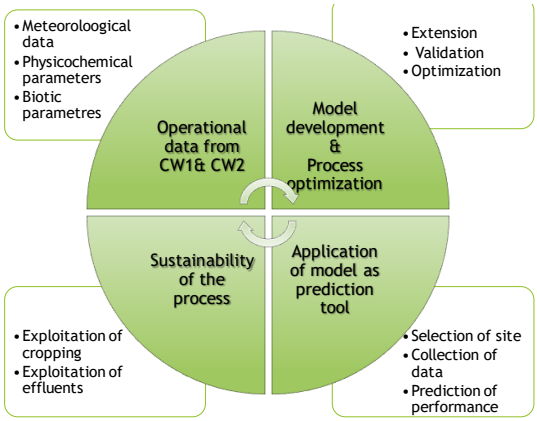

Figure 1. Schematic illustration of the project methodology

The data from CW1 were mainly be used for the development of the platform model into which all main functional and operational parameters and relevant mechanisms were be incorporated.

The upgraded platform model is used for predicting the optimal performance of both CWs and according to the outcomes, their operational strategy will be adequately adjusted. The model is also adequate for predicting the performance of different CWs and based on that, dimensioning, operational parameters and efficiency of CWs at various conditions could be determined.

The exploitation strategy of CW effluents and cropping was also investigated. As such, the exploitation of CW1 effluents for the irrigation of citrus trees and maize crops, in lab scale was evaluated in Greece, whereas in Cyprus the effluents of CW2 (not suitable land for crop cultivation) an industrial forest of 100-150 *Paulownia* trees is planned to be. Cropping exploitation is also accessed via anaerobic digestion (AD), based on Biochemical Methane Potential (BMP) tests and also for the production of organic fertilizer via composting, at lab scale.

Finally, demographic and meteorological data of different *BalkanMed countries* is planned to be collected, and recording of the current situation on the wastewater collection and treatment practices, in communities of less than 2,000 p.e will be carried out. Data will be linked to the model and thus the applicability of the proposed technology for other BalkanMed countries that could benefit from the outputs of the DOMUS_CW will be assessed.

2.2. Expected outcomes

The main outcomes of the project are expected to be

- *Improvement of the existing infrastructure* in the communities involved in the project and the optimization of the operation of the respective CWs there, with the active involvement of the communities
- *Creation of a software tool*, a platform model that will be adequate for predicting the performance of different CWs and will be freely distributed in order to be applied for the determination of best wastewater management
- *Demonstration of sustainable solutions the reuse of water* via its exploitation for crops growth and development of an industrial forest and reuse of associated natural resources.

Figure 2. Schematic illustration of the project methodology

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