

Two years monitoring of the wastewater natural reclamation system in Santa Lucía – Gran Canaria Island

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Abstract

The principle aim of this work are to define the contribution of Santa Lucia's Wastewater Natural Reclamation System on local treatment a reuse of reclaimed wastewater after two years of operation. Besides, it contributes to assess the application of sustainable and low costs solutions for subtropical areas with water scarcity and to extend its application in coastal areas. The present system offers several evident advantages such as allowing wastewater to be treated in situ without electricity costs or without of leakages of wastewater or uncontrolled dumping due to breakdown of the wastewater pipelines. In addition, this system has allowed local re-use of treated wastewater and the use of the macrophytes to obtain vegetable fibres that can be used in the confection of local handicraft. In spite of working in forced conditions (hydraulic overloads of 200% at the constructed wetlands), the system has achieved removal efficiencies higher than 80% for BOD₅, 75% for COD and 90% for TSS. Nitrogen and phosphorus removal were 50 and 30% respectively, while the abatement of faecal indicators reached 2 log units. The Santa Lucia's Wastewater Natural Reclamation System is a case of study to transfer this experience to other rural or littoral communities with lack of sanitation and reclamation systems. Moreover, the possibility of reusing treated water to obtain a zero discharge system is highly attractive in arid and sensitive zones.

Keywords: domestic wastewater; constructed wetland; vertical subsurface flow; horizontal subsurface flow; treatment performance; hydraulic overload

Introduction

DEPURANAT project – co-financed by Interreg IIIB Atlantic Arc Programme –, developed, between 2004 and 2008, several Wastewater Natural Reclamation Systems (WWNRS) in rural and protected areas in Portugal and Spain. These projects were pioneers in Canary Islands in the use of low energy cost wastewater treatment technologies for small and medium scale communities. The biggest constructed WWNRS within DEPURANAT project was the demonstrative pilot project in the municipality of Santa Lucía in the *Caldera de Tirajana*, at the southeast of Gran Canaria Island. The *Caldera de Tirajana*, in Gran Canaria Island, has complicated physical layouts and an arid climate, with mild temperatures in the winter and highly sporadic downpours, concentrated over a few days, after long periods of total lack of rainfall. The water scarcity and the existence of traditional crops such as olives, fruit trees and vegetables, together with the best palm groves of *Phoenix canariensis* on the island, offer a unique rural landscape. However, this ecosystem is extremely fragile and over-

dependent on the few water resources available. This system started to receive wastewater at the end of July in 2008. Until now, Water Department of Instituto Tecnológico de Canarias (ITC) with the Joint Municipalities of the south-east of Gran Canaria and the support of the Acciona Agua company, have carried out an exhaustive monitoring program of physical, chemical and microbiological parameters. These entities in the framework of another current project, a trans-national cooperation Programme between Madeira, Canary Islands and Azores archipelagos has achieved financial supporting of this monitoring campaign. This cooperation project, called CARMAC, is looking for sustainable solutions to preserve the quality of bath and recreational water in coastal areas. One task of CARMAC project is to assess the application of sustainable and low costs solutions in littoral areas. The Santa Lucia's WWNRS is a case of study to transfer this experience to the littoral communities with lack of sanitation and reclamation systems with the possibility of reuse treated water to obtain a zero discharge systems. This paper focus on the evolution of the system during the last two years and its contribution as a demonstrative project to disseminate these technologies in Canary Islands, not only as an isolated treatment plant to solve a local environmental problem but also as a totally integrated system into the environment, the economy and the direct participation of the local communities.

Methods

The Santa Lucía's WWNRS collects the wastewater from various rural hamlets and villages inside the erosion crater of the *Caldera de Tirajana*. The resident population is around 1,000 inhabitants and the Villa de Santa Lucía represents the most significant focus of local population. This system was designed to deal the wastewater load associated to 100 inhabitants equivalent and a daily average flow of 12.5 m³. Therefore, the system only must receive a part of the wastewater that the general pipeline habitually transports from the population to the conventional wastewater treatment plant located on the coastline, 20 km away. However, the burst in that pipeline have forced the derivation to Santa Lucia's system of all the wastewater generated in Santa Lucía. These extreme working conditions are of interest in the evaluation of the efficiency of this WWNRS, submitted to overflow and operational problems, and the benefits of mild temperatures, typical of the Canary Islands. This system has a flow-span, manually-cleaned bar screen, an old septic tank and a prefabricated Imhoff tank with 15 m³ of capacity, two parallel vertical-flow constructed wetlands (VFCW) of 150 m² each one, followed by a horizontal flow constructed wetland (HFCW) planted with *Typha latifolia* and a surface of 300 m². The whole area is complemented by a storage lagoon of treated wastewater, which may be re-used or discharged. Due to operational problems with the discharge siphon to VFCW, the water has been released at continuous flow since the system was first implemented. Generally, the VFCWs has operated in alternate mode, one VFCW was set on constant mode for at least one month, to then divert the flow towards the VFCWs in repose. At the present, the VFCWs have no macrophytes and the effective treated surface is from 50 to 80 m² by the incomplete distribution of the wastewater onto wetlands surface.

Since the WWNRS was implemented, sampling has been carried out at various points along the system. Over the period of study of two years, since 29th July 2008 to the 26th August 2010. The physical-chemical parameters measured at each sampling point were the following: BOD₅, COD, TSS, pH,

Conductivity at 20 °C, Turbidity, Total Nitrogen, Ammonium, total Nitrates and Phosphorus. The microbiological parameters evaluated were the total Coliforms and *Escherichia coli*. As the inflow before the bar screen was so variable during the days measured, to evaluate the pollutant load at the input to the system, it was considered convenient to take the inflow water to the Imhoff tank. Moreover, the quality of the effluents was analysed according to the Spanish law for reclaimed water re-use (RD 1620/2007) in order to identify its aptitude for reuse applications. Besides, important agronomical parameters were measured at the outlet, like Chlorides, Sodium, Potassium, Calcium, Magnesium, Boron, Bicarbonates and intestinal Nematode eggs. In each sample, it was gathered information from the various flow meters, which have allowed us to estimate the evolution of the average daily through-flow. The State Meteorology Agency (AEMET) was also consulted in order to chart the evolution of daily rainfall and temperatures. To study the possibility of use this WWNRS as reference in coastal areas, it has been consulted meteorological stations at sea level and sewage raw of two coastal communities have been sampled, too.

Results and Discussion

In the course of two years of monitoring, the Santa Lucía's WWNRS real operational conditions have overloaded more than twice the designed operational conditions. Although, the theoretical average daily inflow should be 12.5 m³/day, the real daily flow has been around 28.8 m³/day, with a maximum value of 65 m³/day. At the inflow to the Imhoff tank., for two years, it has been obtained an average value of 413 mg/l of BOD₅ (n=92, std. dev. = 113) and an average value of 751 mg/l of COD (n=98, std. dev.= 221)It was also obtained an average value of 299 mg/l of TSS (n=98, std. dev. = 169). The pollutant load expressed in terms of the population equivalent (pe) really handled by the system at the input to the Imhoff tank fluctuated between 175 and 250 pe with peak loads of 450 pe. The characteristics given by the inflow to the Imhoff tank allowed us to conclude, from the relative values of BOD₅/COD, that there is no problematic waste in the sewage system running into the WWNRS since all the wastewater received has been clearly bio-degradable.

The Santa Lucía WWNRS has treated more than 22,000 m³ of wastewater in two years. The performances obtained achieved removal efficiencies over 80% of BOD₅, 75% of COD, around of 90% of suspended solids, 50% elimination of nitrogen species, 30% of phosphorus and 2 log units reduction of faecal indicators (Imhoff Tank + VFCWs+ HFCW, without considering old septic tank). The characteristics measured of the effluent from the HFCW to the storage lagoon was an average value of 69 mg/l of BOD₅ (n=98, std. dev. = 44), an average value of 181 mg/l of COD (n=104, std. dev.= 72). The average value of TSS was 17 mg/l (n=104, std. dev.= 21). During these two years, the tendency of the system has been to improvement the effluent quality. The worst outflow qualities were observed in winter and spring and the best ones were registered in summer and autumn of both years.

In the first year of monitoring, the total annual rainfall was 169.5 l/m², with a maximum of 47.5 l/m²·day, and in the second year, were 612.4 l/m² and 137 l/m²·day, respectively. The temperatures registered gave a maximum daily temperatures average of 24.1°C and minimum average of 13°C. The warmest month in the period under study was July 2009 and the coldest period was between December 2008

and January 2008. The maximum daily temperature of the minimums measured, during two years, was 15°C. This data confirms that the WWNRS has not suffered extremely cold along all the testing period.

Conclusions

In general, the WWNRS performances were optimum at all levels in spite of the overload. Specifically during the second year, the implication of local authorities and local agents, like farmers and artisans, has improved the performance of the system and the exploitation of the reclaimed water and the macrophytes. It is estimated that the mild temperatures have contributed favourably to optimum reduction of contaminants. This result indicates that the required useful surface for this constructed wetland is lower than the case of systems located at other latitudes with lower temperatures. Although, the lack of respect for the design conditions of the system during operations has affected the hydraulic residence time. For example, it is estimated that the influence of the Imhoff tank in the overall wastewater treatment performance is relatively minimal since the operational hydraulic retention time is under half a day, well below the recommended levels of any standard.

As far as the possible re-uses of the treated water are concerned, the reference is the Royal Decree 1620/2007, (7th December) where the legal regimen of reuse of wastewater in Spain is established. The average content of suspended solids in the HFCW effluent is well below the maximum values allowed for most uses foreseen under the law. However, this value logically increases in the storage deposit due to the growth of phytoplankton. On the contrary, the indicator of the microbiological contaminant *Escherichia coli*, is positively influenced in the reservoir. According to the RD 1620/2007, the reclaimed water obtained from HFCW is apt for irrigation of forests, green zones and similar areas with no public access. Meanwhile, the reclaimed water from storage lagoon is apt for localised irrigation of ligneous crops impeding contact of regenerated water with food for human consumption.

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