ABSTRACT

Uncontrolled discharge of nutrient rich wastewater to the environment is a common source of pollution and it is partly responsible for the eutrophication of surface water, as well as degradation of the quality of groundwater. Constructed wetlands have proven to be an effective and affordable alternative to reduce BOD, suspended solids and even to reduce the concentration of nutrients from domestic wastewater, if the design, operation and establishment of the system meet certain conditions.

Two of the most important nutrients are nitrogen and phosphorus. To remove nitrogen it is necessary that first nitrification and then denitrification occurred. The first process is aerobic and autotrophic bacteria carry it out whereas denitrification happens in anoxic conditions by heterotrophic bacteria. Phosphorus is removed basically by precipitation with aluminium, iron and calcium.

This paper shows the removal processes of these nutrients as well as the removal of undesirable wastewater parameters through a system made up of the following components: (i) a 2-m^3 three chamber sedimentation tank; (ii) a first stage 10-m^2 vertical flow constructed wetland; (iii) three P-filter units; and (iv) a second stage 5-m^2 vertical flow CW. The pilot plant is placed in the vicinity of Århus (Østjylland, Denmark), and the study took place between October 2002 and January 2003. Furthermore, these results have been validated in an operational single household autonomous system.

In order to improve the removal of nitrogen (to complete the nitrification-denitrification process) part of the effluent volume from the system was recycled back into the sedimentation tank. The percentages recycled were 0%, 100%, 200% and 300%. Therefore, the study consisted of separate: three consecutive days grab sample campaigns, which evaluated the overall performance of the system. During all the campaigns, the wastewater treatment system operated with approximately the same inlet flow (500 l/d), while the recycled percentage of treated wastewater varied.

On the other hand, the removal of phosphorus was focused in the P-filter unit. They were filled up with calcite due to this material has a high P-binding capacity.

Results show that the system has a removal efficiency of TSS over 99%. In COD removal the performances were over 85% as concentration in all the campaigns. The effect of dilution in the wastewater was an important effect to take into account because it helped to reach high efficiencies in the processes.

The amount of dissolved oxygen was over 10 mg/l in both beds, thanks to the intermittent supply that permitted to refill them with DO, and it was lower in the sedimentation tank due to the high concentrations of COD, and the lower was the volume recycled the lower was the concentration of DO.

In the sedimentation tank denitrification occurred in all the campaigns due to existed areas where the amount of DO where low, but nitrification also succeeded in the 200% and 300% runs. In both beds, nitrification was successful in all the campaigns but denitrification also occurred. It is important to take into account the effect of temperature because Denmark belongs a cold climate region and consequently biological processes are affected decreasing their activities.

It can be concluded from the results obtained that the highest amount of nitrogen removed succeeded in the 300% run, but the optimum recycled percentage corresponded to the 100% run because the nitrogen disposed to the environment was the same in all the runs ($p=0.106$) and the 100% run was the one that needed the less amount of energy.

The phosphorus removal was over 95% while the P-filter units worked but when they lost their P-binding capacity the system was not able to remove phosphorus any more.