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Annual nitrogen mass balance in a CW receiving treated wastewater based on continuous water monitoring, sludge and plants samplings

S. Papias^a, S. Prost-Boucle^a, M. Coquery^a, M. Masson^a, M. Arhror^a, C. Boutin^a

^aIrstea, UR MALY, 5, rue de la Doua, BP 32108 - 69616 Villeurbanne Cedex, France
(sandrine.papias@irstea.fr; stephanie.prost-boucle@irstea.fr)

INTRODUCTION

Constructed Wetlands receiving treated wastewater (CWtw) are systems placed between Wastewater Treatment Plants (WWTPs) and receiving water bodies. They have recently become attractive in France under the perception that they increase water quality of the WWTP outlet. In order to assess the efficiency of these systems, a 6-years project has been launched with 3 sites (full and pilot scales). A comprehensive monitoring is carried out to understand the fate of conventional pollutants (C, N, P, TSS, etc.), micropollutants and faecal contamination.

One of the CWtw monitored, located in Marguerittes (Southern France), is a 2-ha full-size site made of 2 ponds. The fate of pollutants depends on processes occurring within the different compartments of this CWtw: (i) free water; (ii) sludge deposits; (iii) plants.

This study focuses on the CWtw performance assessment based on different methods used (including ion-selective electrodes, bathymetry and quadrats) to measure nitrogen (N) in each compartment. It gives the N mass balance over a 1-year period (2015).

METHODS

Site description

The CWtw is in operation since June 2013 and consists in 2 watertight ponds P1 and P2 in series (Fig.1). P1 receives an average of 1500 m³/d of treated wastewater from the activated sludge WWTP. This water flows into P2 before discharging to the river.

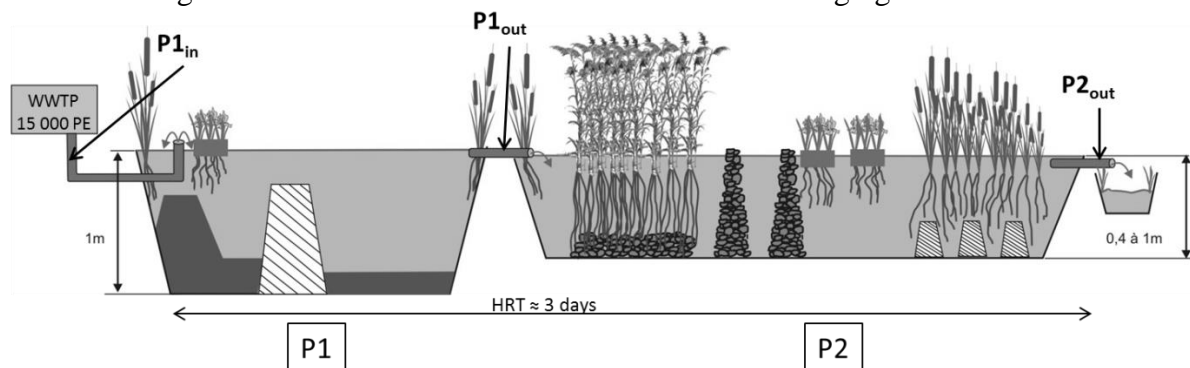


Fig.1: Schematic view of the CWtw located in Marguerittes – (not to scale)

Water balance

The CWtw has been instrumented with 3 flowmeters located in P1_{in}, P1_{out} and P2_{out} (Fig.1). Daily hydraulic loads were recorded at 5-min intervals.

Continuous nitrogen monitoring in free water

Ion-Selective Electrodes (ISE). The CWtw has been instrumented with 6 ISE probes that measure NO₃-N and NH₄-N concentrations with 5-min intervals. Combined to water flows measures and other chemical analyses, it is possible to calculate daily applied N loads.

Sampling campaigns. Three 48-h flow composite samplings were carried out during the year. Grab samples were also achieved every 2 weeks in order to calibrate and validate data gathered from ISEs. In steady-state operation, they are used to consolidate other results. The obtained results from grab and 48-h flow composite samples can be compared with the ones obtained by the ISEs.

Amount of nitrogen in the sludge deposits

A bathymetry was performed in order to measure sludge heights. Composite samples were collected at the same time. TSS, TVS, KN and TP were analysed on these samples. Thus the sludge volume and the KN storage were estimated.

Amount of nitrogen in the plants

2 sampling campaigns of both emerged (*Phragmites*, *Typha*) and invasive floating leaves (*Lemna*, *Azolla*) macrophytes were performed by using quadrats. Analyses were carried out in order to determine the amount of biomass and N that can be either stored or exported.

RESULTS AND DISCUSSION

Free water compartment

Ammonification occurs into P1. Then nitrification and denitrification are observed into P2: the successive different areas (depth, plants, rockfilters, etc.) help to create aerobic and anaerobic conditions favorable to N degradation. Overall, almost 2 t/year of TN can be removed from the CWtw, for 4 to 5 tTN incoming per year.

Sludge deposit compartment

After 2.5 years of operation, the results show a deposit mineralization along P1: TVS decreases from 39 to 14%. TN quantity stored into the sludge is about 0.25 t/y for the studied period. In contrast, there is no sludge deposit in P2.

Plants compartment

Plant samples allow to estimate N amount that could be exported. The floating plants harvests could represent 0.1 tTN/y. Moreover, TN stored into plant roots would be 0.02 to 0.03 tTN/y which is considered negligible for N balance on this site. If emerged macrophytes were harvested, they would account for about 0.1 to 0.2 tTN/y.

CONCLUSIONS

Tendencies show that a small amount of N is stored in sludge and mineralized in P1. P2 has a good potential for TN removal thanks to its configuration. Besides, even if N stored into the plants is negligible at the CWtw scale, it remains necessary to harvest regularly the floating macrophytes to maintain aerobic conditions. The results from each compartment must be linked to provide a N mass balance of the CWtw and its annual performances.

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