

USING ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT) TO EVALUATE WATER FLOW IN A VERTICAL FLOW CONSTRUCTED WETLAND.

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Abstract

Electrical Resistivity Tomography (ERT) is a geophysical technique widely used in studies related to soil water content, but its application to constructed wetlands (CW) represents a novelty. Variations of the resistivity through time in a vertical CW have been imaged in order to obtain information about the vertical water flow paths. The results show that there exists some areas of preferential water infiltration related to the point-to-point irrigation system of the CW. In addition to this, some resistivity variations have been interpreted as changes in porosity related to textural and fabric gravel variations. These results indicate that ERT is a fast, non-destructive method to adequately investigate the heterogeneity of the gravel infill and water flow paths in CWs.

Keywords: Constructed Wetlands, Electrical Resistivity Imaging, preferential water infiltration, heterogeneity

Introduction

Flow constructed wetlands (CW) is a wastewater treatment technology based on water flows through a porous material where biological and inorganic reactions transform and remove pollutants from the water. The removal efficiency depends on the hydrodynamic behaviour of the system. Thus, a non-homogeneous flow distribution defined by the installation of preferential flow paths produces a considerable variability of the hydraulic residence time, which is affecting its treatment efficiency. Electric resistivity tomography (ERT), an geophysical technique applied to investigate soils (e.g. Lillo *et al.* 2009), seems a promising tool to study the distribution of water flow in CWs, allowing the identification of preferential flow paths and stagnant zones with no water flow. The ERT method provides a 2-D image (profile) of the resistivity distribution in the CW substrate. As the resistivity is function of type of material, water content and water conductivity, information of water flow variations may be obtained by tracking the changes of resistivity in the ERT profiles through time. This work presents the preliminary results of a ERT study carried out in a vertical flow CW located at the Experimental Wastewater Treatment Plant of Carrión de los Céspedes (PECC) (Seville – Spain), managed by the CENTA Foundation.

Methods

The studied vertical flow CW consists of a substrate composed of gravel beds and isolated from the ground by an impermeable PVC liner membrane. Wastewater input is done by a distribution system consisting of 7 longitudinal pipes with holes regularly spaced. The ERT equipment used in this work was a Syscal Junior 48 resistivimeter. A unique line of electrodes with a total length of 28.2 m was installed in the CW, parallel to a longitudinal pipe, consisting of 48 electrodes spaced 0.6 m apart. A Dipole–Dipole array was selected to get the best lateral resolution, imaging the horizontal variation in resistivity associated with the water flow. The study of water flow distribution was done by comparing the spatial and temporal water content changes in the ERT line. A first resistivity profile prior to any water discharge (i.g. dry conditions during the previous 2 weeks) was obtained as reference profile. Afterwards, 7 successive ERT lapse–time profiles were acquired representing the water infiltration of 2.800 litres (7 discharges x 400 litres each, mean time interval of 45 min) in 5h 55'. Data analysis and modelling were carried out by using a commercial geophysical inversion program, Res2dinv.

Results and discussion

The successive ERT lapse–time profiles display a similar resistivity pattern which is marked by a large heterogeneity in water content along the line (Fig. 1). Thus, the profiles show two distinct parts in the CW. The largest one (A), closer to the drainage exit of the CW, is characterized by an average lower resistivity and a more homogeneous water distribution compared to the other part of the CW (B) which displays a more heterogeneous water distribution and contrasted resistivity values. In both sections, there are regularly distributed discrete zones with more water content (i.e. lower resistivity) defining preferential vertical flow paths. The non–homogeneous flow distribution in a CW may be due to: a) changes in porosity (e.g. related to size distribution, bed compaction, etc), b) presence of rhizomes and plant roots, c) biological, physical and chemical clogging, and d) system of water input. In the studied case, field observations preclude the b) and c) factors. Changes in porosity occur as function of grain size distribution, they cannot explain the whole observed pattern characterized by repeated high lateral gradients of water content. Alternatively, the discontinuous system of water input (i.g. point–to–point irrigation system) fits well to the pattern defining the zones where preferential vertical flow paths occur. In fact, those zones with low water content seem to be related to discharge holes partially occluded. However, the heterogeneity at larger scale in the CW and identified by the contrast in sections A and B could be due to the changes in porosity related to textural and fabric gravel variations in the beds. The similarity of the resistivity/water content pattern in all lapse–time profiles indicates that in each pulse the profile departs from similar water content conditions, and therefore is no water accumulation along the pulses.

Conclusions

The results from the ERT survey show that the water content is not homogeneously distributed along the vertical flow CW. Thus, two sections are recognized showing differences in average water content. In both of them, a distinct minor pattern is marked by regularly distributed discrete zones with lower resistivity. Those zones are defining preferential vertical flow paths controlled by the point-to-point irrigation system on which is based the wastewater input to the CW. Alternatively, the heterogeneity at larger scale in the CW identified by the contrast in the two sections seems to be due to the changes in porosity related to textural and fabric gravel variations. No significant differences in the resistivity pattern are observed among the ERT lapse-time profiles, which reflects that there is no water accumulation in the CW among the wastewater input pulses.

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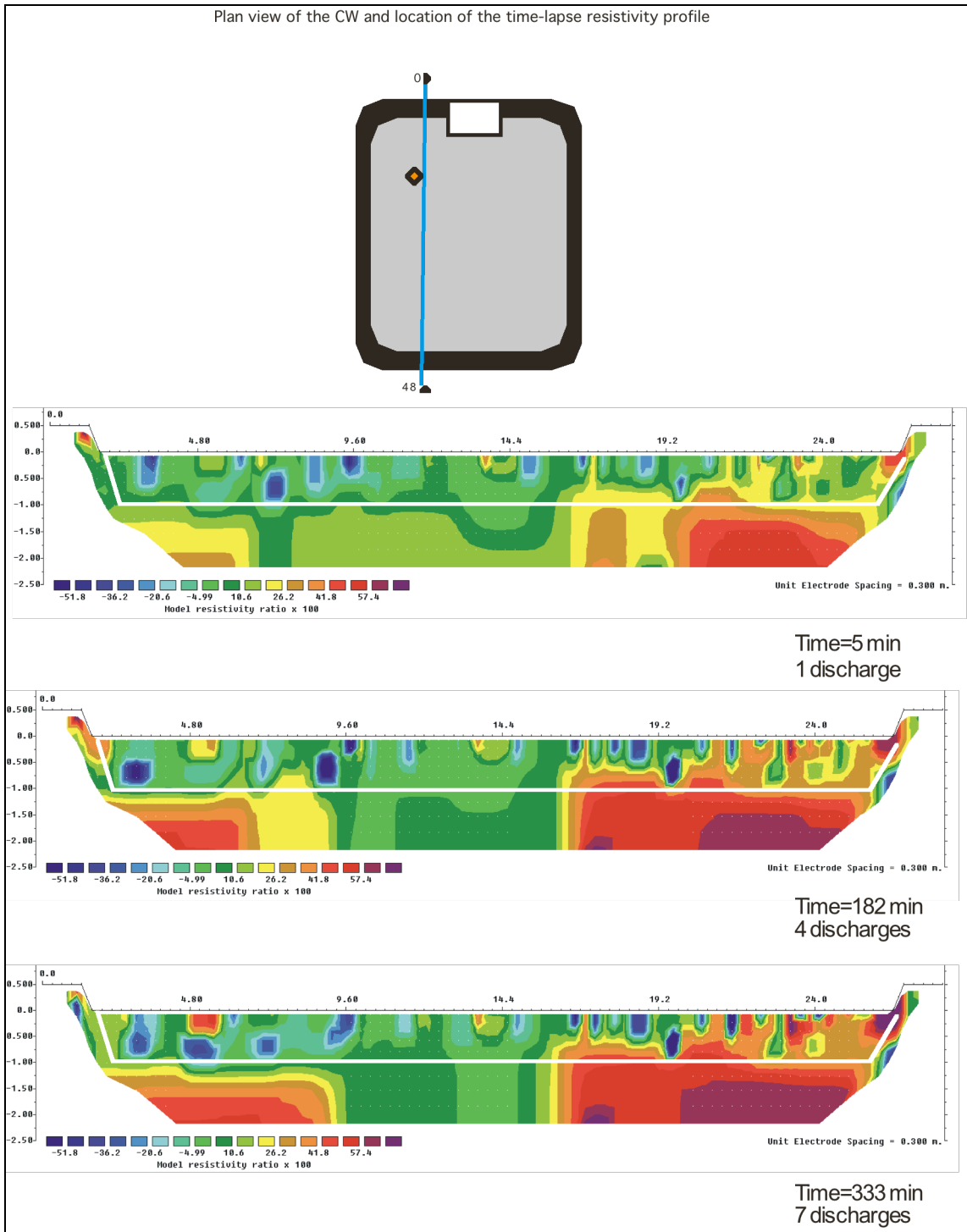


Figure 1. Plan view of the vertical flow CW with ERT line location and resistivity time-lapse profiles obtained for 5', 182' and 333'.