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Assessment of wastewater contaminants retention for a Soil-Aquifer Treatment system using soil-column experiments

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Abstract

Soil-Aquifer Treatment systems are increasingly seen as a relatively inexpensive and complementary water quality enhancement process, which may be particularly relevant in water scarcity scenarios. In this context, a set of soil-column experiments were conducted aiming to replicate the conditions of infiltration basins using soil as a depuration media for wastewater quality increment previous to managed aquifer recharge. The results showed a decrease in a set of contaminants analysed, when comparing to the inflow concentrations, showing that retention and degradation are occurring inside the experimented soil. Ultimately a set of conclusions were achieved that allowed to define the composition of a reactive layer to be installed in real scale infiltration basins that will act as a complementary wastewater treatment method.

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Keywords: Soil-column experiments; Soil-aquifer Treatment; Contaminant retention; Wastewater

1. Introduction

Soil-Aquifer Treatment (SAT) is a well-established Managed Aquifer Recharge (MAR) complementary method which main purpose is to increase water availability in aquifers and simultaneously improve its quality during the injection process. SAT-MAR methods are an important way of addressing water scarcity challenges by reusing water of impaired quality, such as wastewater, converting it into a reliable resource. This can be quite useful in water resource management, particularly in semi-arid regions, helping to face decrease of rainfall and long drought periods resulting from climate change. In this context, SAT can also present itself as a relatively simple and inexpensive complementary method of treatment, lessening possible environmental problems.

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The research presented was developed in the framework of EU 7th Framework Project MARSOL project which aims to demonstrate the reliability of MAR processes to face water scarcity problems in Southern Europe and Mediterranean regions. Soil-column experiments were conducted at National Laboratory for Civil Engineering (LNEC) using a soil collected in São Bartolomeu de Messines (SBM), one of the DEMO sites in Algarve region (Portugal) where SAT-MAR basins are to be constructed using treated wastewater as primary infiltration water source.

2. Objectives

These experiments aimed to characterize the soil behaviour at lab scale by simulating infiltration basin conditions, determining the hydraulic characteristics and contaminant retention capacities. Natural soil results obtained were compared to those obtained for a soil mixture produced in LNEC. This soil mixture purpose is to act as a reactive layer to be installed in the bottom of the infiltration basins, increasing its capacity to retain certain contaminants detected in the infiltration water, but also keeping acceptable hydraulic conductivity without hindering the water-soil interaction. The referred mixture results from a combination of easily available and inexpensive materials with the natural soil.

3. Soil-column experiments

3.1. Materials and methods

Several soil-column experiments were conducted for different time lengths, testing different methods of column assembling, thickness, soil packing, saturation conditions and injection method. This was done both for natural soil and produced soil mixture. Outflow samples were collected for the experiments that used wastewater as injection source and several parameters were analysed giving special attention to metals, nitrogen cycle components and major ions. Fig. 1 presents the soil-column apparatus. This consists in an acrylic transparent column with 5 cm diameter with enough height to allow the existence of a controlled height of water on the top of the soil, simulating the conditions of real scale infiltration basins. The material follows the DEMEAU[2] project specifications for this type of experiment.

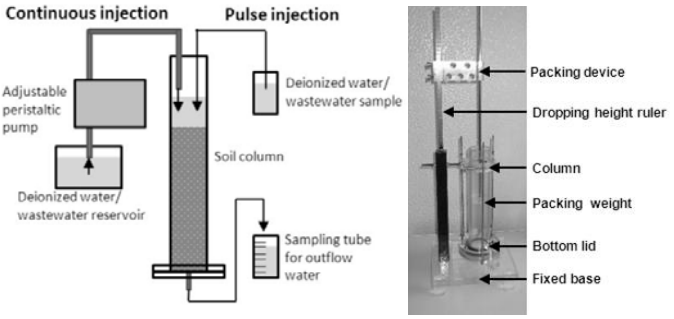

Fig. 1 – Soil-column experiments apparatus

The DEMO area natural soil that was used in experiments is a loamy sand (81.91% sand, 15.95% silt and 2.14% clay), having quartz, calcite, montmorillonite and anorthite as major mineral constituents and traces of dolomite, illite, kaolinite and hematite. It has 24.02% of carbonates percentage, low organic matter (OM) content (2.66%), average bulk density of 1.44 g/cm^3 and average porosity of 43.6%. Soil samples were collected at the approximate location of the infiltration site in the outskirts of SBM wastewater treatment plant, from a depth of 5 to 20 cm. The soil was dried at 40°C and large organic matter (roots, leaves, etc.) was manually removed.

For the soil mixture different components were considered. An increment of OM percentage, particularly in this natural soil which has low OM content, can greatly contribute to the increase of biological activity and therefore the chances of biodegradation processes to occur, as it represents a supply of dissolved organic carbon. A commercial