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UMA EXPERIÊNCIA DE INVESTIGAÇÃO EM ÁGUAS SUBTERRÂNEAS: ADAPTAÇÃO A UM MUNDO EM MUDANÇA

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Texto de apoio à Palestra

GROUNDWATER ARTIFICIAL RECHARGE SOLUTIONS FOR INTEGRATED MANAGEMENT OF WATERSHEDS AND AQUIFERS

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ABSTRACT

The objective of Gabardine project1 experiments in Campina de Faro aquifer (Algarve, Southern Portugal)was the assessment of infiltration rates in the very permeable yellow sands and to assess the unsaturated zone, and saturate zone transport parameters with a tracer test. To accomplish this purpose Areal Gordo Basins 1, 2 and 3 (Figure 1 and Figure 2) have been constructed for in situ infiltration and tracer test experiences. Besides, laboratory soil-column tests were performed in soil samples collected at the bottom of the basin. Areal Gordo Basin 2 had an area of 61 m^2. The bottom was excavated up to the third layer of yellow sandy soils at approximately 8 meters depth. The source of water for this infiltration test comes from a nearby well opened in the confined aquifer. To fulfil the objective of measuring the infiltration rate capacity, the water level in the basin was maintained constant (with a water column of approximately 90 cm) for a period of 3 days, and the infiltration rate was calculated by dividing the volume of water added by the basin area. At that time, the piezometric level and the groundwater quality parameters have been continuously recorded in LNEC4 well. The arrival time to this well was 70 hours. This allowed estimating the permeability of this sandy layer as 0.21 m/d, considering the distance of 8 meters between the bottom of the infiltration pond and the well (*i.e.* up to 1.5 m in the vadose zone + 6.5 m distance in the aquifer).
In the case study area of Campina de Faro a large amount of 5.0 m diameter wells equipped with a waterwheel are common, the so called "noras" (Figure 3). Some of them are still used for agricultural irrigation or even domestic consumption. In Areal Gordo an injection test was performed in one of those wells with the objective of assessing if they could be effective infrastructures to be used, as already available facilities for AR. Also foreseen was the assessment of the infiltration rate vs. the recharging depth of water column, ranging from the surface to water table depth. Besides recording the level inside the large diameter well the effect of the recharge in the regional water level was monitored in the nearby monitoring well. This well allowed assessing a first approach to the groundwater hydraulic conductivity and some transport parameters. The input water discharge from a close deep well was controlled during the injection periods. The main characteristics of this large diameter well are presented hereinafter: area at the bottom of the "nora" with a diameter of 5 m = 19.625 m; depth to water table at the beginning of the first test=19 m; available storage volume at the "nora" for the test=373 m^3; total well depth=24 m. The monitoring equipment used was the following: multiparametric water sensors for continuous monitoring installed in the "nora" and LNEC5 well; from the discharge well a flow meter was installed for continuously recording the discharge water volume.Three injection tests were developed. A maximum value was assessed when the water level at the "nora" stabilized near the surface (at 1.5 m depth) allowing the recharge water input of 20 m^3/h to be incorporated in the aquifer. The values vary with the water level inside the "nora" ranging from 0.25 m/d - 1.18 m/d to a maximum value of 24.5 m/d, respectively for the 1st, 2nd and 3rd test (Figure 4). As expected, it was concluded that increments in the infiltration rate are strongly connected to the increase in the water column inside the well
Another (one day) injection test was performed in an experimental medium diameter well of 0.5 m, located in Areal Gordo,

1Gabardine project results are available in http://www.lnec.pt/organization/dha/nas/estudos_id/gabardine and called LNEC6. The objective of this test was to determine the infiltration capacity and to compare it to the one assessed for the 5 m large diameter "nora". The injection test was performed during 4 hours and the depth to water table was recorded during the test. The input water discharge from a close deep well was controlled during the injection periods. Two injection discharges were considered, one to fill up the well and the other necessary to stabilize the water level: Qi_ascend=20m^3/h and Qi_descend=2.2 m^3/h. The main characteristics of LNEC6 well, opened in the unconfined sandy aquifer, are the following: section area (diameter 0.5 m)=0.196 m^2; depth to water table=18.9 m; available storage volume=3.7 m^3; total well depth=28 m. The monitoring equipment used was the same as in the previous injection test. The depth to the water table recorded in LNEC6 is plotted in Figure 5 as well as the two injection periods (4 hours total time duration). The infiltration rate was calculated by the change in the water level after the stop of the injection and during the necessary time interval to achieve the initial head, before the injection test (*i.e.*7.4 m of water level variation during 0.6 days = 11.5 m/day of infiltration rate).

In Rio Seco river bed, two 100 m^2 (20m(H)x5m(W) with 5m(D)) infiltration basins were constructed and filled in with clean gravels for AR tests (Figure 6). The main objectives of the experiment were to assess the effectiveness of this type of AR structures for surface water infiltration, including the computation of groundwater recharges rates and evaluating groundwater mass transport parameters in unconfined aquifer via the monitoring of a breakthrough tracer curve. Two concrete sections were constructed and two pneumatic gauges for river water levels control were installed, upstream and downstream of the infiltration basins, during January, 2007, in order to measure the river discharge upstream and downstream the AR infiltration basins. Tracer tests have been performed during May, 2007 (Figure 7 and Figure 8).

Results of the groundwater quality and quantity assessment recorded in the monitoring wells during the rainy months of November and December 2006, when surface runoff infiltrates in basins, show NO^{3-} concentrations strongly decreasing the same period, tending to get closer to the NO^{3-} quality value of the river water (Figure 9).

This is a remarkable fact, and of paramount relevance regarding the achievements of artificial recharge experiments towards the rehabilitation of the polluted unconfined aquifer, confirmed by LNEC 1 piezometer 2.5 m downstream of the infiltration basin.

As main conclusion, we may state that artificial recharge may be seen as one good solution aiming a scientific based adaptation to climate change and/or climate variability conditions in the near future. This technology allows the use of surplus water in wet years, so that extra supply water may be available later in dry years. As we have clearly shown in this chapter for Campina de Faro, other uses can be aimed for artificial recharge facilities, e.g. for cleaning polluted aquifers. So, the solutions proposed are worthy to be considered in implementing integrated water resource management plans, being part of a variety of solutions to minimize the water scarcity, for instance in the Algarve during severe drought situations.

Several in situ artificial recharge experiments and laboratory tests were performed in the framework of the Gabardine Project for a selected area of the Campina de Faro aquifer system. The comparison of different lithologic materials in situ and in the lab, and the assessment of artificial recharge efficiency allowed data gathering regarding performances (on rates of infiltrations) and the adequacies of the different techniques for different geological layers (Figure 10). The in situ experiences showed very favourable rates of infiltration in yellow sands, especially in the large diameter well ("nora") experiment, when infiltration rates were as high as 24 m/day. In the case of the "nora" a function of the infiltration rate vs. the water column depth in the "nora" was computed.

The aim of all these experiments was to improve the knowledge on real case studies application of different AR methodologies to assess the parameters needed to develop optimization models. The model may incorporate restrictions and parameters of the objective function with the values evaluated in the experiments, described above. The results presented in this chapter allow the selection of most appropriate AR techniques aiming the maximization of groundwater storage and/or quality improvement, while minimizing costs.

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Figure 1 –Vertical profile of lithological materials in Areal Gordo (at right) and LNEC4 well lithological column and, infiltration basin in the first layer (at left)

Figure 2 – Infiltration basin in the second layer and monitoring equipment used for the infiltration test.

Figure 3 – Injection test developed in the “nora”: water levels at the beginning and at the end of the test

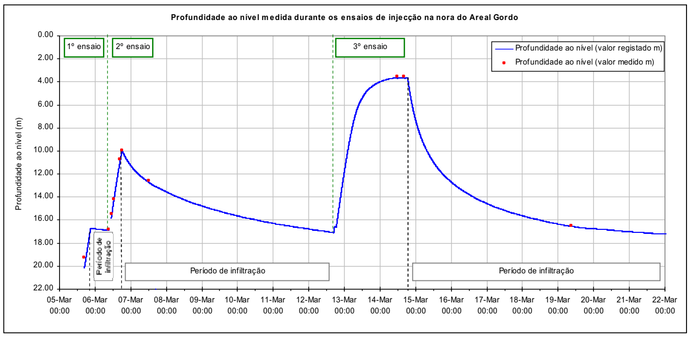

Figure 4 – Depth to the water table automatically recorded and manually measured during the injection tests performed in the “nora”

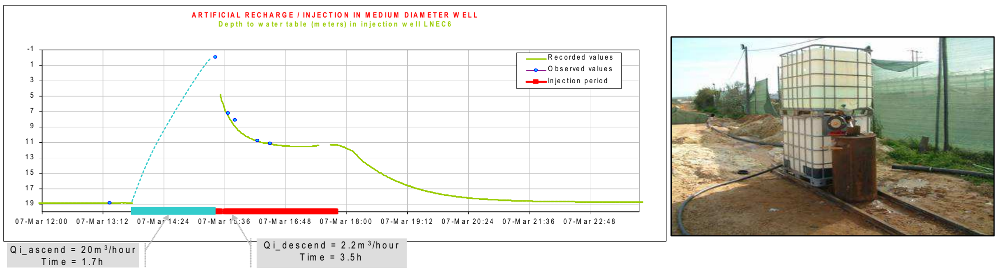

Figure 5 – Depth to the water table automatically recorded and manually measured in LNEC6 (medium diameter well) during the injection test

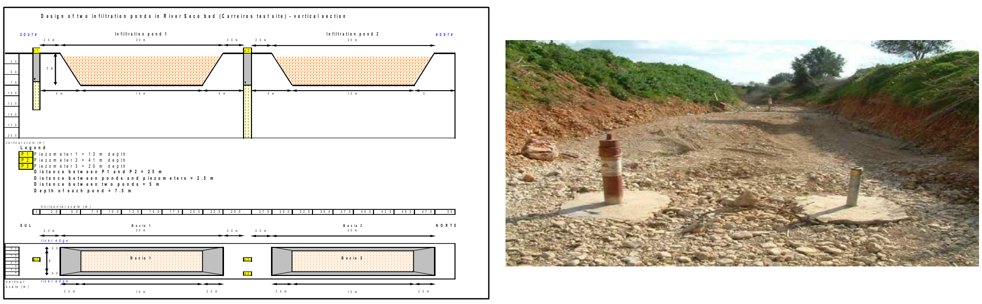

Figure 6 - Design configuration of the two infiltration basins in the river bed of rio Seco (Carreiros)

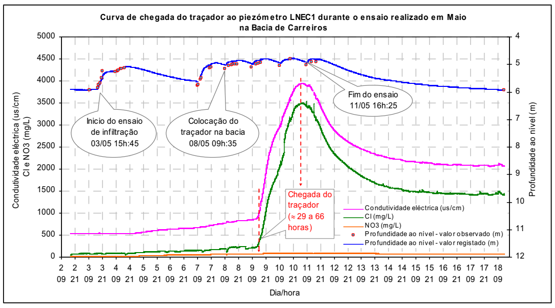

Figure 7 - Breakthrough tracer experiment curves at Rio Seco infiltration basin (Carreiros)

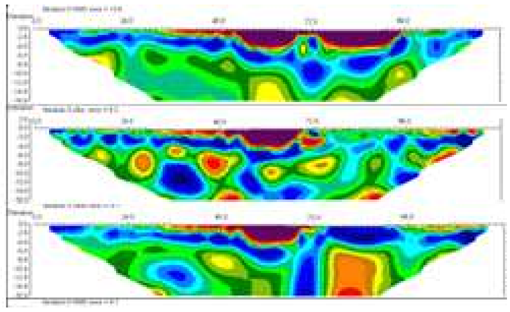

Figure 8 - Electric resistivity models obtained before, during and after the tracer test at the infiltration basin in Rio Seco, Carreiros (Mota et al., 2008)

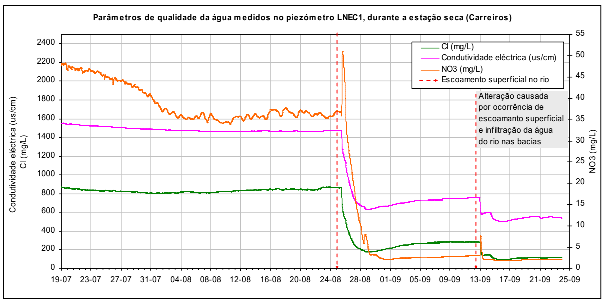

Figure 9 – Variation of the water quality in Campina de Faro unconfined aquifer, after runoff events in Rio Seco, monitored in LNEC 1 piezometer 2.5 m downstream of the infiltration basin

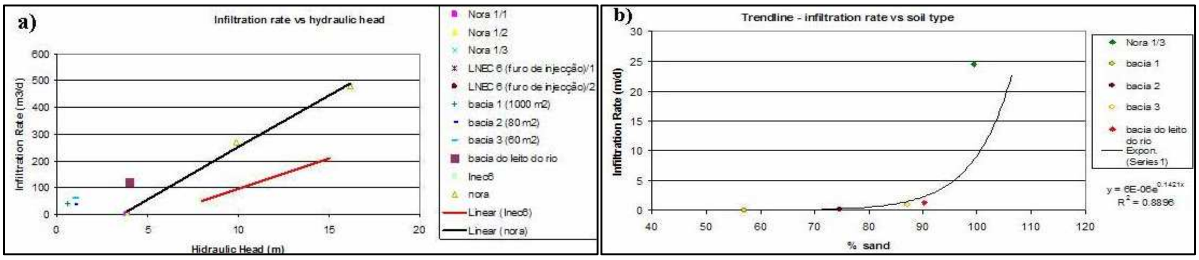

Figure 10 – a) Infiltration rates vs. the type of technology used (infiltration basins in the field or in river bed and, large and medium diameter recharge wells) ; b) Infiltration rates vs. the type of soil available in the Algarve at Campina de Faro and Rio Seco

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