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LIVRO DE RESUMOS

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NEW TEST OF THE GABARDINE INFILTRATION BASIN FOR MAR IN RIO SECO (CAMPINA DA FARO AQUIFER SYSTEM, ALGARVE)

Manuel M. OLIVEIRA[1], João Paulo LOBO FERREIRA[1], Teresa E. LEITÃO[1], Luís R.D. COSTA[2], Tiago CARVALHO[3], Rui AGOSTINHO[3], José Paulo MONTEIRO[2]

1. Laboratório Nacional de Engenharia Civil (LNEC), Av. do Brasil, 101, 1700-066 Lisboa, moliveira@lnec.pt, lferreira@lnec.pt, tleitao@lnec.pt

2. Centro de Ciências e Tecnologias da Água, Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, lrcosta@ualg.pt, jpmontei@ualg.pt

3. Terra, Ambiente e Recursos Hídricos (TARH), Rua Forte Monte Cintra 1B3, Sacavém, tcarvalho@tarh.pt, rdagostinho@tarh.pt, jmc@tarh.pt

ABSTRACT

The infiltration basin constructed in the GABARDINE project in Rio Seco stream (Algarve, Portugal) was rehabilitated during MARSOL project and a new infiltration test has been performed. The hydrogeological framework is presented and the new infiltration test is described and interpreted. The results are similar to those obtained during GABARDINE project, with calculated infiltration rates varying with water height. When the infiltration basin is saturated and the water level is more than 0.16 m above the ground surface the infiltration rate raises to values of more than 1.19 m/day. The increasing rate of water level variation registered near the end of the filling stage of the infiltration basin indicates a lower porosity stratum that clues the presence of clogged stratum near the surface.

Keywords: Artificial river infiltration; clogging; infiltration basin; infiltration rate; MAR.

1. INTRODUCTION AND ANTECEDENT STUDIES

The test is developed in the framework of the MARSOL project which is briefly presented in Leitão et al. (2015a). The main objective of the project in Campina de Faro aquifer system is to demonstrate that aquifer water quality can be improved by means of MAR. For this purpose, infiltration basins were built or rehabilitated in the Rio Seco riverbed to promote infiltration of surface water. Infiltration in typical existing large-diameter dug wells is also being considered, using rain water intercepted by greenhouses' roofs, with a complementary benefit of minimising frequent drainage problems provoked by concentrated runoff in the flat area surrounding the city of Faro.

The present test was conducted in the rehabilitated south infiltration basin constructed in 2006 during GABARDINE project (Lobo Ferreira et al., 2006). The basin filled with gravel material has dimensions of 20m long x 5m wide x 6m depth. During the infiltration test of GABARDINE, conducted on May 2007, an infiltration rate of about 1.2 m/day was calculated for saturated conditions and keeping a constant +20 cm head above the surface of the basin (Dimitriadis et al., 2007). Roseiro (2009) also refers average infiltration rates between 1.8 and 0.7 m/day estimated from the observed drawdowns in the basin after the injection period (no flow input in the basin).

2. HYDROLOGICAL AND HYDROGEOLOGICAL FRAMEWORK

The area of the river basin upstream the infiltration basin is 62.7 km^2. It spans over five groundwater bodies (GWB) represented in Fig. 1-Left.

Data measured at Rio Seco surface flow gauge station located downstream the infiltration basin (IB, see Fig. 1-Left) was analysed from 01-10-1995 until 30-09-2005. Water stage data and rating curves or stage-discharge determinations were provided by APA/ARH-Algarve. The 10 year daily data was sorted in ascending order and the cumulative distribution function (CDF) was computed (range 0-1). This was multiplied by 365 days to generate values between 0 and 365 days. The 365 day CDF (365d-CDF) gives the probability in average number of days per year that the surface flow is below a specific value. Fig. 1-Right shows the 365d-CDF curve. It can be seen that in average, the river only has flowduring 69 days per year.

The infiltration capacity values of any constructed IB may be confronted with the 365d-CDF curve enabling a perception of the available natural water for MAR and the period during which water is available.

Geologically, the IB is situated in the Quaternary alluviums near the north part of the Campina de Faro GWB, where the Rio Seco crosses the GWB downstream. Accordingly with the well perforation conducted during the GABARDINE project (Fig. 2), the alluviums are composed of very low permeability 6 m thick clays with gravels; below these alluviums appear 10 m thickness Upper Miocene formations, composed of sand and muscovite; these formations are separated by a 2 m low permeability to impervious clayey sand with ferromagnetic materials from a confined older Miocene formations composed of sands, sandstone and limestone with fossils. During the construction of the IB, located between wells LNEC1 and LNEC2 (Fig. 2) the 6 m clay with gravels formation was removed so that infiltrating water could reach the sandy aquifer below.

As referred by Almeida et al. (2000) flow in the Campina de Faro GWB is divergent towards SE and SW from a central zone, in accordance with the hypothesis of natural recharge of the system from the Jurassic limestones that contact the system in the North and also from the Rio Seco stream. Thus the location of the infiltration basin is adequate as a source of fresh water for the GWB.

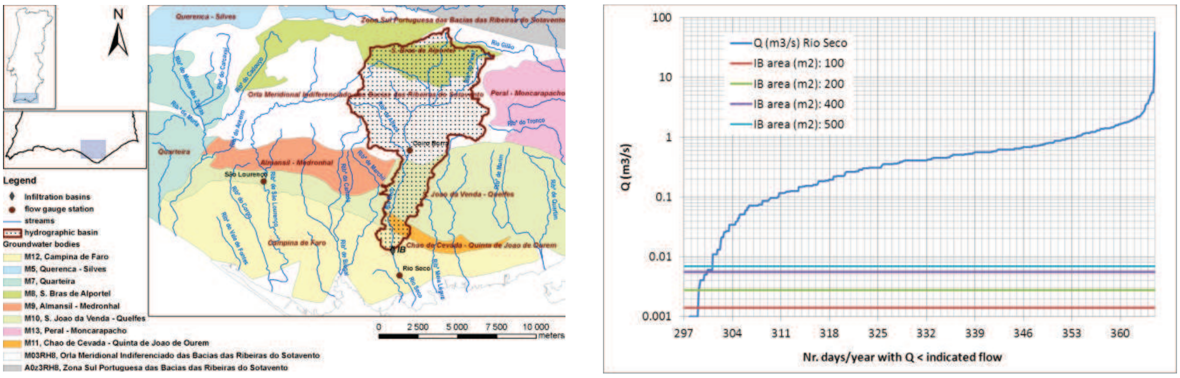


Fig. 1. Left: River basin upstream Rio Seco MAR facilities and groundwater bodies; Right: River flow cumulative curve and infiltration capacity of area dependent infiltration basins (Oliveira et al., 2015)

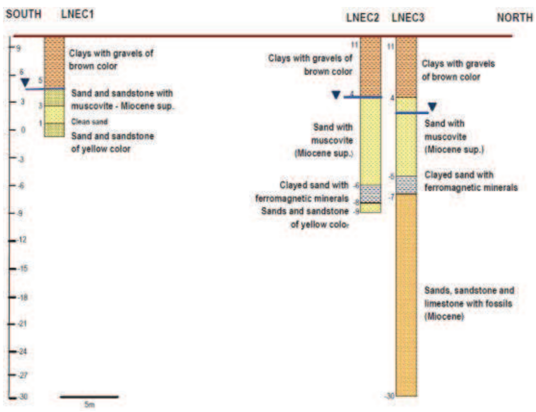


Fig. 2. Lithological characteristics of the Rio Seco riverbed where the IB is installed (Lobo Ferreira et al., 2006)

3. DESCRIPTION OF THE TEST

A new infiltration test, developed in the framework of the MARSOL project, took place on 1 July 2014 in order to identify different infiltration conditions and the possible clogging effect since May 2007. The new test may be divided in the 4 stages depicted in Table 1. Leitão et al. (2015b) presents a more detailed description of the test.

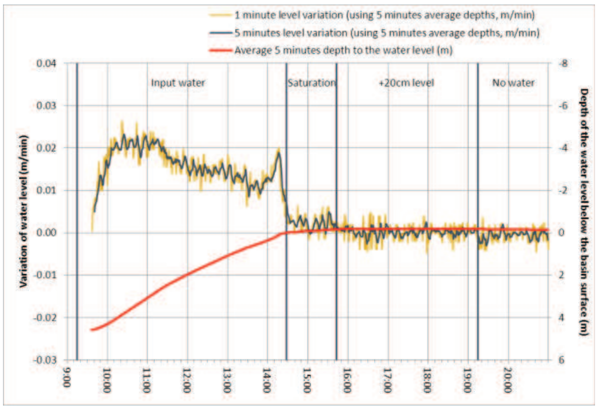
The injection flow rate of the test was 18 m^3/h with source water pumped from the underlying confined Miocene aquifer. After saturating the basin with water, a constant level of about 20 cm above the surface of the IB was kept constant diverging the surplus water to a discharge point downstream the river. The inflow to the IB was calculated by subtracting the ouflow from the original flow (18 m^3/h) during steady state conditions.

Monitoring was performed during and after the test, using automatic probes for water pressure, temperature and electrical conductivity, measuring every minute. These probes were installed in the piezometers and in perforated tubes placed within the basin. Manual measurements were also taken for control.

Levels showed oscillations of up to 4 cm between consecutive records. In order to decrease this oscillation, a 5 minute centred moving average was calculated. The result is shown in Fig. 3-Left. The levels variations were then calculated, and a second smoothing process was applied by considering the 5 minutes level variations. These are also shown in Fig. 3-Left. The same figure also represents the stages referred in Tab. 1

Tab. 1 – Discharge control during the infiltration test of 01-July-2015

Stage	Time	Description
1 – Filling the IB	9:15 – 14:28	Water input into the infiltration basin until saturation
2 – Increasing level above IB	14:28 – 15:43	Raising the level from 0 cm till 20 cm above the infiltration basin surface
3 – Keeping 20 cm level above IB	15:43 – 19:15	Keeping the water level at 20 cm head above the infiltration basin surface
4 – No water input	19:15 – 21:25	No water input in the infiltration basin and measuring water level drawdown



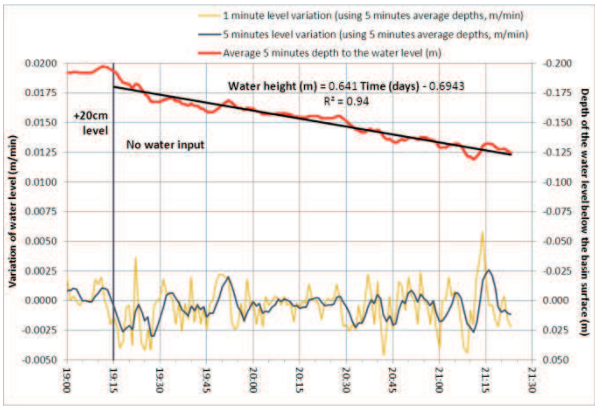


Fig. 3. Left: 5 minute moving average depth of the water level below the basin surface, and 1 minute and 5 minutes average variations of the water level. Right: Detail of the “No input water stage” and linear fit between water level and time (Leitão et al., 2015b)

Filling stage: During the filling stage, several behaviours can be detected concerning average level variations: (1) Initially, there is a constant increase in the rate of the water level variation in the IB; this may be related with an increase in the intersticial velocity due to the increasing water content in the unsaturated IB; (2) Then there is a quasi-stabilisation in the water level variation; this can either be related to a stabilisation of the intersticial velocity inside the IB without infiltration below the bottom of the IB, or an equilibrium between these two processes; (3) A new period occurs in which the rate water level variation decreases; this may be explained by the increase of the water level inside the basin, promoting higher infiltration rates below the IB and a correspondant reduction of the the water level variation rate; (4) With the approximation of the filling of the IB, the variation on water level suddenly increases; this may be related to the proximity of the ground surface (between 33 cm below ground and 9 cm below ground), that can be slightly more compressed and with less porosity due to the rehabilitation of the basin or clogged due to past infiltration processes; (5) Finally, near the end of the filling period, the rate of the water level variation decreases with time; this should be related with the transition to the open air, where there is a reduction of the solid phase and an increase of voids.

Increasing level above infiltration basin stage: This situation is quite adequate to infer the infiltration rate below the IB by the difference between water input and the variation of surface storage above the ground. Total input water during this 75 min period was 22.5 m^3. The variation of surface storage necessary to increase 0.163 m of the water level (instead of 0.20 m) is 16.3 m^3. This represents an infiltration of 6.2 m^3 of water during 75 minutes or an average infiltration rate of 1.19 m/day. However, for level change rates observed during higher water level periods, the infiltration rates increased to more than 2 m/day.

Keeping 20 cm level above infiltration basin stage: Equilibrium between levels and water leaving the basin was considered achieved for an average level of +0.189 m above ground (instead of +0.20 m) and a rejected discharge of 13.69 m^3/h. For this level water input to the IB was determined as 4.29 m^3/h representing an average infiltration rate of 1.03 m/d.

No input water stage: This may be the best situation to determine the infiltration rate of the IB. After water input is stopped the variation of the level as a function of time, while the level is above the ground surface, is a direct estimate of the infiltration rate. It was possible to fit a straight line between levels and time (Fig. 3-Right); the 0.64 m/day slope of this line represents the average infiltration rate. However, if one considers the initial level variations after stopping inputting water, infiltrations rates would be as high as 3.6 m/day when the water level is 0.183 m above ground (as inferrible from Fig. 3-Right). Mean infiltration rate would fall to 0.78 m/day when the water level is between 0.155 m and 0.120 m above ground.

4. FINAL REMARKS AND CONCLUSIONS

The test aimed the determination of the basin's infiltration capacity. Different stages of the test allowed different estimates as summarised in Table 2. The infiltration rate varies with water height in the infiltration basin. When the basin is full and the water level is more than 0.16 m above the ground surface the infiltration rate can rise to values from 1.19 m/day to 3.6 m/day. For lower water height values, the infiltration rate may be as low as 0.64 m/day and these values may become lower with decreasing water height. These values are in accordance with those determined during the GABARDINE project.

Tab. 2 – Infiltration rate as determined using different stages of the infiltration test in the GABARDINE basin

Period of the test	Methodology	Infiltration rate
Increasing surface storage above infiltration basin	difference between water input and the variation of surface storage above the ground	1.19 m/day
Keeping surface storage above infiltration basin	control outflow discharge to the river so that the water level above ground surface of the infiltration basin could be kept at an approximated value of +20 cm	1.03 m/day
No input water	slope of level drawdown vs. time linear fit	0.64 m/day
	relation between long term level decrease and time	0.78 m/day

Concerning clogging the increasing rate of water level variation recorded near the end period of the filling stage may be an indication of a clogged stratum inside the infiltration basin. This stratum is located between 33 cm and 9 cm below ground. However, when looking to the infiltration rates data the results were very close, hinting that the clogging in the basin can easily be removed with a mechanical flattening operation.

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