USING THERMAL MODELLING TO CHARACTERIZE THE GROUNDWATER DISCHARGE TOWARDS A PERMANENT POND (DOÑANA NATIONAL PARK, SPAIN)

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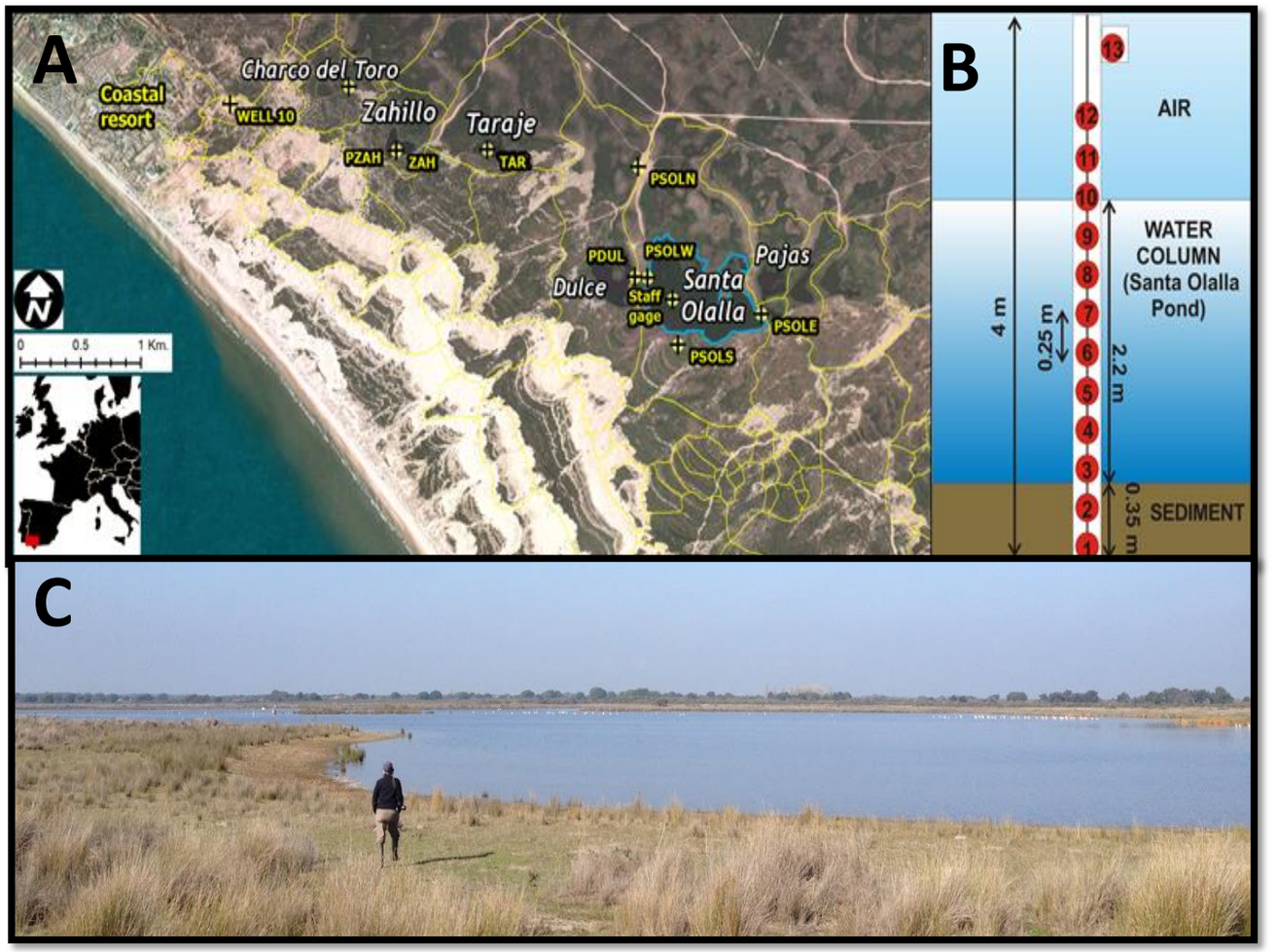
1. Introduction

- Doñana Biological Reserve (68 km^2) is located in Huelva province (southern Spain), where several ponds are found
- Doñana Aquifer (3,600 km^2) mantain the hydroperiod of such ecosystems
- Santa Olalla pond is the largest one (25 ha) and the only with permanent hydroperiod



A) Study zone B) Schematic intallation of the temperature sensors in Santa Olalla pond B) Santa Olalla pond from the East side (December 2016)

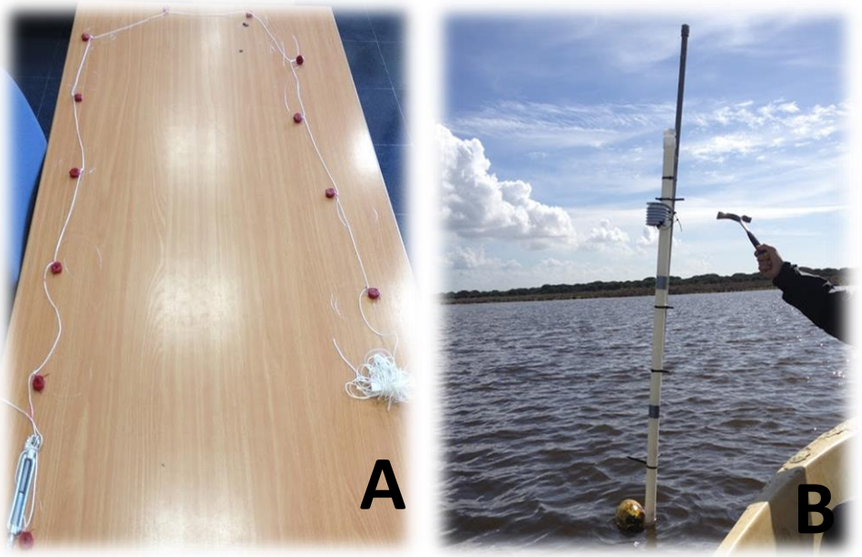
- The objective of this study is to estimate the groundwater discharge from the sand aquifer to Santa Olalla pond by analysing temperature data using a numerical water and heat transfer model

2. Methodology

- 12 autologging temperature sensors (Maxim, iButtons DS1922L-F5), with a separation of 25 cm among them, were installed inside a PVC tube in Santa Olalla pond during three months (February 14 th to May 15 th, 2017). They were programed to record temperature data hourly

- Software 1D-Temp-Pro was used for the analysis of one-dimensional vertical temperature profiles which numerically solves the flow and heat-transport equations

- Water balances (BD= E – P + ΔS) were used as complementary research methods to interpolate the flow rates estimated by the thermistors

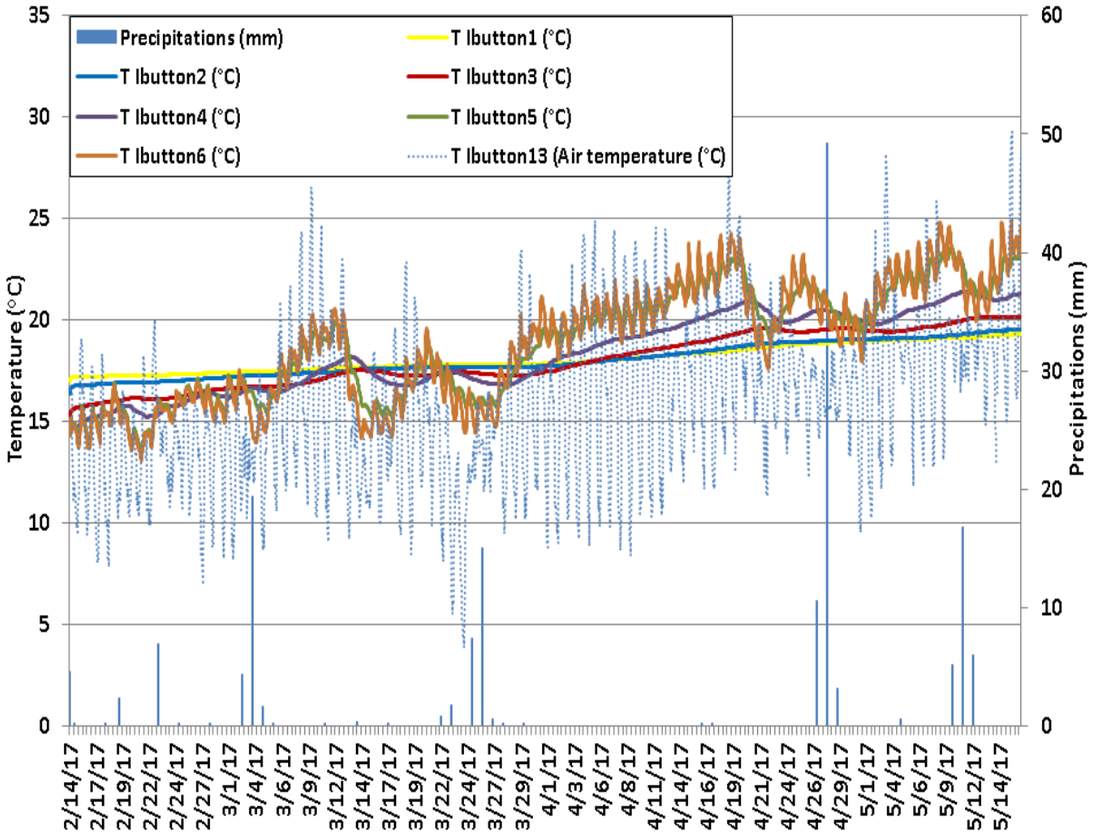


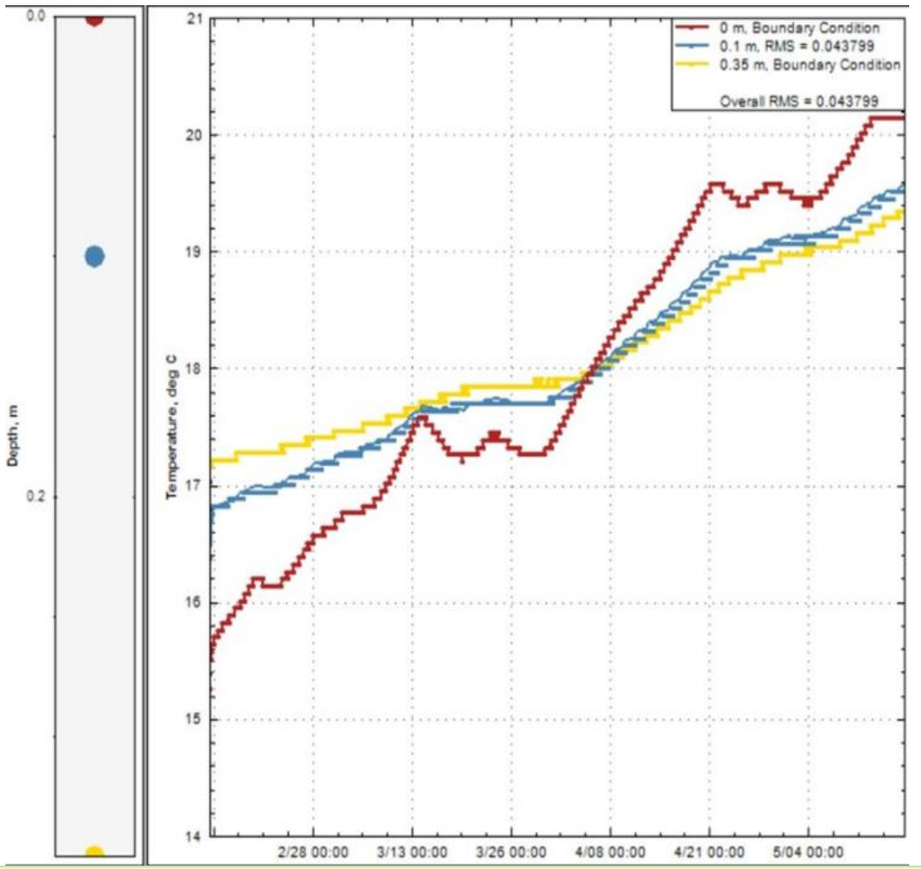
A) Chain of sensors prepared to be installed. B) sensors installed inside a PVC tube in Santa Olalla pond

Modeling conditions 1D Temp PRO V.2	
Porosity Φ_s	0.35 (m^3/m^3)
Thermal conductivity (full saturation) λ_e	2 W(m°C)
Sediment heat capacity Cs	$2 \cdot 10^6$ J/(m^3°C)
Dispersivity α	0.01 m

Parameters introduced in 1-D Temp Pro V-2.

3. Results





- The temperature recorded by IB1 and IB2 (installed 0.35 m and 0.1 m respectively below the pond bottom) show almost no daily oscilations. IB3 and IB4, installed 0.15 and 0.4 m over the bottom illustrate a higher dependence on air temperature. Finally, IB5 and IB6, at 0.65 and 0.9 m over the bottom pond, record daily temperature oscilations. The water level in Santa Olalla pond at the beginning of the study period was 1.6 m and at the end of it 1.7 m
- We used IB3 to set the boundary condition at the sediment-water interface and IB1 to set the lower boundary condition in the sediment. Finally, bottom conditions were stablished by IB2

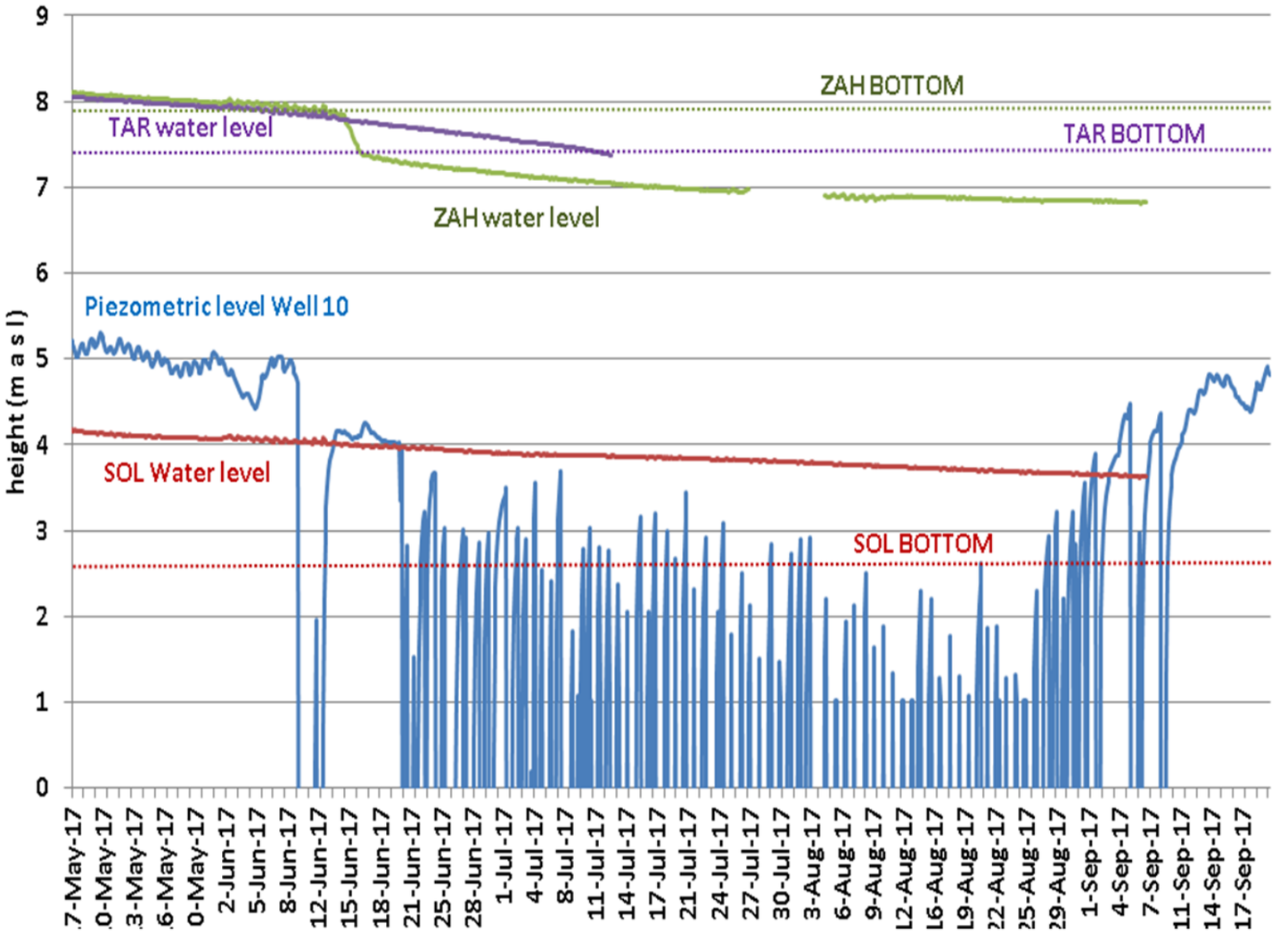
4. Discussion

Groundwater discharge in Santa Olalla pond has been studied previously by several authors (Manzano *et al.*, Rodriguez Rodriguez *et al.*, 2017, Rodríguez-Rodríguez *et al.*, *in press*, Sacks *et al.*, 1992) . The volume of groundwater discharged estimated was 0.36 x 10^3 m^3/year with the water balance equation.

The steady temperature values registered by the thermistors beneath the bottom are in accordance with temperature of the groundwater, which is constant. Anyhow, the discharge result given by the thermal method (0.6 m/d) seems to be an overestimation of the actual groundwater discharge produced in Santa Olalla pond.

The specific groundwater flux calculated by the water balance was 0.005 m/d. This fact reveals that aquifer discharges to this water body heterogeneously: the center of the pond (also its deepest area), where the temperature sensors were installed, seems to be one of the areas where more water is discharged.

4. Discussion



It can be noticed oscilations of some centimeters on the water level of Zahillo (ZAH) , Taraje (TAR) and Santa Olalla (SOL) ponds from 1st to the 13th of June. These oscilations coincided with a decay on the piezometric level in Well 10, located at the coastal resort.

The groundwater abstraction rights for urban water supply at the coastal resort are capped at 2.75 millions m^3 per year, although some authors (Dimitrou et al., 2017) state that real consumption is higher. This water is capted by five wells located in the coastal resort.

5. Conclusion

- The results given by the thermal method (specific groundwater flux:-0.6m/d) constitute a further advance in the knowledge of the hydrogeological functioning of Santa Olalla pond, and more specifically, it is an evidence about the existence of areas within the pond with high groundwater discharge.

- There is evidence of groundwater relation among the pumping area at the coastal resort and the ponds situated at Doñana Biological Reserve, as piezometric level depletions on the former are sometimes translated into centimetric level oscilations in the ponds.

- Further studies need to be done to specify the hydrological functioning of crucial water bodies such as Santa Olalla pond, since the existence of many biological communities depend on them.

6. Bibliography

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