Project: “Monitoring Sea-water intrusion in coastal aquifers and Testing pilot projects for its mitigation” Interreg CBC Italy-Croatia 2014.-2020.

Priority Axis: Safety and resilience

Specific objective: Improve the climate change monitoring and planning of adaptation measures tackling specific effects, in the cooperation area

(D_4.1.2) Report on the test results

Work Package 4: Testing

Activity 1: Neretva coastal plain

Partner in charge: PP4 (UNIST-FGAG)

Partners involved: PP4 (UNIST-FGAG), PP5 (CROATIAN WATERS), PP6 (DUNEA)

Final version

Public report

September, 2022

Contents

Aims and scopes

The report is made to show test results of the modelling activities done on Croatian project site river Neretva delta as an activity proposed by the project: “Monitoring Sea-water intrusion in coastal aquifers and Testing pilot projects for its mitigation” Interreg CBC Italy-Croatia 2014.-2020.

Report shows results of the numerical modelling for dry/salt and wet/fresh hydrologic conditions. Model steady state results shown in continuation were made to show main sources of salinity during different periods and were not used as initial condition for modelling existing state in River Neretva Valley.

Settings for wet hydrologic conditions for the numerical model

In the area of River Neretva Valley, it is possible to distinguish two different hydrologic periods of the year. First one is wet (rainy) period of the year and second is dry (salt) period of the year.

Hydrologic conditions for wet period are shown on next figures. As show on Figure 1 there is a high amount of precipitation. Rain intensifies by the end of the month (after 600 hours for the model). Figure 2 and Figure 3 show boundary conditions for the sea, River Neretva and Mala Neretva during wet period. On Figure 3 it is possible to notice change in management regime during high precipitation values.

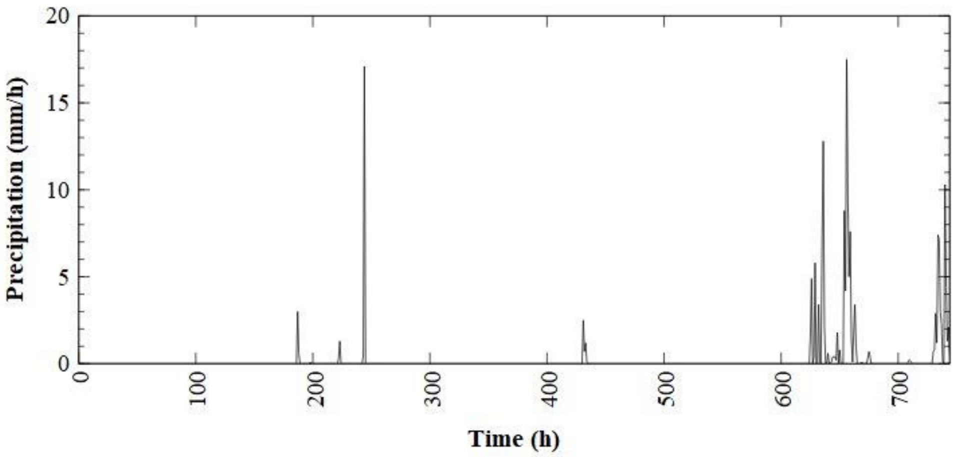

Figure 1 Amount of precipitation for wet period

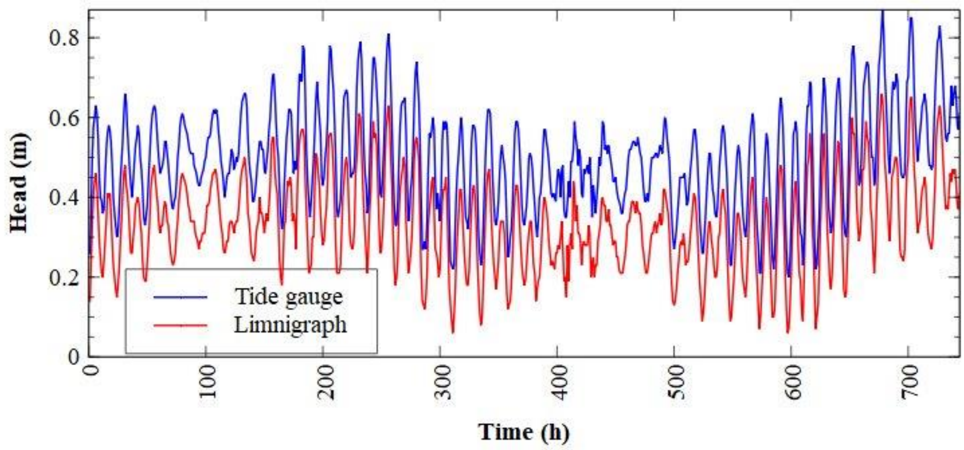

Figure 2 Tide gauge and limnigraph readings for wet period

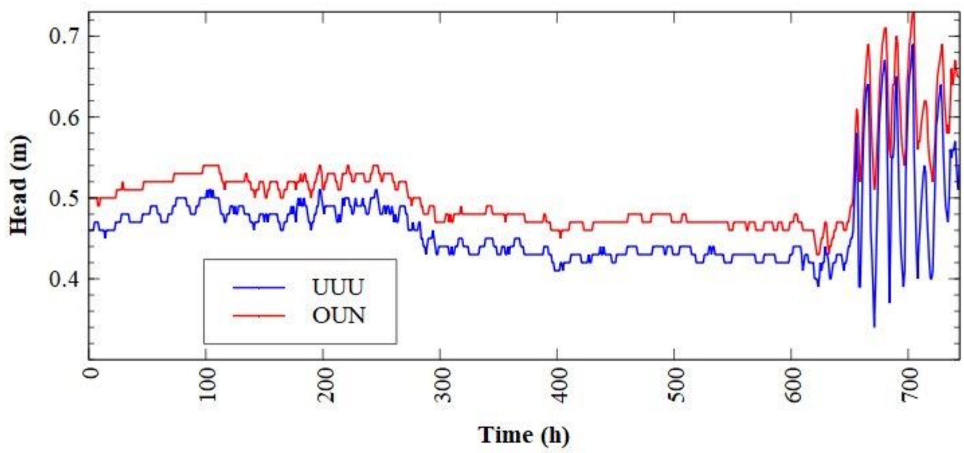

Figure 3 Head readings for OUN and UUU (Mala Neretva) for wet period

Settings for dry hydrologic conditions for the numerical model

Hydrologic conditions for dry period are shown on next figures. As show on Figure 4 there is a no precipitation during dry period. Figure 5 and Figure 6 show boundary conditions for the sea, River Neretva and Mala Neretva during dry period.

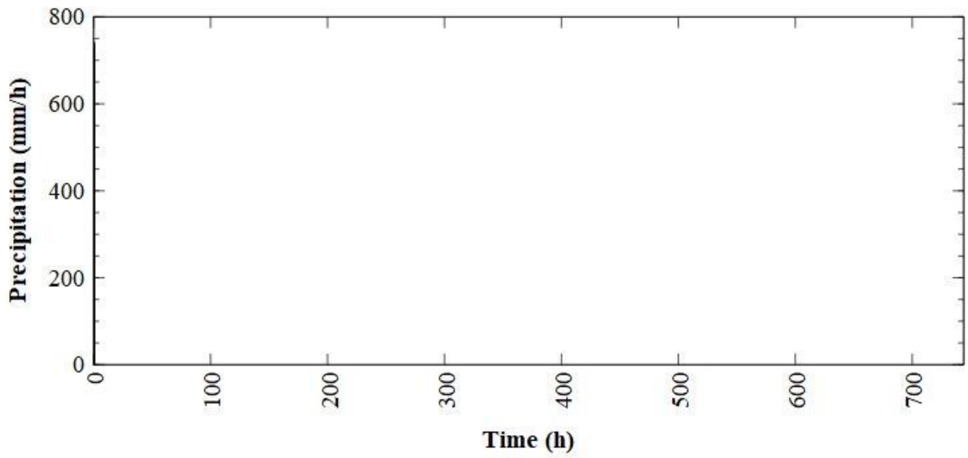

Figure 4 Amount of precipitation for dry period

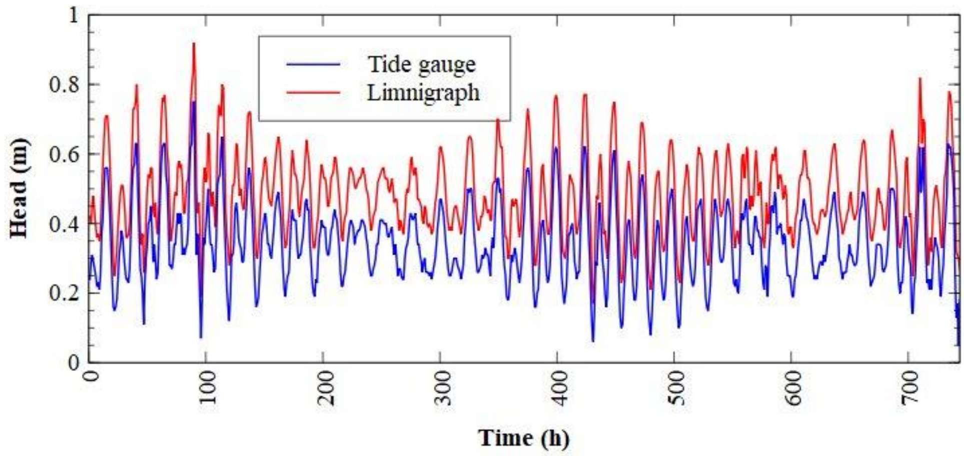

Figure 5 Tide gauge and limnigraph readings for dry period

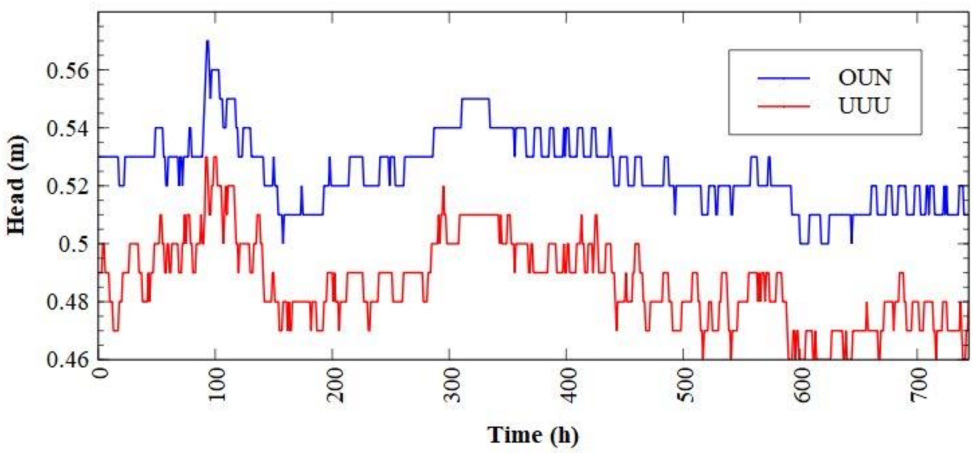

Figure 6 Head readings for OUN and UUU (Mala Neretva) for dry period

Spatial-temporal analysis of salinity fields

To gain insight into change in salinity fields caused by different transport boundary condition for River Neretva, two different flow and transport steady state simulation were obtained. Those two simulations present scenarios for dry and wet period. Aim of these scenarios was to demonstrate main directions of entry and spread of saltwater in River Neretva Valley.

Transport boundary conditions for the sea was the value of 36 g/l and dC/cX≠0, dC/dZ≠0 for Opuzen, Mala Neretva and channels.

Boundary conditions for River Neretva were:

a) Wet (rain) period – River Neretva concentration 0 g/l in all layers
b) Dry (salty) period – River Neretva concentration 36 g/l in all layers

Steady state models were gained for this two scenarios. For every scenario it took between 200 and 500 years for the model to gain steady state. Steady state values were confirmed when there were no changes in head or concentration values during the time. For all simulations horizontal hydraulic conductivity for the layer of clay was set on 0.0005 m/s while the geological characteristics for the rest of the soils were sat as in a model of existing state. Increase in horizontal hydraulic conductivity for the layer of clay was necessary for steady state achievement and it increases salt water intrusion giving the model results with increased values of concentration.

Flow boundary conditions for coupled steady state simulation were mean values of determined boundary condition values. Flow initial condition for coupled steady state simulation were head results of flow steady state simulation.

Transport initial condition for coupled steady state simulation was concentration value of 0 g/l for the whole area of the model.

Figure 7, Figure 8 and Figure 9 show transport steady state results for wet period. The only source of salt water intrusion is a sea with concentration of 36 g/l. Impact of channel Jasenska and Mala Neretva in mitigation of salt water intrusion is noticed in surface layer.

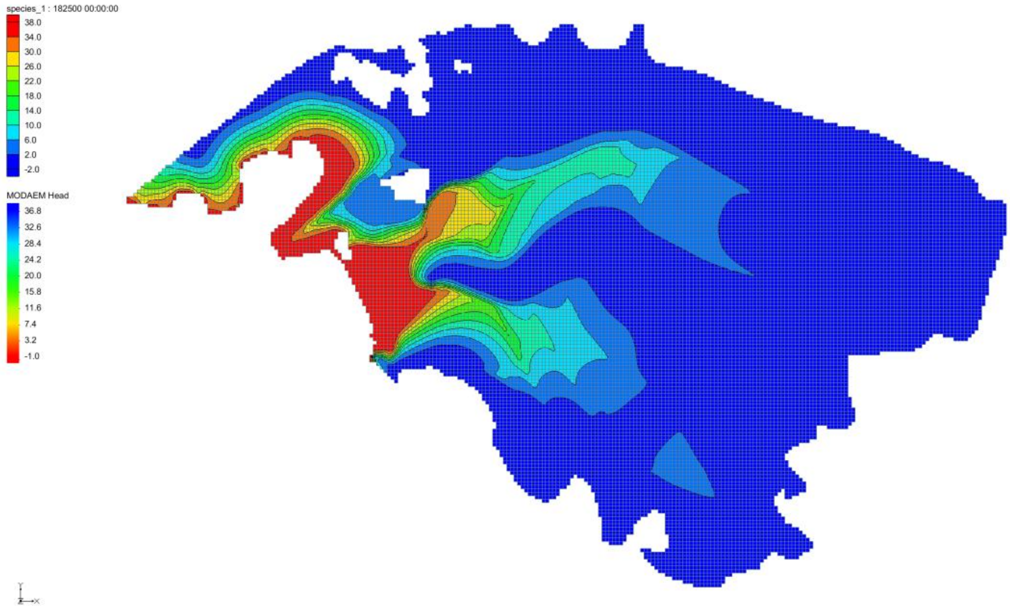

Figure 7 Salinity field for wet period in surface layer

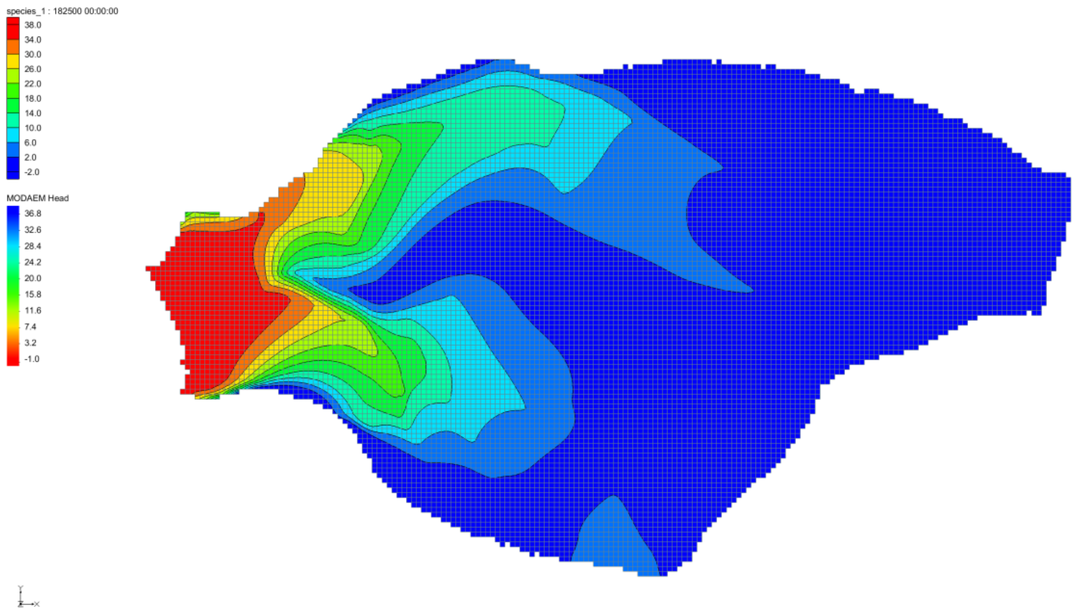

Figure 8 Salinity field for wet period in gravel layer

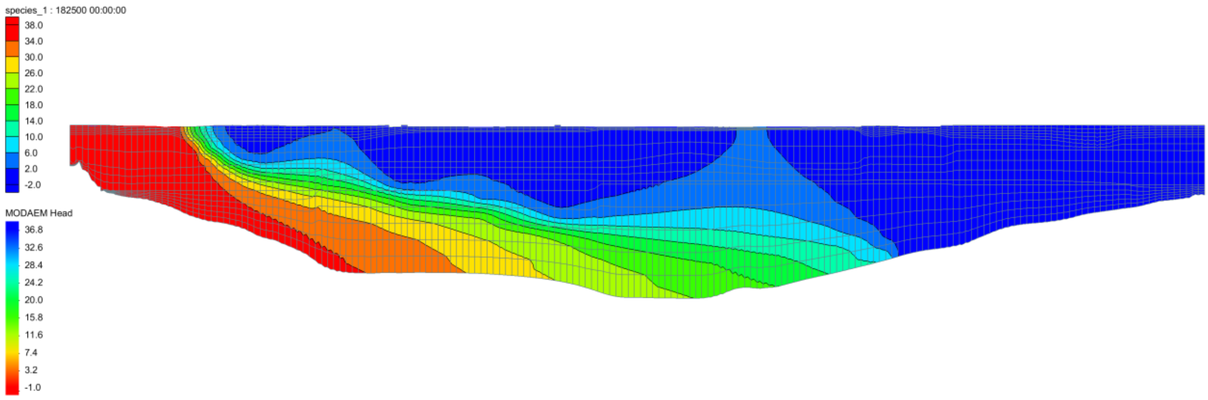

Figure 9 Cross-section of salinity field for wet period

Figure 10, Figure 11 and Figure 12 show transport steady state results for dry period. Sources of salt water were sea and River Neretva up to Opuzen with concentration of 36 g/l. Impact of channel Jasenska and Mala Neretva in mitigation of salt water intrusion is noticed in all layer due to increase of hydraulic conductivity in the layer of clay.

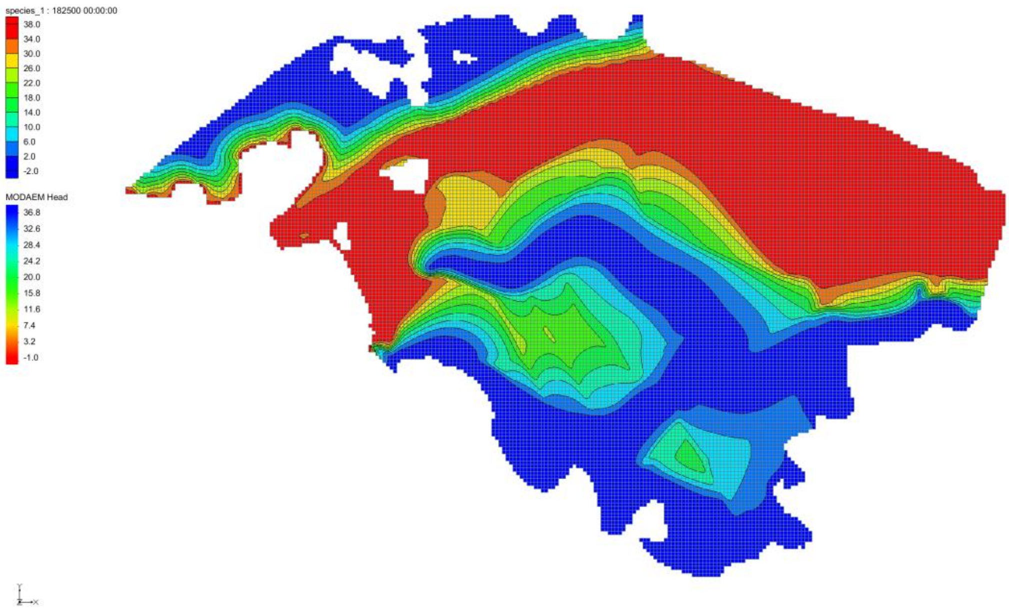

Figure 10 Salinity field for dry period in surface layer

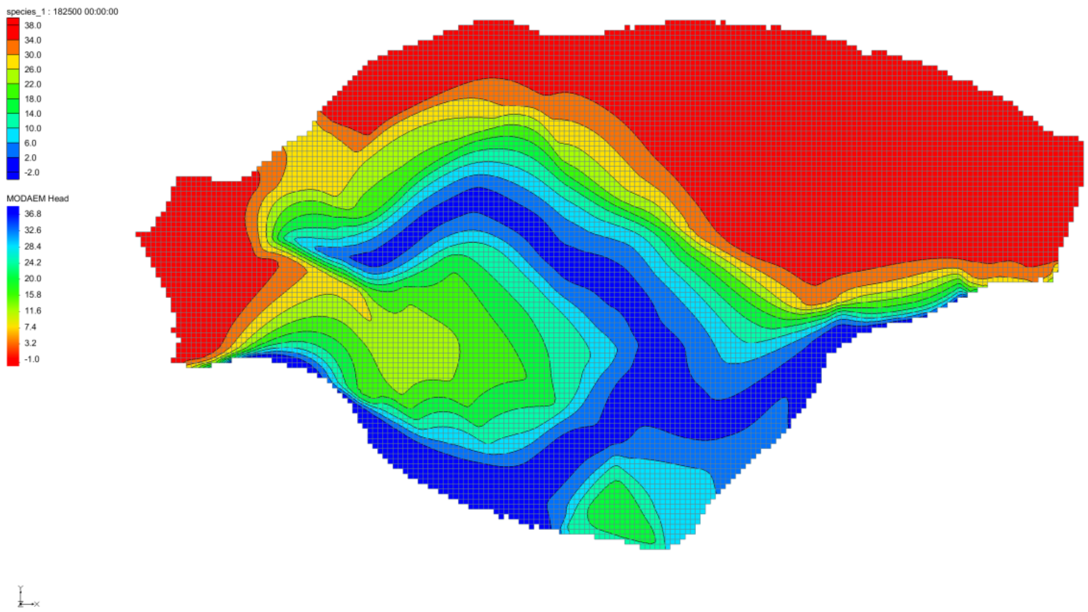

Figure 11 Salinity field for dry period in gravel layer

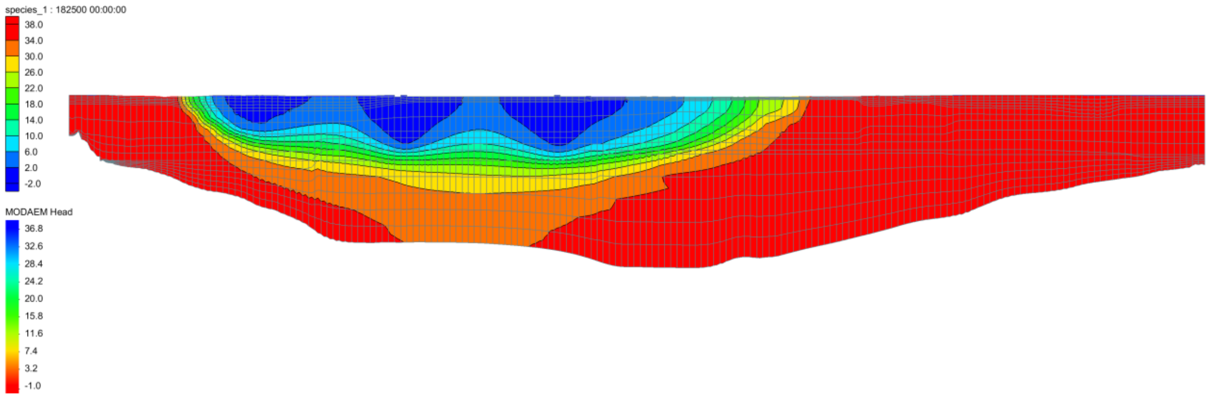

Figure 12 Cross-section of salinity field for dry period

From the spatial distribution of the salinity in the model it was possible to conclude that summer (dry) period is untoward period for the modelling. Concentration values are higher in the whole area of the model and larger area of the model is influenced by saltwater intrusion. These two simulations were made to show main sources of salinity during different periods and were not used as initial condition for modelling existing state in River Neretva Valley.

Model results for wet period

Next figures show model results for wet period. As show on Figure 1 rain was intense by the end of the month and in the model those variations are visible. For all piezometers it is possible to notice leap in average head values during rainy period (after 600 h on the figures). As shown on the figures modelled values follow measured values quite well and don't show deviation during intense rain periods.

On Figure 16 and Figure 21 change in concentration during wet period is shown for shallow and deep piezometers separately. There is leap in measured concentration values for shallow piezometers. Modelled concentration values are constant and rain periods don't affect them as much as measured concentration values.

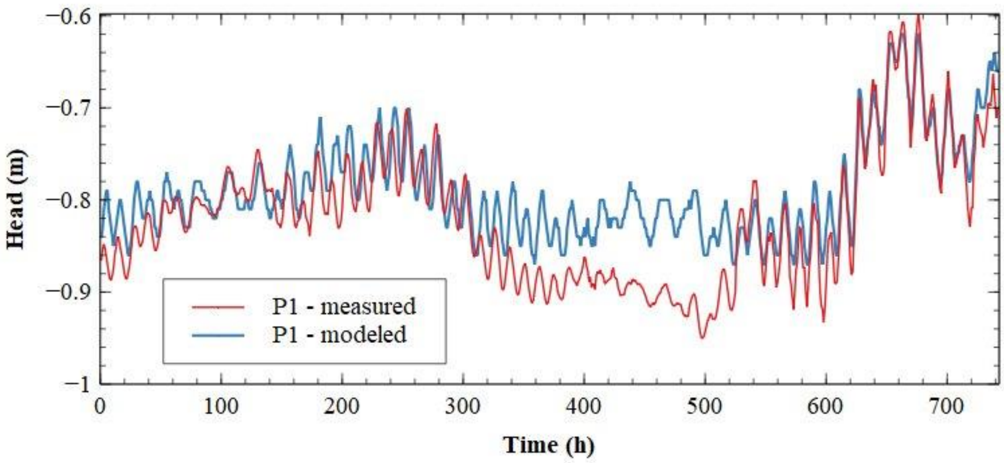

Figure 13 Measured and modelled head values for wet period on piezometer P1

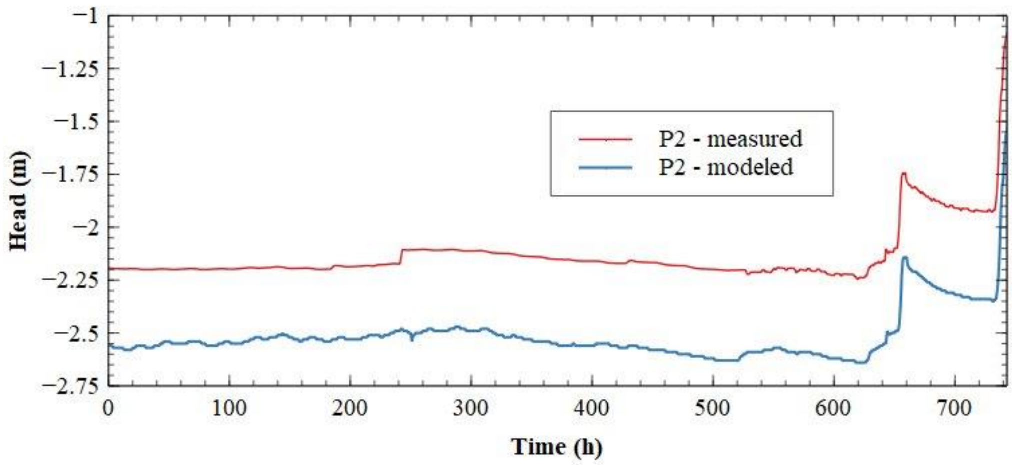

Figure 14 Measured and modelled head values for wet period on piezometer P2

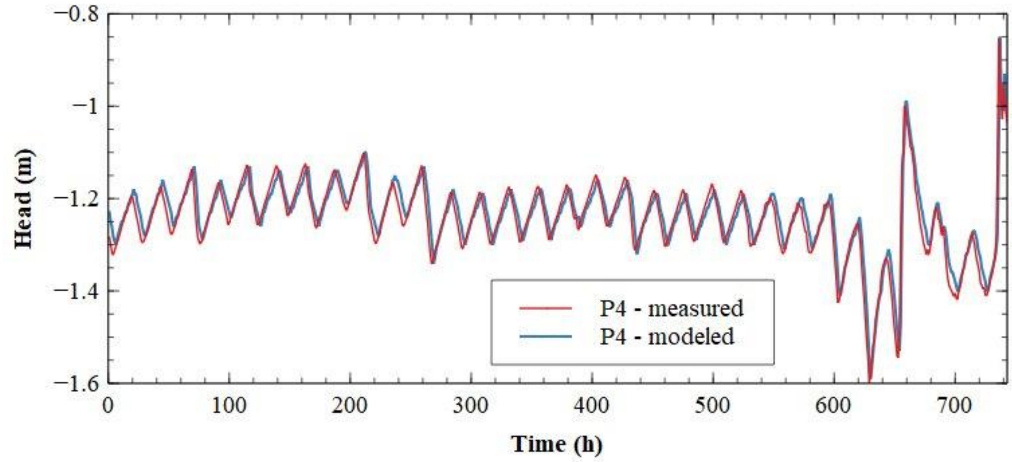

Figure 15 Measured and modelled head values for wet period on piezometer P4

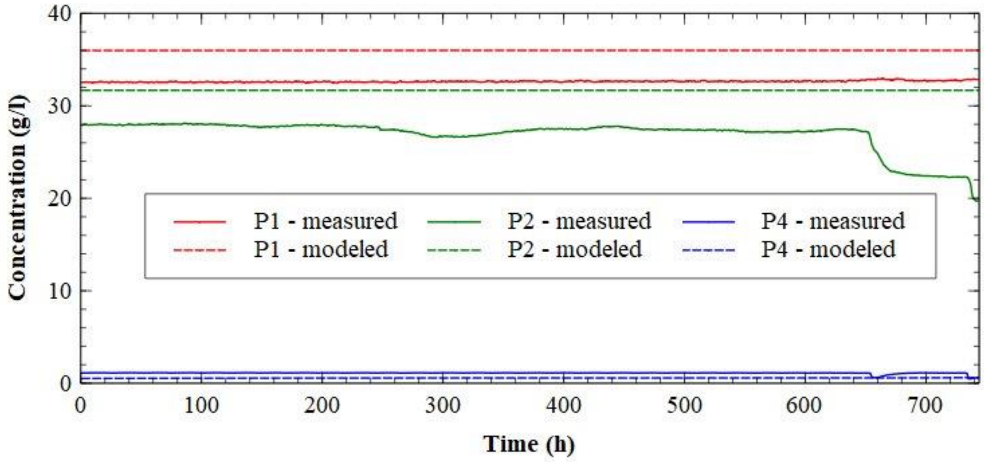

Figure 16 Measured and modelled concentration values for wet period on piezometers P1, P2 and P4

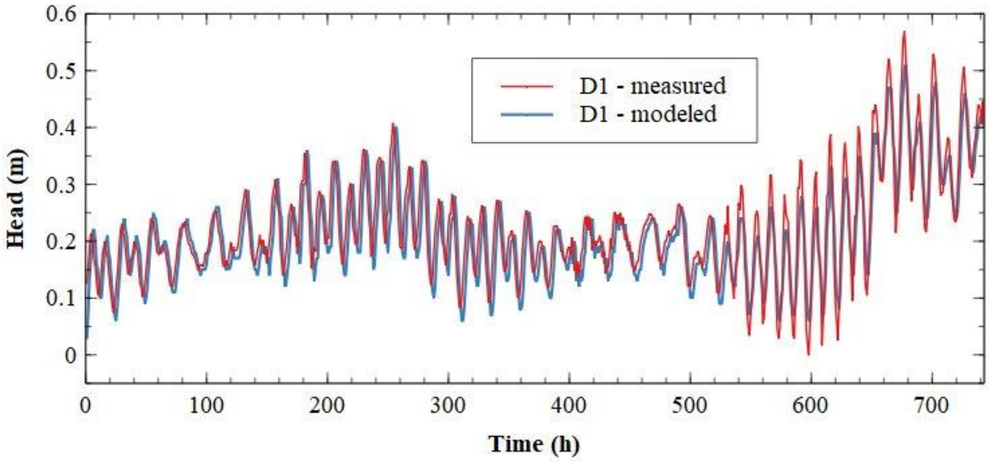

Figure 17 Measured and modelled head values for wet period on piezometer D1

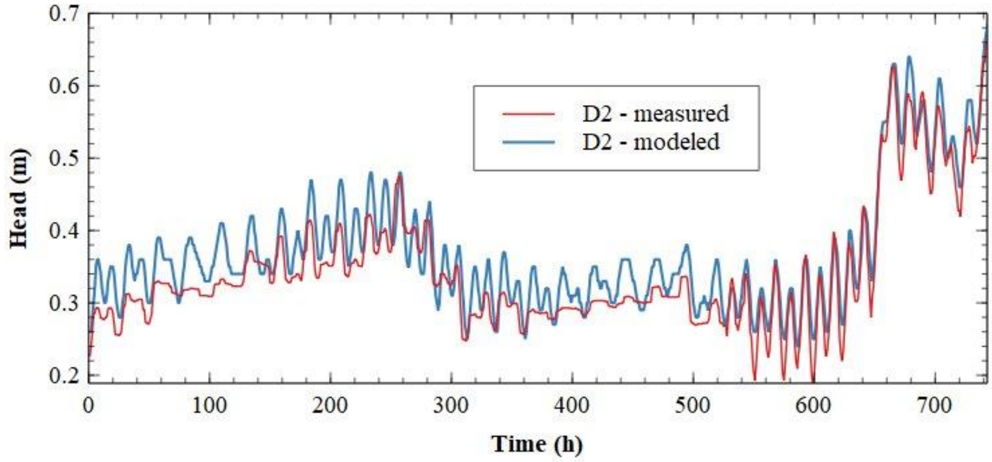

Figure 18 Measured and modelled head values for wet period on piezometer D2

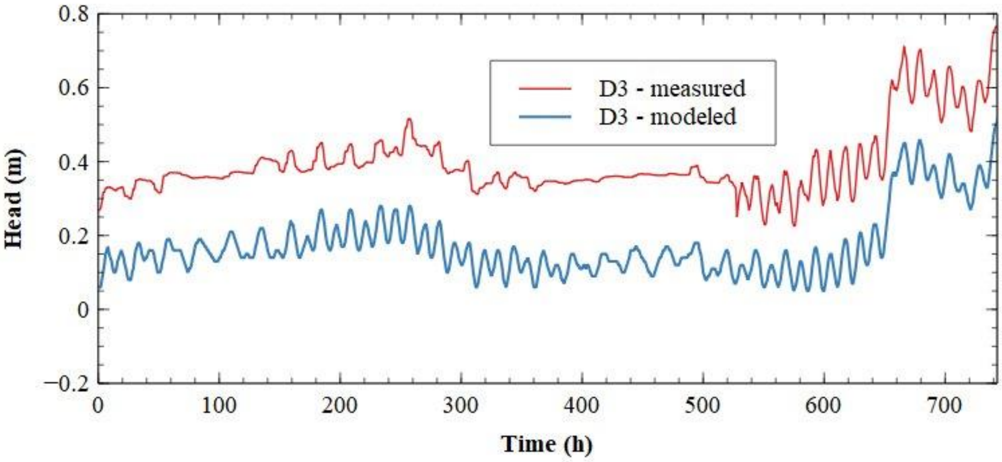

Figure 19 Measured and modelled head values for wet period on piezometer D3

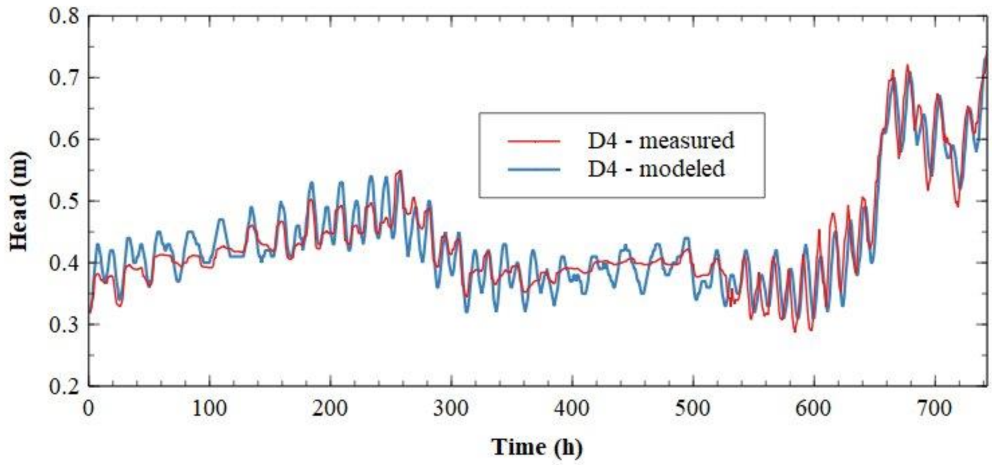

Figure 20 Measured and modelled head values for wet period on piezometer D4

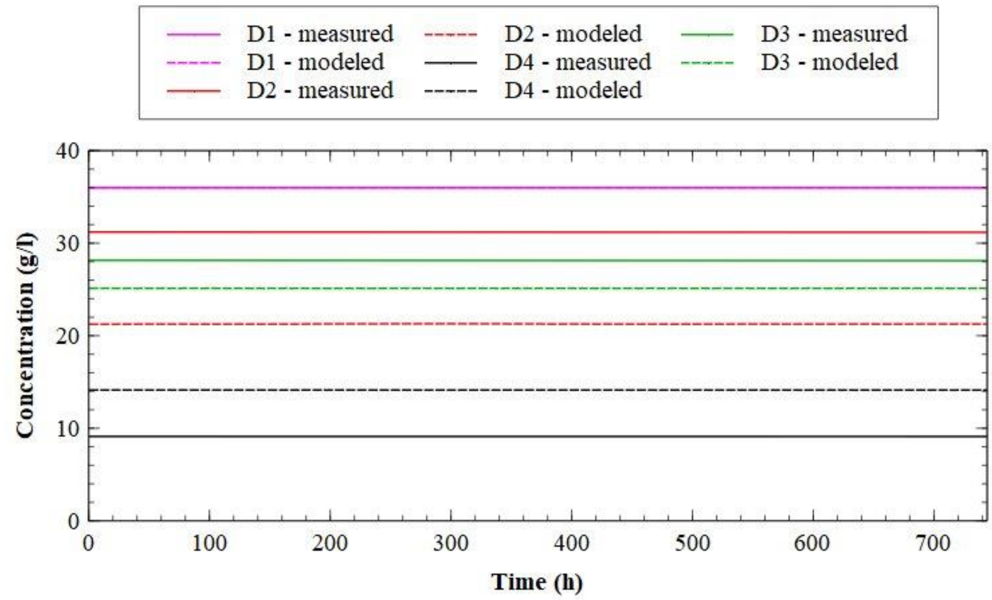

Figure 21 Measured and modelled concentration values for wet period on piezometers D1, D2, D3 and D4

Model results for dry period

Next figures show model results for dry period. As show on Figure 4 there was no rain in the whole dry period. As shown on the figures modelled values follow measured values quite well and don't show deviation during intense dry periods.

On Figure 25and Figure 30 change in concentration during dry period is shown for shallow and deep piezometers separately. Modelled concentration values are constant and don't affect them as much as measured concentration values.

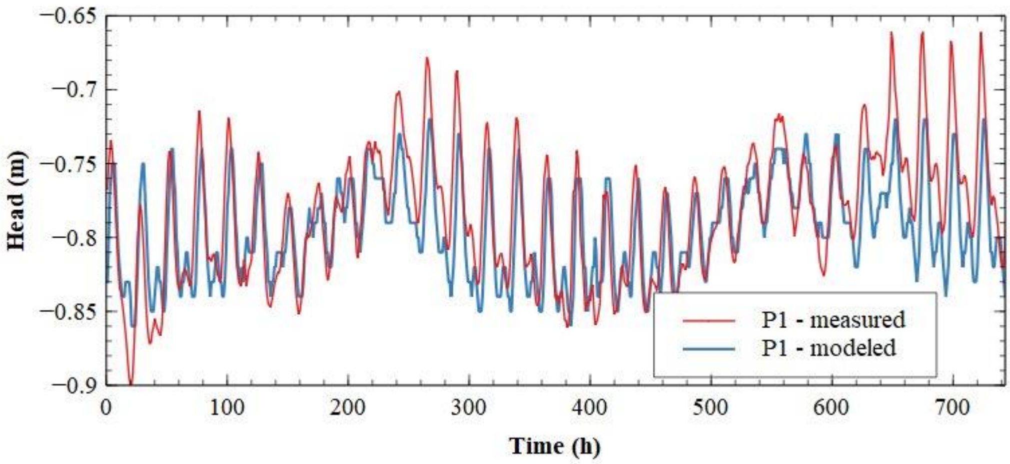

Figure 22 Measured and modelled head values for dry period on piezometer P1

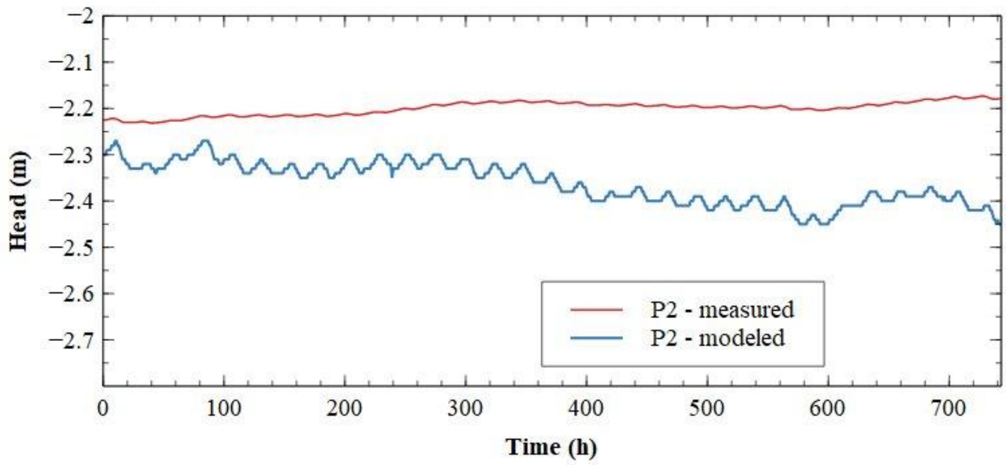

Figure 23 Measured and modelled head values for dry period on piezometer P2

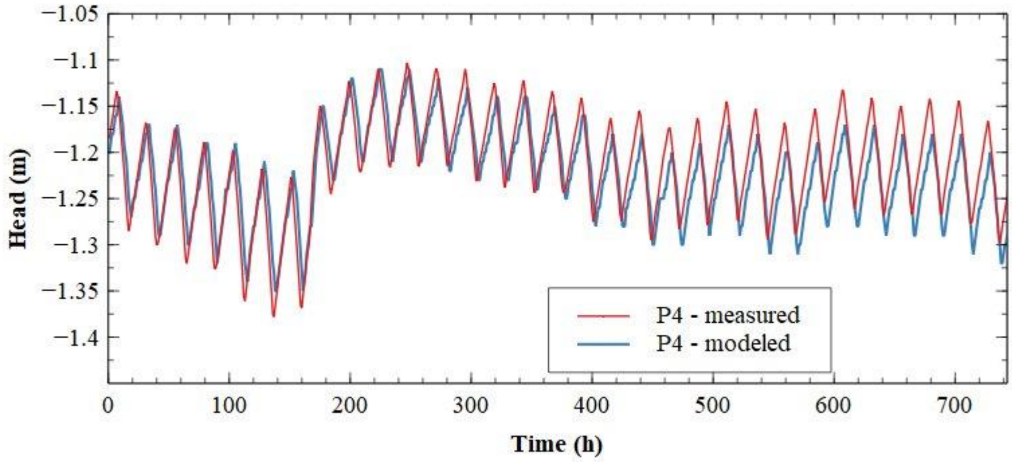

Figure 24 Measured and modelled head values for dry period on piezometer P4

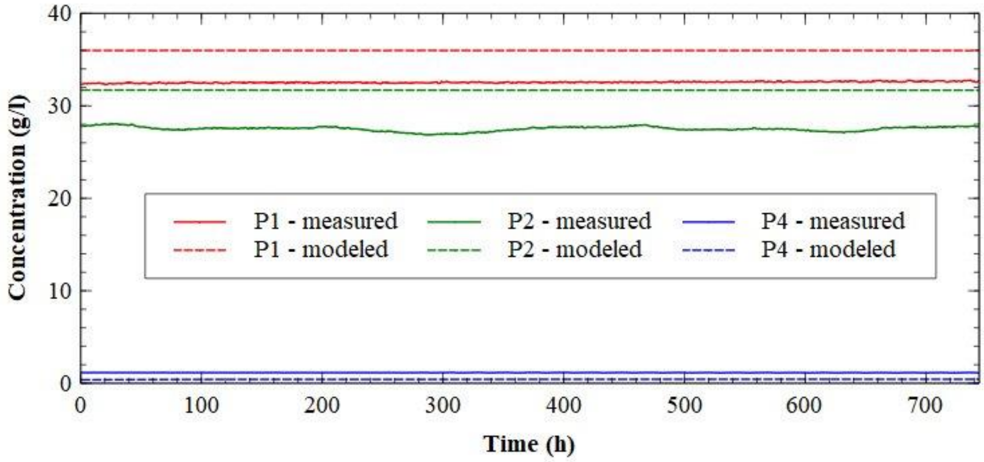

Figure 25 Measured and modelled concentration values for dry period on piezometers P1, P2 and P4

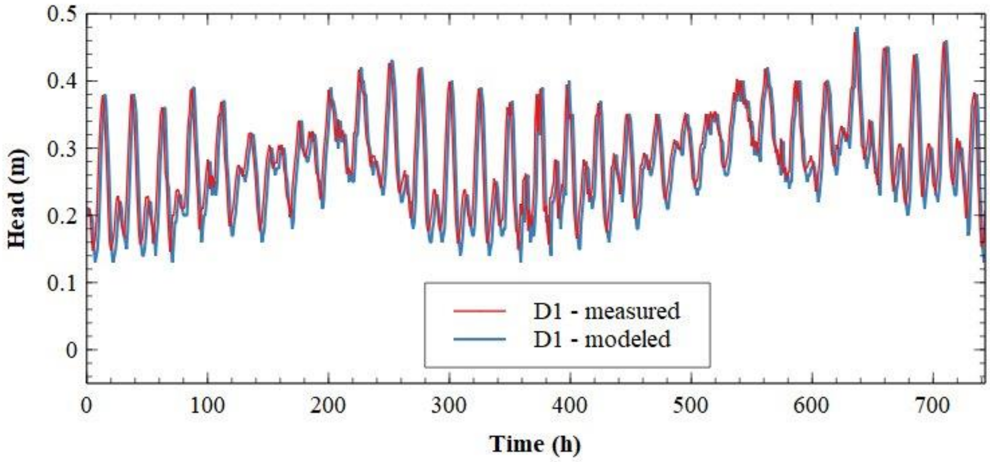

Figure 26 Measured and modelled head values for dry period on piezometer D1

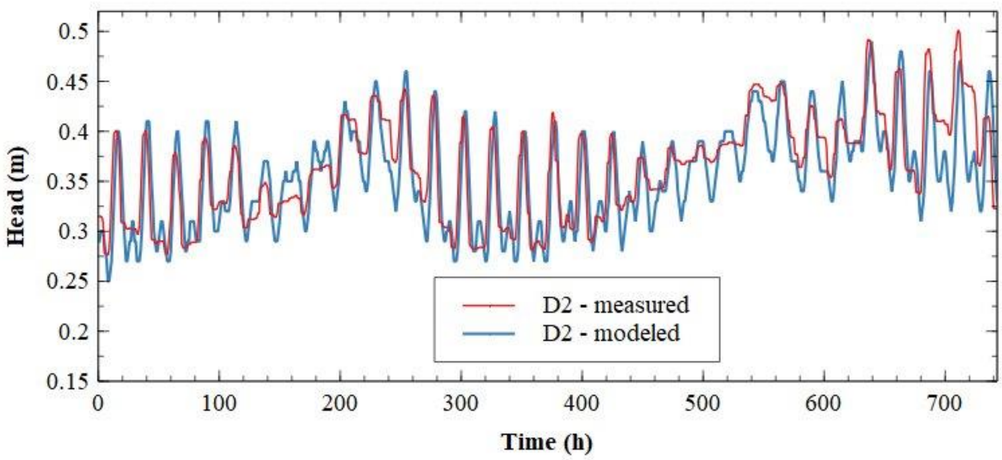

Figure 27 Measured and modelled head values for dry period on piezometer D2

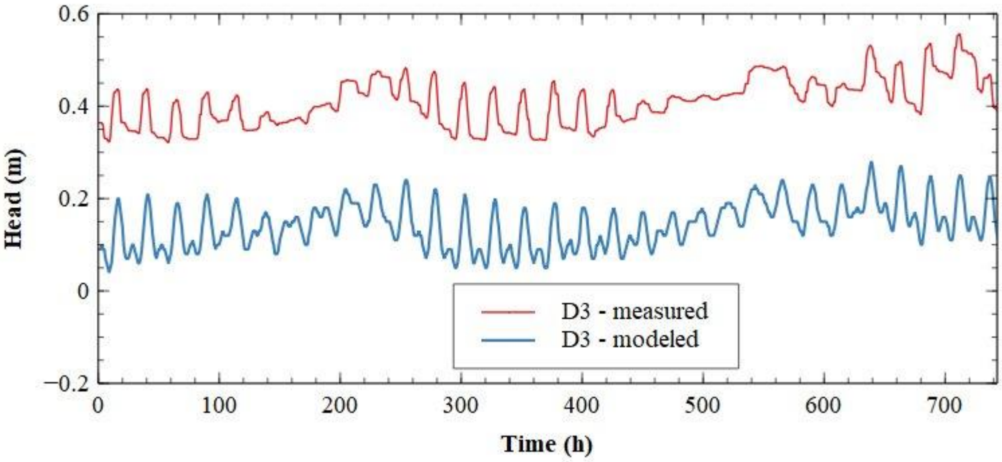

Figure 28 Measured and modelled head values for dry period on piezometer D3

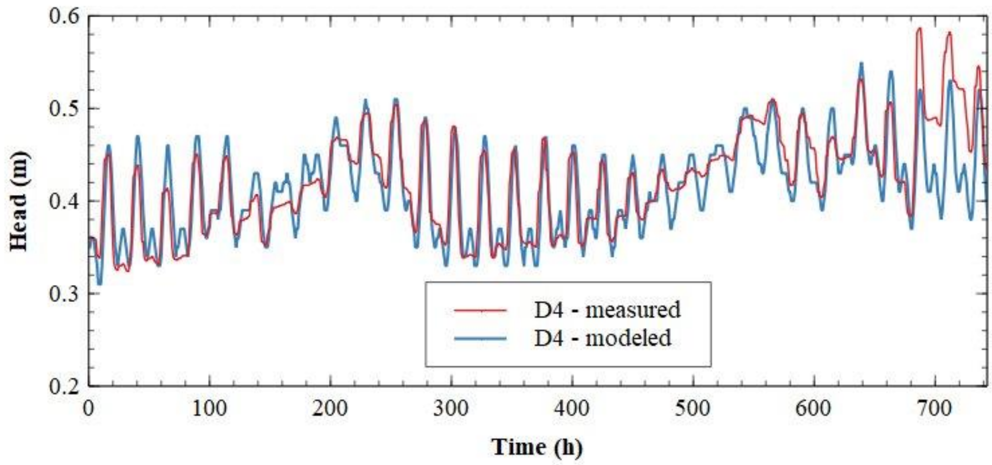

Figure 29 Measured and modelled head values for dry period on piezometer D4

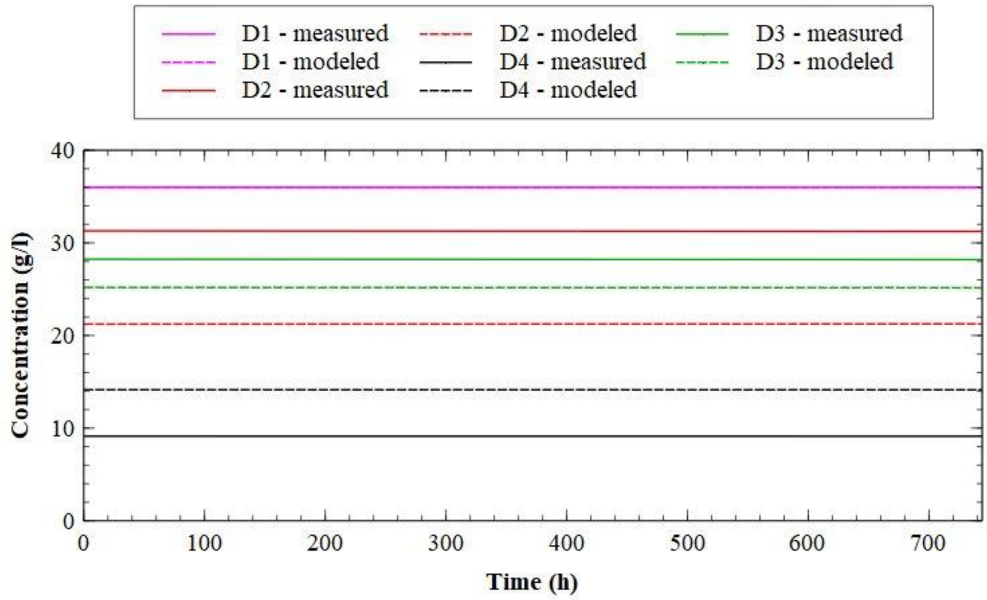

Figure 30 Measured and modelled concentration values for dry period on piezometers D1, D2, D3 and D4

List of figures