Characterization and modeling of water movement and salts transfer in a semi-arid region of Tunisia

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PROBLEMATIC

Arid and semi-arid areas

Water scarcity

Poor quality of groundwater

Aquifers overexploitation

Risks of soils and aquifers salinization

Objectives

Modeling of water movement and salts transfer

Highlighting and assessing of the aquifer salinization risk

Assessment of soil and aquifer salinization risks

Characterization (Field Measurements)

Modeling

Water Movement

Solute Transport

Rehabilitation (Amendments, leaching, drainage, ...)

Laboratory

Field

Improving knowledge about transport process

Prediction of the impact of saline waters

Workshop "Hydrus Software Applications to Subsurface Flow and Contaminant Transport Problems"
Most vulnerable to salinization (Ministry of Environment, 2006)

MATERIALS & METHODS

Land Parcel in Bouhajla (Kairouan – Central Tunisia)

Experimental spot

Surface Well (TDS = 6.5 g/l ; EC = 7.3 dS/m)

Kairouan Aquifer

Kairouan

Saline Soils

Surface Well

01/04/2013

Soil water content monitoring

7 TDR probes (adapted to salinity) : (Apr/05/2006)
depths: 0.1, 0.5, 1, 1.5, 2, 3 and 4 m

Soil salt content monitoring

4 soil profiles : up to 4 m in depth

Automatic weather station

Date Profil
06/12/2006 P1
27/02/2007 P57
08/03/2007 P134
22/07/2008 P57

RESULTS

CHARACTERIZATION OF WATER MOVEMENT AND SALTS TRANSFER
VARIATIONS OF WATER CONTENT

Water profiles: Stratification (5 layers)

- S-L: Exposed to evaporation, rainfall
- L-S: 1st Zero Flux Plan
- L-C: Semi-permeable layer
- L-S: 2nd Zero Flux Plan
- Deep Water Dynamic

CHARACTERIZATION OF SALT MOVEMENT

- SL: Salinization/Desalinization
- LS: Salt transfer zone
- LC: Accumulation of salts
- LS: Salt transfer zone
- LS: Salts dynamic

RESULTATS

SIMULATION OF WATER AND SALTS DYNAMICS
HYDRUS-1D CALIBRATION

Model parameters: 5 layers – 134 days – 2 print times 57th and the 134th day

Initial profiles of water content and electrical conductivity

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>ϑ (cm³ cm⁻³)</th>
<th>ECe (dS m⁻¹)</th>
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<tbody>
<tr>
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Hydrodynamic parameters

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<tr>
<th>Depth (m)</th>
<th>dh cm³ cm⁻³ h</th>
<th>αcm³ cm⁻³</th>
<th>n -</th>
<th>Kc cm⁻¹ d⁻¹</th>
<th>Bc cm⁻³ g⁻¹</th>
<th>Disp cm⁻¹</th>
<th>Kd cm⁻¹</th>
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<tbody>
<tr>
<td>0-0.7</td>
<td>0.02542</td>
<td>0.3723</td>
<td>0.025421</td>
<td>1.7708</td>
<td>128.01</td>
<td>1.38</td>
<td>17.01</td>
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<td>0.7-1</td>
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<td>0.3729</td>
<td>0.019463</td>
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<tr>
<td>2-3</td>
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<td>0.3857</td>
<td>0.018918</td>
<td>1.3666</td>
<td>21.856</td>
<td>1.54</td>
<td>17.05</td>
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<td>0.3857</td>
<td>0.01734</td>
<td>1.3665</td>
<td>54.405</td>
<td>1.60</td>
<td>40.22</td>
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Solute transport parameters

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<th>n -</th>
<th>Kc cm⁻¹ d⁻¹</th>
<th>Bc cm⁻³ g⁻¹</th>
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Hydrus-1d Validation: 557 days

Good agreement simulated and measured soil water content and electrical conductivity

RMSE 557th day

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<tr>
<td>ECe</td>
<td>0.21</td>
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Exceptional Rainfall Effect: 50 mm in March 09 2007

Deep Salts

No Salts

Long term Simulation: 20 years

- Cyclical and reversible salinization in the topsoil under the effect of low intensity rainfall and evaporation
- Continuous leaching of salts
- High risk of groundwater contamination
CONCLUSION

- Reliability of Hydrus-1D in field conditions
- Deep dynamics of water and salts
- Salinization Risk

PROSPECTS

- Complete characterization of the unsaturated zone
- Monitoring groundwater level and quality
- Extrapolation of water and salts dynamics at the watershed scale
- Test other scenarios (Climate change, ..)