Evaluation of groundwater and phosphorus transport in fractured altered wetland soils

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Lake Kinneret basin

Hula Valley

Eastern Galilee

Mt. Hermon

Syria

Upper Jordan River

Golan Heights

The Hashemite Kingdom of Jordan

Lebanon

Lower Jordan River

Lake Kinneret
The Hula Valley is an agricultural area located upstream of lake Kinneret which supplies 30% of Israel's portable water.

The Hula Swamps were drained during the 50’s. The valley was re-flooded in the early 90’s as part of a large remediation project.

In the late 90’s P loads from the Hula valley to the Jordan River (JR) were increased.

Near surface groundwater in agricultural fields leads to P release to pore water.

Up to date no transport mechanism was envisioned to explain P, N & S transport from these East Mediterranean altered wetland soils to the JR.
P and nutrient transport from The Hula Valley

Annual average of 410 MCM are flowing in the outlet of the Hula Valley, from which only 5% are precipitation over the Valley.

The Valley area is 175 km$^2$, which are 11% of the JR basin.

No surface flow occurs in the valley and still the valley contributes 30% (24 ton) of the total P and 60% (9600 ton) of the total S which are transported at the valley outlet.
Hydrological connectivity of the JR to the agricultural fields

Date

Elevation (m)

Well 17

JR

05/01/07 04/02/07 06/03/07

Well 17
Flowing water in the Hula’s soils
Large field Experiment for Evaluating Water and solute transport in the Hula’s Soils

Hypothesis

P and other nutrients transport in these soils is driven by water fluctuations in the drainage canal. Most of the transport from the field occurs through cracks flow which can facilitate both soluble and particulate transport.
Large field Experiment for Evaluating Water and solute transport in the Hula’s Soils

**Experiment Stages:**

**Raising stage – lasted 28 days.**

We closed the outlet of 404 canal and water flowed from the canal to the fields.

**Drainage stage – lasted 5 days.**

We lowered the water level in the canal by opening the canal outlet. During this stage we closed the inlet of the canal and only drainage water was flowing in the canal.

During the experiment we sampled water in OBW, 404 Canal, **Differential Sampling Stations**, & **Cracks**.
## Differential Sampling Stations

<table>
<thead>
<tr>
<th>Connection pipes</th>
<th>Electrodes</th>
<th>Water sampler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack Matrix</td>
<td>Crack</td>
<td>Crack Matrix</td>
</tr>
</tbody>
</table>

![Image of differential sampling stations](image_url)
EC and Water level in 404 Canal

EC (µS/cm)

SO$_4^{2-}$ (mg/L)

<table>
<thead>
<tr>
<th>Day of experiment</th>
<th>EC</th>
<th>SO4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>404 Elevation</td>
<td>61.8</td>
</tr>
<tr>
<td>5</td>
<td>62.0</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>62.2</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>62.4</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>62.6</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>62.8</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>63.0</td>
<td></td>
</tr>
</tbody>
</table>

Start Drainage End
Total P in Canal 404

Graph showing the trend of Total P (µg/L) over the experiment days with markers for Start, Drainage, and End phases. The graph also indicates a percentage of >70%. The X-axis represents the experiment day, and the Y-axis represents TP concentration. There are two lines: one for Crack (in canal) and another for water level, with corresponding markers.
$E_H$ – Matrix vs. Cracks (Sampling Station)

**Absorbed P $^*$**

<table>
<thead>
<tr>
<th></th>
<th>Cracks</th>
<th>Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18.21 mg/kg</td>
<td>1.12 mg/kg</td>
</tr>
</tbody>
</table>

$^*$NaOH Extraction
Preliminary results
Total P in the sampling station

Day of Experiment

TP (µg/L)

Crack 1
Crack 2
Matrix 1
Matrix 2

PP>70%

Drainage  End

PP>70%
# Nutrient Loads

<table>
<thead>
<tr>
<th></th>
<th>TP (kg)</th>
<th>SO₄ (kg)</th>
<th>Water discharge (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>daily</td>
<td>0.128</td>
<td>740</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>0.64</td>
<td>3700</td>
<td>24,500</td>
</tr>
</tbody>
</table>

\[
Q_f = Q_{404up} - Q_{404D} - \Delta Q_S
\]
vertical P mobility from pore water to floodwater (above-ground water) is limited by the oxidized layer in the floodwater-soil contact zone (Young and Ross 2001).
Summary & Conclusions

- Good hydrological connectivity exists between the fields and the waterways.
- Rapid water level rise during high discharge periods in the JR could drive significant flow into the fields. During the river recession, water would flow from the fields to the river.
- On the basis of Sulfate behavior we expecting significant loads during high discharge periods.
- P is adsorbed on the Fe mineral in the cracks faces, thus significant transport is expected only as particulate fraction.
- Attention has to be paid to cracks waters when evaluating nutrient transport in this altered wetland.