Introducing initial findings on geochemical interactions of monovalent-partial desalinated water infiltration into a salinated dune sediment

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Background and motivation

Due to increasing water demand and groundwater contamination, techniques, such as seawater desalination with subsequent managed aquifer recharge (MAR), need to be adapted, securing global fresh water resources. Current desalination plants are cost and energy intensive and the desalinized product water (DSW) needs to be post-treated to increase the total dissolved solids (TDS) concentration. Therefore, it might not be necessary to remove the divalent ions.

→ Aim of the cooperative project "InnovatION":

Development of a monovalent selective membrane for water desalination that Needs less energy and provides a purposeful removal of contaminants in the groundwater (e.g.: Na^+, Cl^-, NO_3^-). **As one potential application of the monovalent-partial desalinated water (PDW) is its recharge into aquifers.**

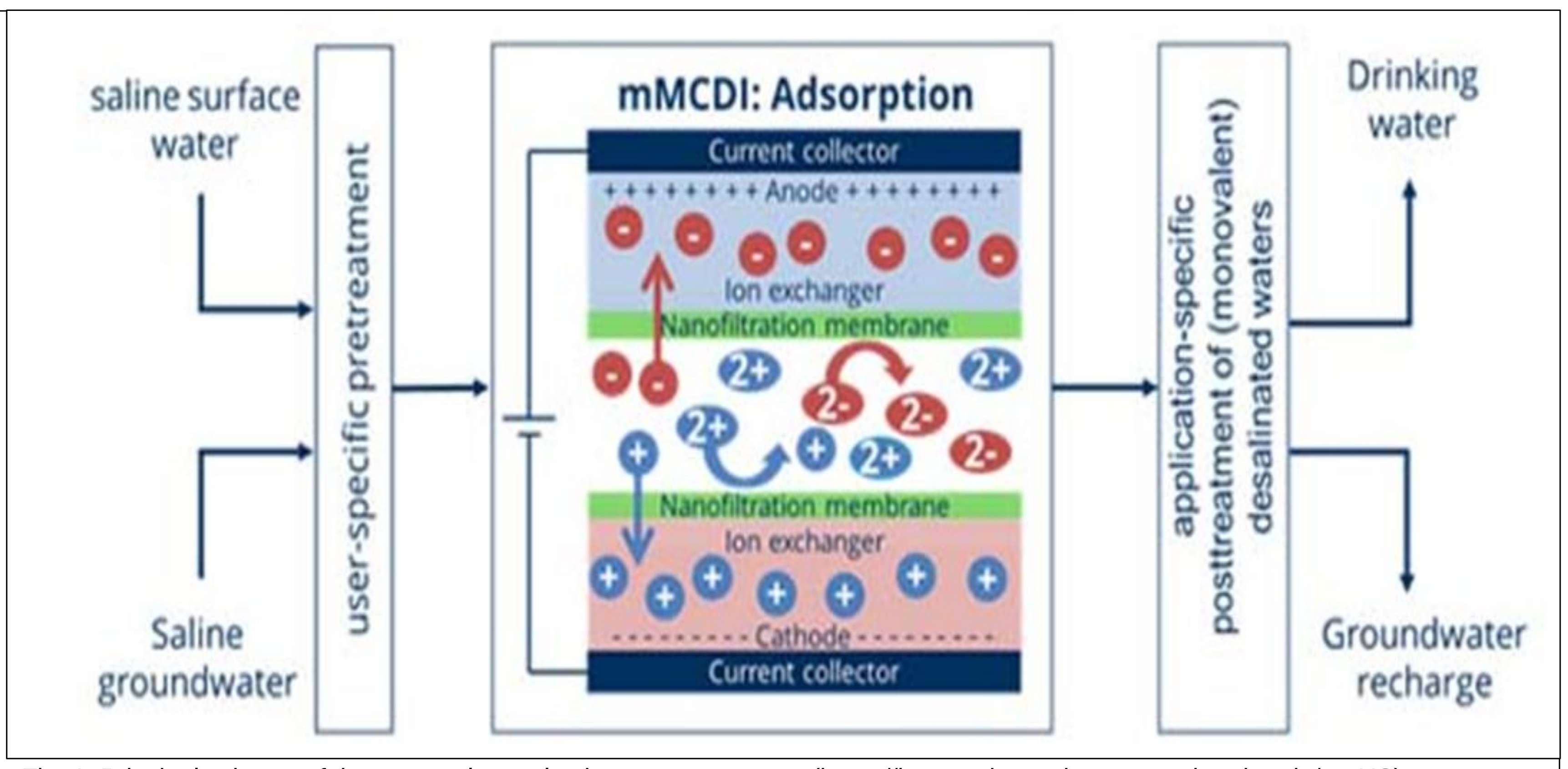

Fig. 1: Principal scheme of the monovalent selective water treatment (https://innovat-ion.webspace.tu-dresden.de/en-US).

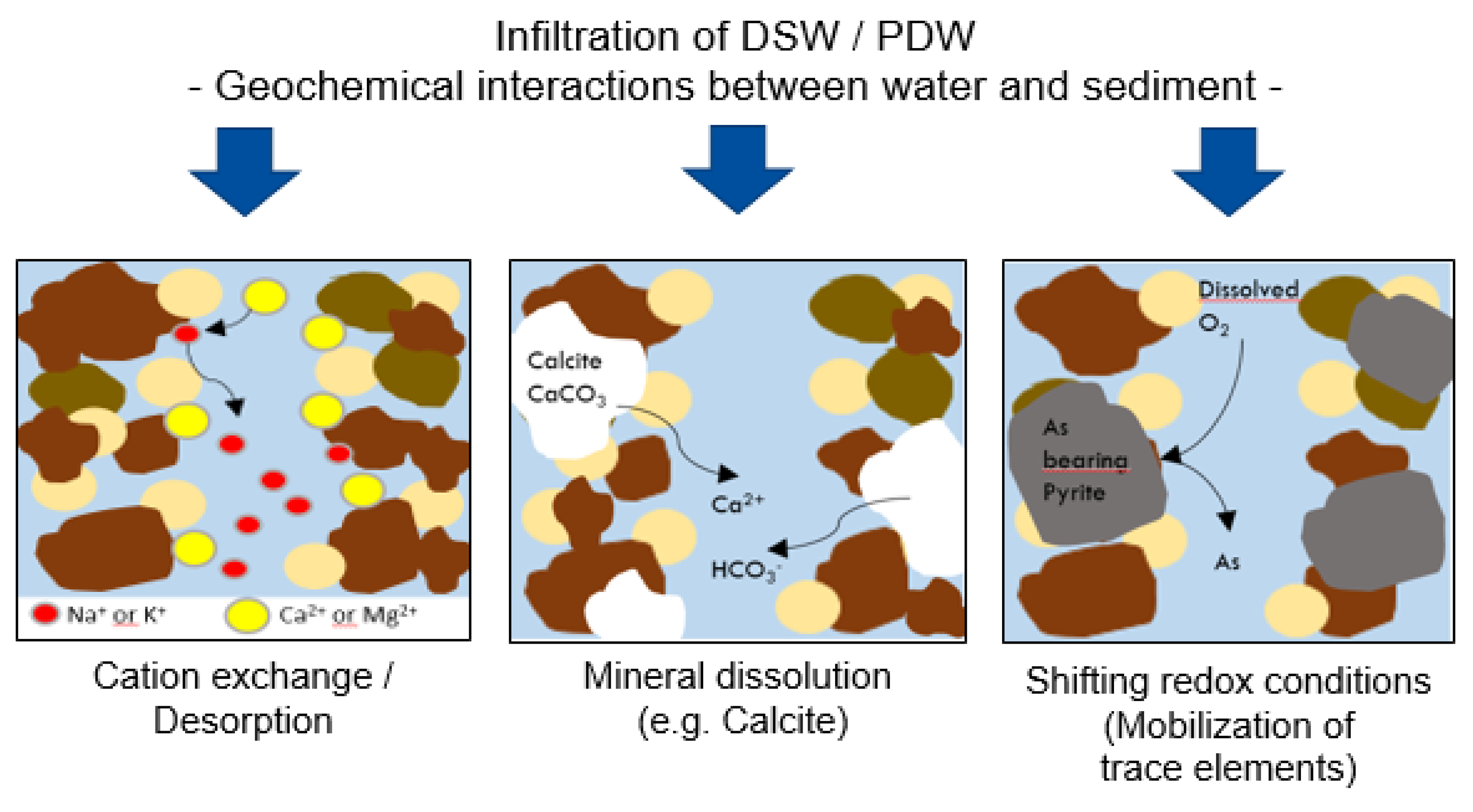

Fig. 2: Schematic geochemical reactions induced by infiltration of water with lower salinity than natural groundwater (modifier after [4]).

However, the recharge water then differs chemically from natural pore and groundwater: **Chemical disequilibrium during MAR triggers geochemical reactions between water and sediment**

→ Depend on the sediment characteristics and need to be investigated for the special infiltration site (e.g.: [1], [2], [3])

→ Cation exchange is the main geochemical process by DSW infiltration [2], [5]

→ Ca^{2+} concentration of inflow water is controlling factor for ongoing chemical processes [2], [4], [5]

→ Recharge with monovalent PDW might mitigate geochemical disequilibrium and resulting reactions

Experimental analysis

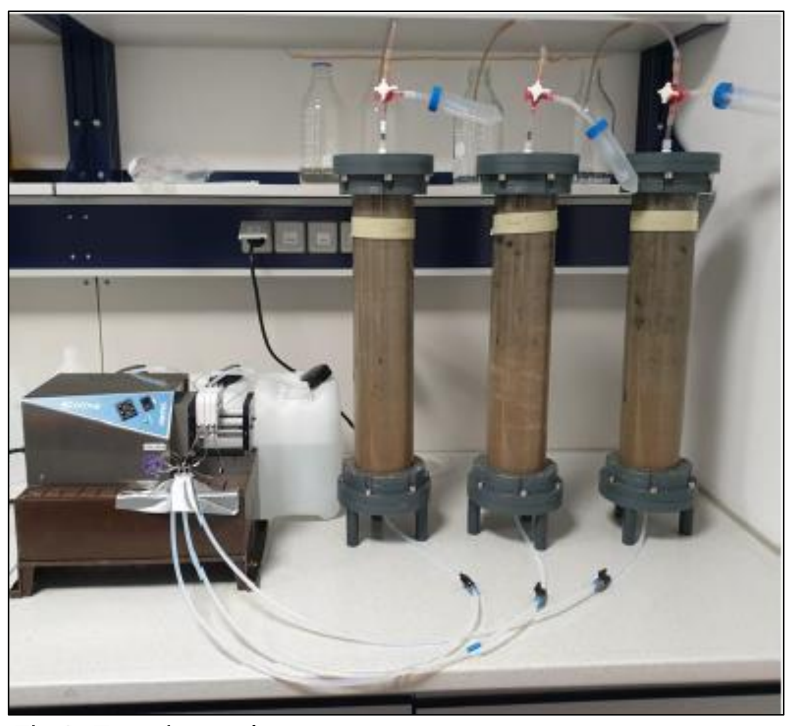

Fig.3: Experimental set up.

Table 1: TDS and pH of inflow and outflow water.

		SW	TDW	PDW
TDS [g/l]	Inflow	5.3	0.006	0.9
pH		7.95	8.90	7.71
TDS [g/l]	Outflow Day 33	5.4	0.045	0.9
pH		7.95	8.29	7.58

Grey dune sediment from east Frisian island Langeoog

Carbonate content: 0.12 %

pH: 7.14

- Three sediment columns saturated with artificial saline water (SW)
- PDW artificially produced by ~ 80 % reduction of monovalent ions from SW
- One column flushed with SW (control), one with total desalinated water (TDW) and one with PDW (Day 0)
- Regular measurement of most relevant ions in the outflow
- Determination of soil characteristics

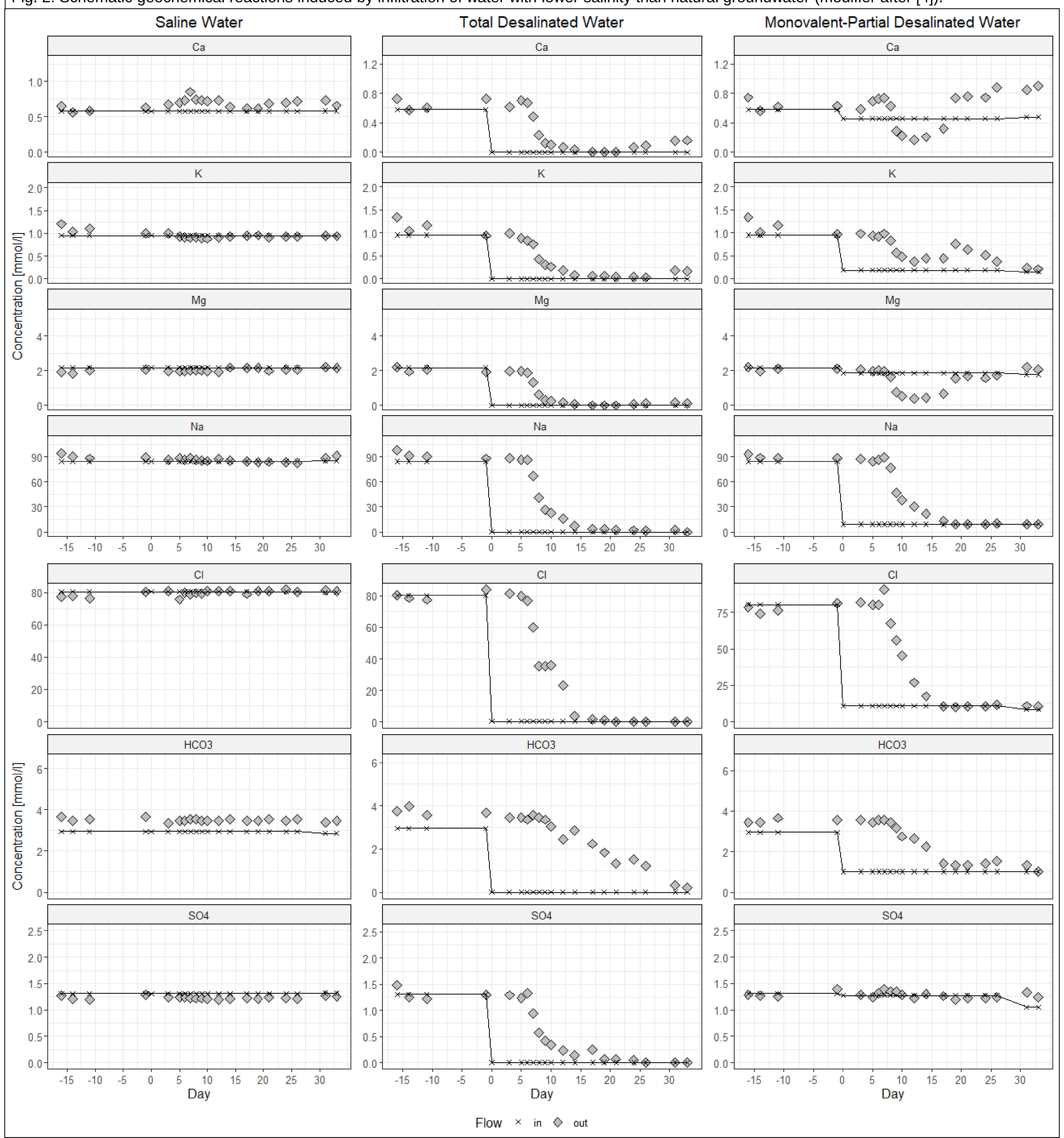

Fig. 4: Inflow and Outflow concentration of the most relevant ions during conditioning phase and changing water type infiltration (Day 0).

Results and discussion

- Just small scale variations of SW outflow concentrations, but slight Ca^{2+} and HCO_3^- increase
- Exchange of pore water 10 days after water change (day 0)
- TDW infiltration: Outflow concentrations (except Cl^- and SO_4^{2-}) at day 33 still higher than inflow → dissolution processes
- PDW infiltration: Ca^{2+} in outflow between day 9 and 17 below inflow concentration, Mg^{2+} from day 9 to 26 → adsorption

→ Cation exchange processes triggered but dissolution processes limited with PDW infiltration compared to TDW

Outlook

- Geochemical reactions during PDW infiltration differ by initial soil characteristics → investigation of infiltration with different sediment types → Mobilization of trace elements?
- Modelling of (reactive) solute transport during infiltration for better process understanding

Literature:

[1] Vandenbohede, A., Van Houtte, E., Lebbe, L. (2009): Water quality changes in dunes of the western Belgian coastal plain due to artificial recharge of tertiary treated wastewater. Applied Geochemistry 24: 370 - 382.
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innovatION
Selektive Entfernung monovalenter Ionen aus salzhaltigen Wässern