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Submarine groundwater discharge (SGD) in the springs of Sahlenburg tidal flat, Germany: a geochemical approach.

Roger Carvalho da Silva, Hannelore Waska, Kai Schwalfenberg, and Thorsten Dittmar
Carl von Ossietzky Universität Oldenburg, ICBM, Marine Geochemistry, Oldenburg, Germany (roger.carvalho.da.silva1@uni-oldenburg.de)

Submarine groundwater discharge (SGD) is an important connection between fresh groundwater and the marine ecosystem. The scientific interest in SGD has grown considerably during the last decades due to the recognition of SGD in coastal environments as a significant source of nutrients and pollutants. The Sahlenburg area (Northern Germany) is known by its highly permeable sediments and high rainfall precipitation that produces a large reservoir of groundwater. Such characteristics are essential for industry, agriculture and drinking water supply with a large regional importance. In addition, this groundwater discharges in the form of highly productive springs directly into the adjacent tidal flats, with so far unknown effects on the local biogeochemistry. The aim of this study was to characterize the spatial distribution of salinity, fluorescence dissolved organic matter (FDOM), dissolved organic matter (DOC) and total dissolved nitrogen (TDN) of the springs of Sahlenburg tidal flat area in Cuxhaven, Germany. We hypothesize that the SGD composition is changing on its way through the tidal flat due to biogeochemical factors. This may affect the composition of the water in the final part of the pathway with more influence of seawater. Porewater springs were sampled in February 2019 during low tide in three different types of locations in the tidal flat area: nearshore where the springs are located close to the vegetated shoreline (salt marsh), offshore approximately 70 meters from the vegetation and in the middle from both locations. In addition, porewater from a nearby sandy beach (around 500 meters away from the area of spring sampling), and surface samples from a nearby lake and seawater, were obtained. Salinity and FDOM were measured in situ, and DOC and TDN in the laboratory. The preliminary data showed low average values for salinity in all springs (0.2-1.4), as well as in beach porewater, indicating strong influence of fresh groundwater in the whole area. When comparing the three spring location types, the lowest salinities were found offshore, and the highest nearshore. This difference could be due to the size of the springs, since nearshore springs usually were smaller when compared to offshore springs. Furthermore, depressions in the tidal flat relief close to nearshore springs favored seawater retention in pools during low tide. Additionally, we found higher average values for DOC and FDOM in the nearshore when compared with the other spring areas, but lower compared to the lake, beach porewater and seawater. The average values for TDN (272-452 µmol L^{-1}) in the groundwater springs were higher when compared to all other sample types (beach porewater, seawater, and lake water) in this study. These values suggest an anthropogenic input (e.g., agriculture influence) in the surrounding watershed and might stimulate primary productivity in the tidal flat. We conclude that

groundwater springs in Sahlenburg tidal flat differ locally in their biogeochemistry due to different residence times, heterogeneity of sediment layers, and size of the springs.