Assessing methods for studying submarine groundwater discharge

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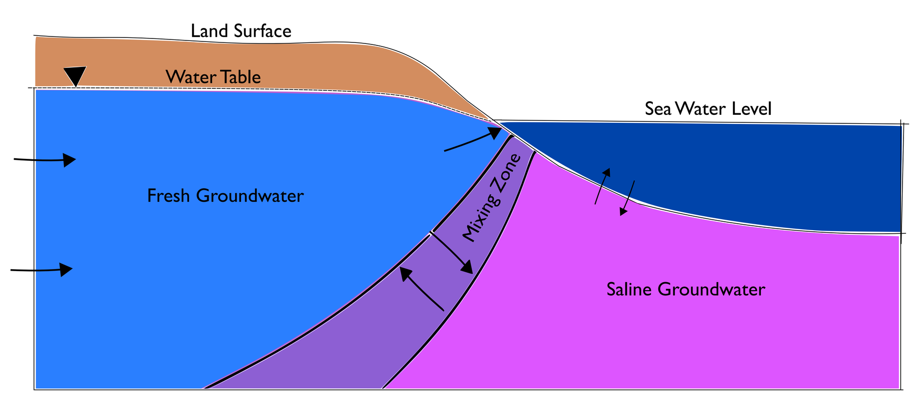
Introduction

Submarine groundwater discharge (SGD) is the flow of groundwater into coastal seawater irrespective of origin, driving force, or salinity. It requires specific methods as it takes place underwater and its quantification can be challenging. The purpose of this poster is to approach the methods of SGD measurement from multiple angles and flesh out connections between them.

The methods being reviewed are tidal effects on seepage meter measurements, prefilling seepage meter bags, and the use of radon as a tracer. Tidal fluctuation changes the gradient which then changes the discharge measured by seepage meters. Plastic bags are attached to caputure discharging groundwater but the bags have some internal frictional resistance so they are traditionally prefiled with some water to limit that resistance. Prefilling the bags dilutes discharging water so it is difficult to get accurate salinity or radon measurements. Typically radon is used as a tracer to measure SGD on a large scale and is calculated from end members. Looking at radon on a smaller scale is to review the accuracy of those studies and to connect it with the use of seepage meters.

Location

The study was conducted in Indian River Bay at Holts Landing State Park, DE.



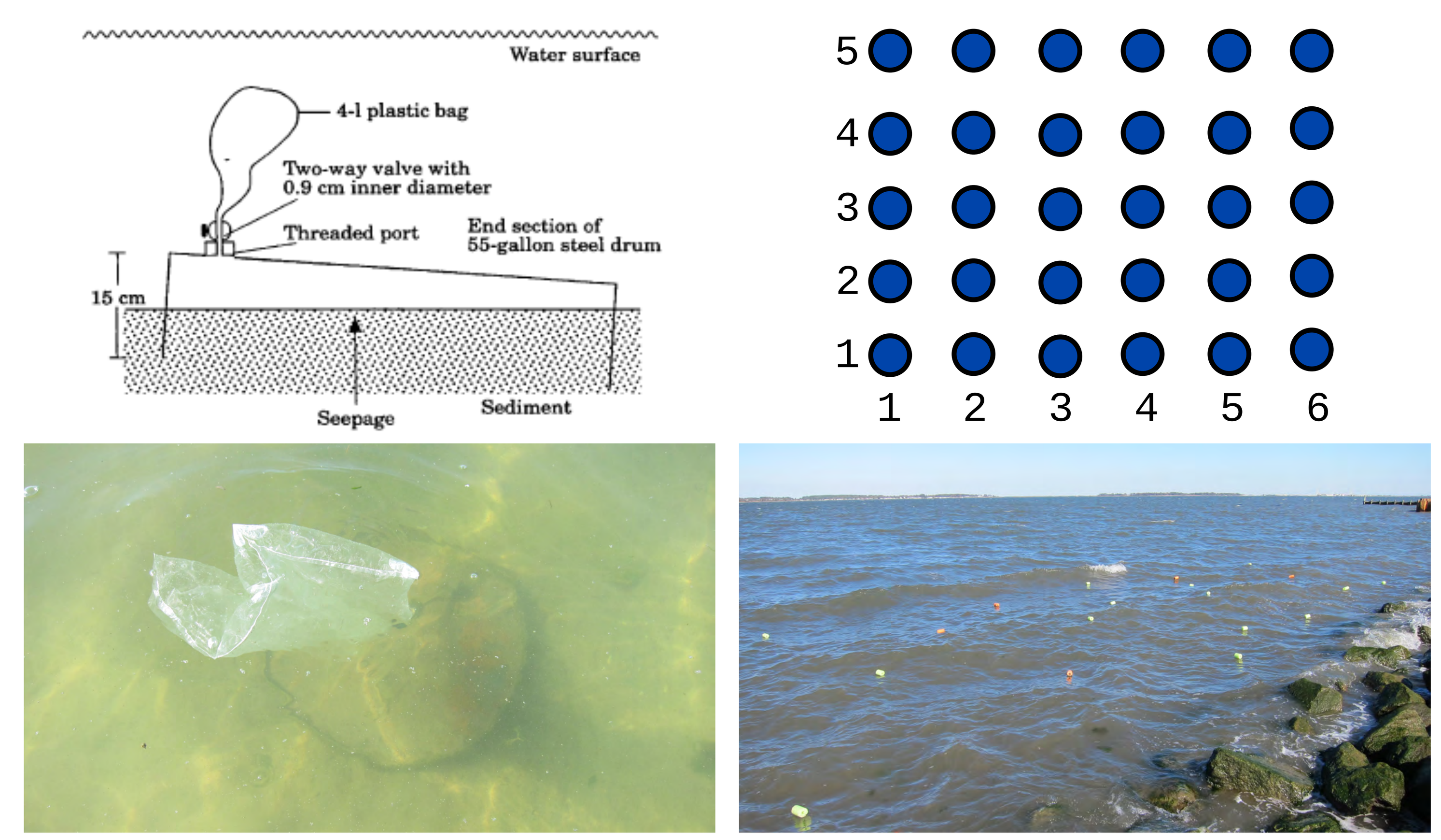
Cross sectional diagram of SGD

The fresh component of SGD is terrestrial in origin and driven to the coast by hydraulic gradient. Saline groundwater is from sea water recirculating through sediments. Due to a difference in density between salty and fresh water there is a boundary seperating them where a small amount of mixing occurs.

Methods I

Seepage Meters & Radon

Seepage meters are the only way to directly measure SGD (Burnett, 2001). As water seeps up through the sediment it displaces water already in the chamber of the seepage meter forcing it into the attatched bag. 30 Seepage meters were deployed 3 m from each other in a homogeneous 5 by 6 grid. Radon samples were colleted with a sipper next to each seepage meter at a depth of 25 cm below the ground surface then cycled through a RAD7 for 5 hours.



Clockwise from top left; Manual seepage meter schematic (M.Taniguchi, 2006), arrangement of seepage meters, field site at Holts Landing State Park, deployed seepage meter

Methods II

Salinity & Tides

Salinity measurements were taken from the collected seepage meter bags to gather time series data. Measurements were also taken from the sipper samples from each seepage meter and along several transects.

Tides were calculated from data gathered by Aquatrolls placed in the open air, at a nearby terrestrial well, and the end of the pier at Holts Landing. The tide was measured to see how it changed the hydraulic gradient and its influence on flux.

Aquatroll and seepage meter locations

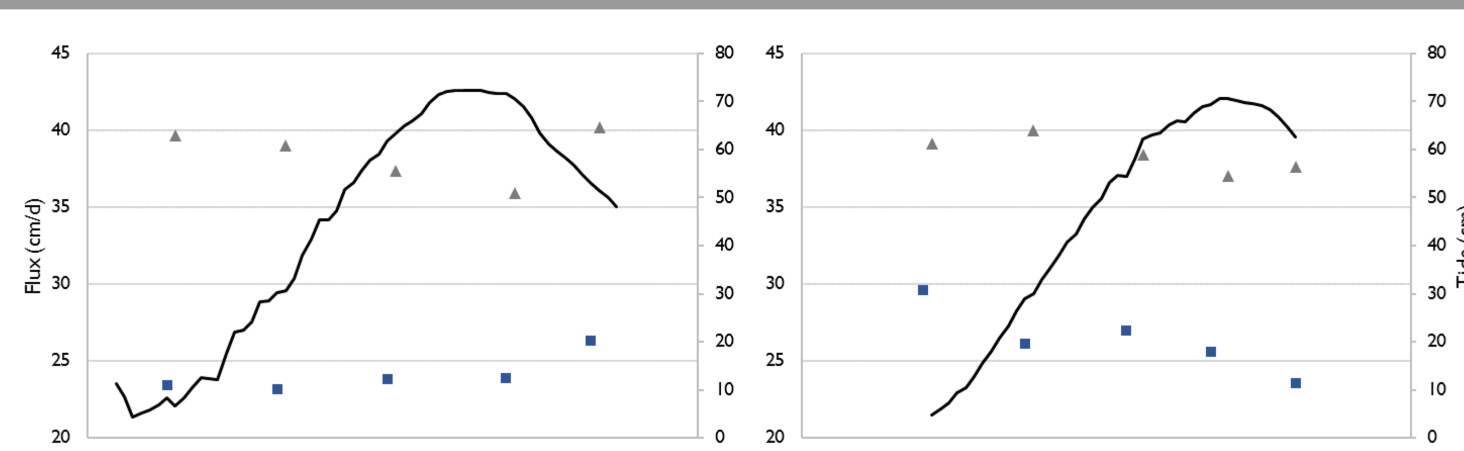
Research Questions

1. How does tide effect flux? Gaining a better understanding of tidal effects on flux is important because it can be extrapolated to larger spatial and temporal scales.

2. Is it necessary to prefill seepage meter bags? Traditionally the bags are prefilled with water to reduce their frictional resistance but doing so dilutes the groundwater entering the bags.

3. How are radon and seepage meter data connected? Taking measurements with seepage meters and radon simultaneously checks the accuracy of using radon as a tracer. It also gives a better look at the connection between radon and seepage meter measurements for a more rounded approach to SGD.

Results

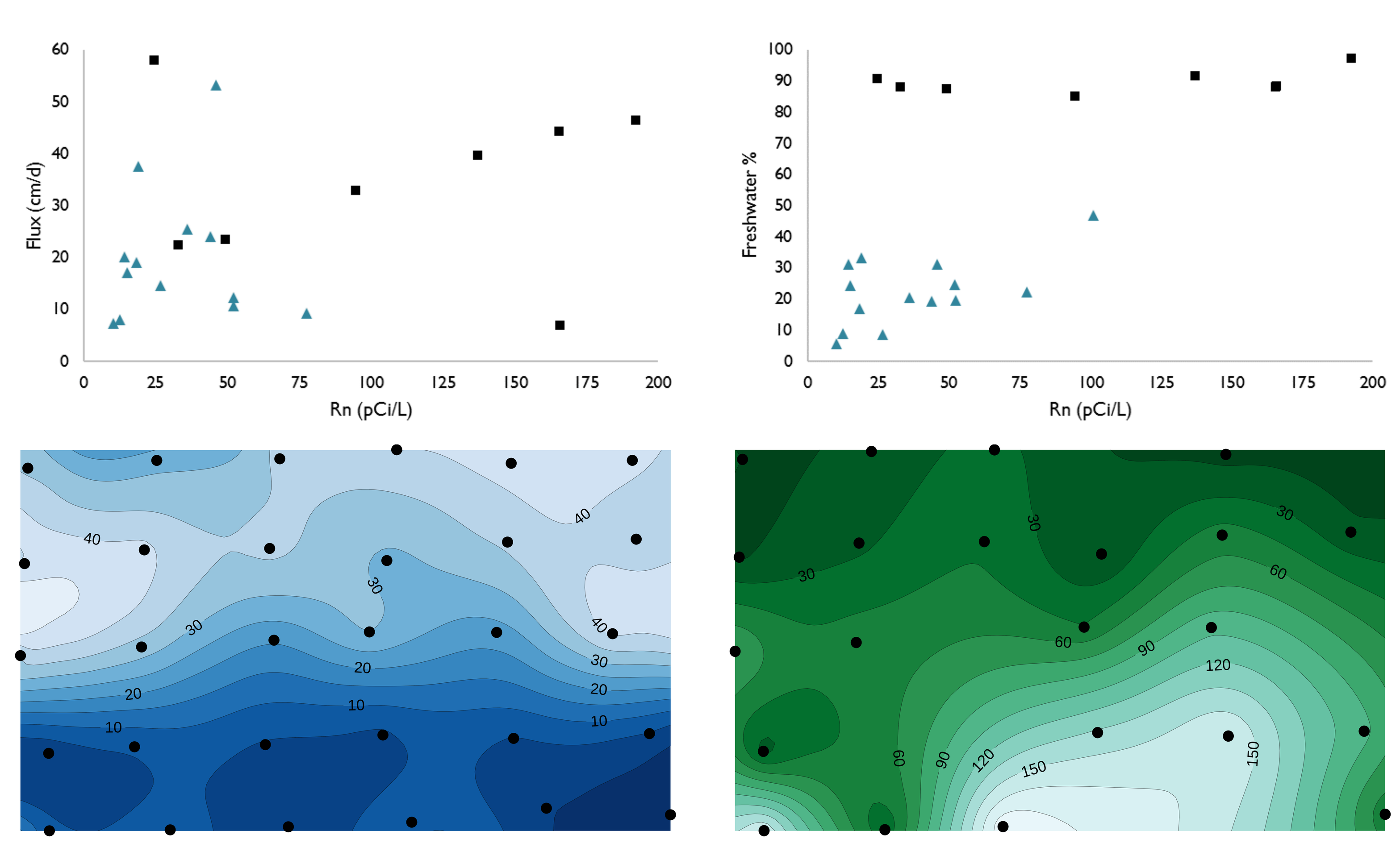


Left: without prefilled bags. Right: with prefilled bags
Black line - tide; grey triangles - flux of rows 1 and 2; blue squares - flux of rows 3, 4, and 5

Flux data on the above graphs was recorded with seepage meters. The markers differentiate between the first two rows which were located shoreward of the mixing zone where primarily freshwater discharge occurs and the last three rows located where saline discharge is prominent. The graph on the left shows flux with initally empty bags to compare it to prefilled bags on the other graph. The first two rows of seepage meters do not show much difference between the graphs but the last three rows show some variability. Freshwater is used to prefill the bags and is less dense than salt water possibly causing a bouyancey effect that pulls more saltwater into the bags. Also, data was collected over a two day period indicating a different variable could be changing the saline flux.

Tidal change was calculated from measurements taken by several Aquatrolls placed in the open air, at the end of the pier, and in a nearby well during the sampling period. The gradient could then be calculated from the seepage meter location and well located in a nearby parking lot. At low tide there is a larger difference between the height of the water table and sea level increasing the gradient which then drives a higher volume of freshwater discharge. Saline discharge is from recirculated seawater which is why it is not correlated to the changing tides.

Radon content is controlled by the length of the groundwater flowpaths. Radium occurs naturally in sediments and decays to radon which then is dissolved by groundwater. When the residence time of groundwater is longer it has more time to pick up extra radon before discharging into the bay. The upper right graph below indicates that the seepage meters recording a higher percentage of freshwater can have any amount of radon but the more saline locations have less radon. This is because saline water is recirculated through the sediment and therefore has a short flowpath where as freshwater is terestrially derived and can have a flowpath of any length.



Clockwise from top left: Comparison of flux and radon, comparison of freshwater percentage and radon, radon measurements at seepage meters, salinity measurements at seepage meters.
Upper graphs: black squares - first two rows, blue triangles, last three rows.

Conclusion

Tidal cycles have a strong influence of freshwater discharge but it is not clear how it effects saline discharge. More work needs to be done to see what other variables change the amount of discharge.

There does not appear to be a clear difference between prefilling or not prefilling seepage meter bags for freshwater measurements but it might have an influence for saline discharge.

Radon concentrations are variable for freshwater discharge and low for saline discharge. The controlling factor is residence time of the groundwater. Freshwater has variable residence times and saline water has shorter residence times indicating different driving forces for fresh and saline water.

Acknowledgements and References

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