Geophysical Research Abstracts
Vol. 13, EGU2011-4168, 2011
EGU General Assembly 2011

Submarine Groundwater Discharge in Taiwan Strait

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The submarine groundwater discharge (hereinafter SGD) into the ocean is the least well quantified component of the ocean's water budget. While it is generally small compared with the other components, such as evaporation, precipitation, and fluvial runoffs, and often considered negligible on the global scale, it is capable of contributing significantly to the regional water budgets in specific areas, especially in confined water bodies like the inland and marginal seas. SGD is also a potentially important pathway for nutrients, as well as pesticides and other pollutants, into the coastal ocean, especially in the regions where the groundwater table is subject to anthropogenic pressures associated with extensive agricultural or industrial land use. One of such regions is the island of Taiwan. It is expected based on the available land geology and hydrology data that the SGD should be the strongest on the southwestern shelf of Taiwan, in the area adjacent to the Pingtung County of the island.

This study was aimed at identifying the locations of SGD on the Pingtung shelf by means of oceanographic measurements, quantifying its influence on the hydrographic conditions in the area, and estimating (to the extent feasible) the volume rates of the discharge. Two high resolution hydrographic surveys of the region, including water and bottom sediment sampling campaigns, were accomplished in February and October of 2009. Water samples were also collected from a number of neighboring on-land groundwater wells.

At some locations in the study regions, the vertical profiles exhibited slight (0.01 to 0.06 psu) but detectable decrease of salinity manifested in the near-bottom portion of the water column. Although convectively unstable, this feature appeared robust and persisted through the 8 months separating the two surveys. The salinity anomalies in the near-bottom layer were often accompanied by maxima of dissolved oxygen and organic matter content, iron and phosphorus concentrations, and minima of turbidity. We attribute these effects to manifestations of SGD.

Another important evidence resulted from chromatography of the water and sediment samples. In February, 2009, the n-alkane composition of organic matter in the water collected from a on-land groundwater well exhibited high content of C24 alkane. A similar anomalously high concentration of C24 alkane was encountered in the bottom sediment samples from the suspected SGD sites. In October, 2009, the dominant marker of groundwater was the C16 alkane.

Based on all these data, we specify the likely locations of the SGD sources in the study area (all of which were restricted to the inner shelf at the depth smaller than 10 m). We argue that the influence of SGD on oceanographic regime in the region is small but observable. It is confined to the lowermost 0.3-1.5 m layer of the water column. The groundwater seepage rates roughly estimated under the assumption of advection-diffusion balance based on the eddy diffusivity values typical for the bottom layer are of the order of 0.1 to 1 gm2s-1. However, in horizontal, the SGD sites are typically organized as relatively small scale (10-100 m) patches, so the larger scale area averages of the discharge rates should be much smaller.