AN INTERNATIONAL PERSPECTIVE ON SUBMARINE GROUNDWATER DISCHARGE

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Abstract

The discharge of groundwater into overlying surface waters, more recently known as submarine groundwater discharge (SGD), has prompted increased research efforts within the past several years attributing to the uncertainty involved in its quantification. Several different techniques have been developed to quantify SGD. In response to these developments, a group of international scientists from various disciplines has formed a working group to evaluate the effectiveness of these techniques. To accomplish this, a series of seepage intercomparison experiments has been initiated. A subgroup representing Cornell Cooperative Extension Marine Program, Suffolk County Department of Health Services, and the State University of New York at Stony Brook is involved in these experiments utilizing an ultrasonic seepage meter to quantify SGD. Preliminary results from the first of these experiments show consistency between ultrasonic, heat pulse, and manual measurements above 10 cm/d and trends appear to agree with those obtained from radon concentrations.

Introduction

The exchange between groundwater seepage and overlying surface waters has become increasingly important due to potential impacts resulting from anthropogenic land uses. Groundwater discharge originates inland and carries with it contaminants or nutrients, dissolved or colloidal, that have the potential to impact the chemical budget of surface water ecosystems. This impact, both chemical and physical may be heightened in smaller bodies of water such as embayments or lagoons due to their limited volume and restricted fluid exchange with the open ocean. In addition to freshwater inputs, groundwater discharge occurs as saltwater re-circulation induced by tides. This discharge contributes to the chemical budget as well, stripping nutrients and contaminants from bottom sediments. A major obstacle in studying submarine groundwater discharge (SGD) is accurate quantification primarily attributing to very low velocities as well as numerous factors that take place in the environment such as tides, benthic flux, etc. Several measurement techniques have recently been developed and some of these have been compared in the field as part of an international intercomparison experiment.

The Scientific Committee on Oceanic Research (SCOR) and Land-Ocean Interaction in the Coastal Zone (LOICZ) have recently sponsored the development of Working Group 112 which includes scientists from several disciplines including marine science, hydrogeology, and chemistry. An objective of this working group is to evaluate and demonstrate methodologies for quantifying SGD. Some of these techniques include: radon-222 (Cable et al, 1996), manual seepage meters (Lee, 1977), ultrasonic seepage meters (Paulsen et al, 2000), heat pulse seepage meters (Taniguchi and Fukuo, 1993;

Krupa et al, 1998) and radium isotopes (Moore, 1996).

Several intercomparisons in numerous geologic environments will be initiated. To date, two intercomparisons were completed. The first was held in the Gulf of Mexico at Florida State University Marine Laboratory in Turkey Point, Fl (Fig. 1). The second was held in Cockburn Sound, just south of Perth, Western Australia. Preliminary results from the first intercomparison are presented below.

Figure 1 FSUML intercomparison site.

Intercomparison Results

The first intercomparison was held in August 2000. Two transects of manual seepage meters were deployed perpendicular to the shoreline. One of these transects included ultrasonic and heat pulse meters alongside manual seepage meters. An example data set from a station along this transect is shown in Figure 2. Ultrasonic and heat pulse data were collected in 15-minute intervals, radon data were collected in one-hour intervals, and manual seepage measurements were collected in approximately one-hour intervals during field collection periods (morning and afternoon).

Data in Figure 2 show similar trends and are in good agreement throughout a 24-hour period for discharge rates above 10 cm/d. Discrepancies are most likely attributed to bottom variability and technique. Radon concentrations were collected approximately 25 meters west of the transect, directly parallel to the seepage meter measurements. Although radon data are not direct measurements of velocity, the trend of discharge determined from relative radon concentrations is similar to the trend measured by seepage meters.

The ultrasonic seepage meter may have an advantage to other methods for measuring very low seepage rates and recharge (negative flux). At high tide (not shown on figure), the ultrasonic seepage meter measured recharge (beginning of data set), while other

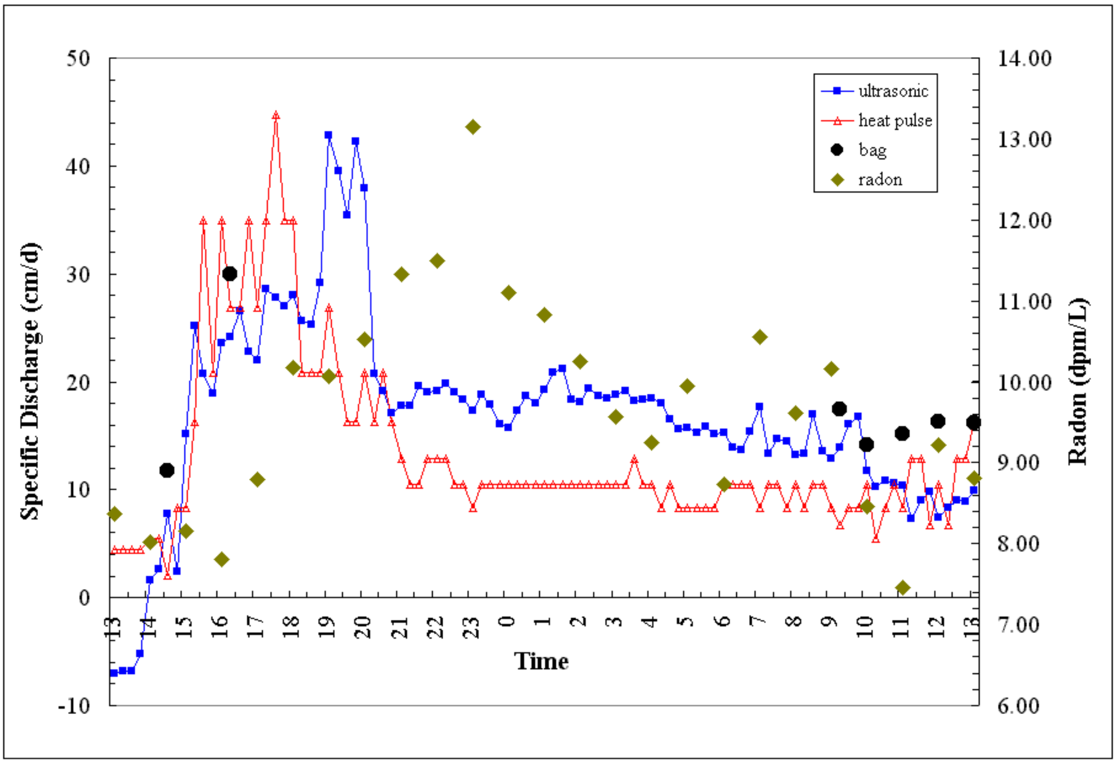

Figure 2 Data set comparing preliminary SGD measurements at one station along a seepage transect (radon and manual measurements, Burnett, 2001; heat pulse data, Taniguchi, 2001).

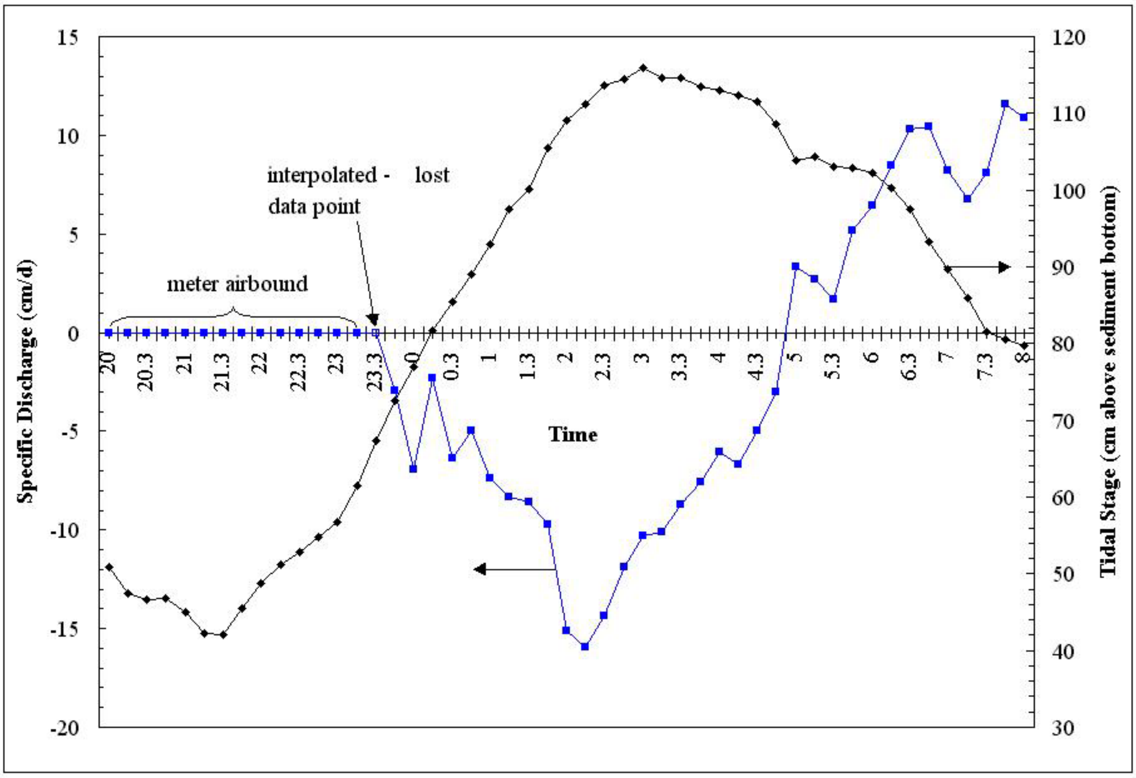

Figure 3 Data set depicting the ability of the ultrasonic seepage meter to collect data in intertidal areas.

methods measured very low discharge rates. An additional advantage of the ultrasonic seepage meter is the ability to measure discharge rates in intertidal areas (Fig. 3).

The intercomparison in Perth was conducted late November – early December 2000 and was hosted by Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO). The experiment was conducted in Cockburn Sound (Fig. 4) and participants included those from the Florida intercomparison as well as several others. Data collected by the CCE/SCDHS/SUNY group show a good correlation to tidal stage. However, data have not been completely analyzed by all participants and therefore cannot be reported as of yet.

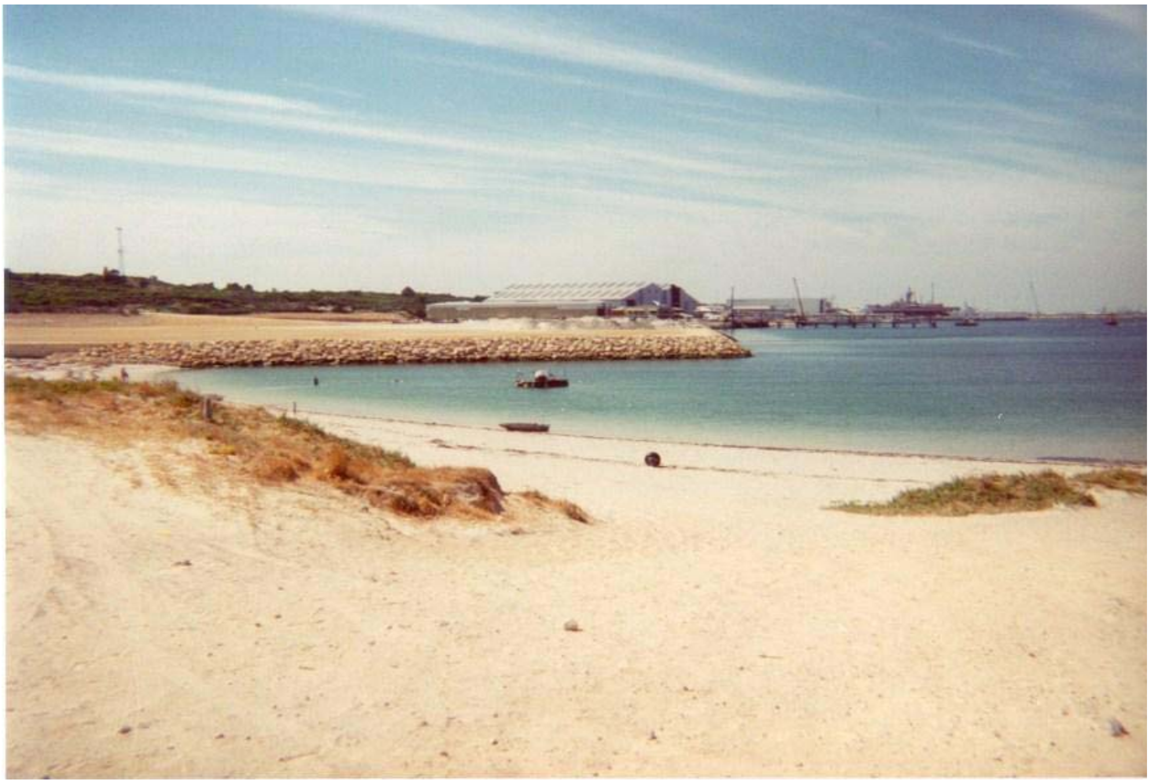

Figure 4 Field site for Perth intercomparison.

Summary and Future Work

Seepage intercomparison experiments have been initiated to compare several methods for quantifying SGD. These experiments act as a means to compare these various methodologies and promote beneficial communication between researchers of several disciplines. Results from the intercomparison at FSU Marine Laboratory show good agreement between four of these methodologies especially at higher seepage rates (above 10 cm/d). Several other intercomparison sites are being considered including eastern Long Island.

The CCE/SCDHS/SUNY group is also involved with SPAWAR Systems Center San Diego to develop an ultrasonic seepage meter that will allow for automated water sampling so that contaminant and nutrient loading can be conducted *in situ*. As part of that project, groundwater seepage measurements have been collected in the Anacostia River, Washington, D.C.

Additional SGD measurements are planned for Long Island to examine contaminant and nutrient loading and possible relationships between SGD and the growth and stabilization of eel grass.

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