GROUNDWATER AND SURFACE WATER INTERACTIONS IN THE TINCHI TAMBA ESTUARINE WETLAND, SOUTHEAST QUEENSLAND, AUSTRALIA

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Abstract

A method integrating hydrogeology and hydrogeochemistry was developed to evaluate the surface water and groundwater interactions on the Tinchi Tamba Wetlands (TTW), a peri-urban estuarine system located in Moreton Bay, Queensland, Australia. TTW is an important part of the Moreton Bay ecosystem for the habitat of juveniles of many commercial shellfish and finfish, and an important nesting site and feeding grounds for both local and migratory birds. Due to its geological complexity, little is known about the hydraulic connectivity within the TTW aquifer and its role in contributing to pollutant and nutrient fluxes into Moreton Bay. This thesis demonstrated how to effectively carry out a hydrogeological study in a complex wetland system using geographic information system (GIS), modelling, and field/laboratory-based geochemical investigations. This thesis also evaluates the strengths, limitations and applicability of some geochemical tracers (major cations, radon and rare earth elements + Yttrium) in wetland hydrology studies.

A field survey and groundwater sampling program was conducted to establish the hydrogeologic framework of the study area. The field works included wetland elevation survey, a drilling program, and a long-term continuous measurement of groundwater levels and river stage monitoring. A rigorous 3D hydrogeologic framework of TTW was built using a GIS software based on collected and existing data. The model revealed that the subsurface of the wetland is composed of a network of sediment layers with different grain-size distribution (gravel to clay sizes) and thickness. The subsurface lithological facies are laterally and horizontally discontinuous, and the basement is found at a depth of less than 20 m form the surface. The model also showed that the patchy gravel deposits found in the river bed channels extend laterally across the wetlands, and may provide hydraulic connectivity between the wetlands and the river. Despite the low-lying setting, hydraulic head data showed that the TTW aquifer's response to tidal fluctuation is limited to less than twenty metres from the river channel.

The geochemical data has provided important information on groundwater sources and processes within the wetland system. The spatial and temporal variability of major cations, radon and rare earth elements + yttrium (REY) concentrations in groundwater and surface water were monitored over 12 months. The hydrogeochemical characteristics of groundwater and surface waters indicated that the TTW aquifer is composed of a wide range of isolated groundwaters with different chemical signatures. The analysis of Sr/Ca and Mg/Ca ratios revealed that the lithological heterogeneity results in significant variability over the hydrological processes which ultimately control the groundwater

maturity/residence time and chemical equilibria in the aquifer. This finding is consistent with radon and REY results. The monitored groundwater radon concentrations showed rapid response to rainfall (concentrations varying between 1 and 13 Bq/L), indicating that the recharge pattern is not evenly distributed across the aquifer. Moreover, the groundwater velocities in shallow groundwaters were calculated using the radon disequilibrium technique, and the obtained results ranging from 0.15-1.58 cm d^{-1}. The spatial and temporal REY variability showed that each water source has its distinctive REY pattern which is mainly controlled by pH and particle-solution interaction. Convex MREE-enriched patterns were observed in groundwaters under acidic conditions (pH<5.5), whereas both MREE- and HREE- enriched patterns were observed at slightly acidic to circum-neutral conditions (pH 6.1-7.5). In the estuary, the measured pH and REY patterns in surface water ranged from 6.85 to 7.73 and showed LREE-depletion relative to HREE, a positive Gd and Y anomaly, and a negative Ce anomaly closely resembling seawater REY patterns. These unique REY patterns were used to delineate the extent of the seawater intrusion. During a recharge event, competition between natural organic matter and iron rich minerals to scavenge REY from the solution lead to REY fractionation in the groundwaters. To the best of the author's knowledge this is the first field observation reporting this phenomenon in the literature.

Overall, the results of this thesis show that the TTW aquifer consists of a very dynamic subsurface hydraulic system. The groundwater chemistry is largely dependent on the vertical and lateral continuity of individual water lenses within the aquifer. Moreover, this thesis demonstrated the importance of an interdisciplinary approach to provide a holistic analysis of the hydrology, hydrogeology and water quality in a complex wetland system.