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Beach Groundwater Dynamics – Field Observation and Analysis

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The purpose of this study is to facilitate better understanding of groundwater environments in sandy beaches. The geological setting of Taniyagi Beach which is featured by a long stretch of sea cliff of Pleistocene soil and the associated gently sloping shore platform motivated the authors to select Taniyagi Beach, a nourished and constructed one, as a field observation site.

Observation of tidally induced beach groundwater fluctuations over a six months period shows the beach groundwater table mostly fluctuated above the mean sea level (T.P=0.0m), indicate the occurrence of groundwater discharge from inland.

Series of tidal and beach groundwater fluctuation data obtained from the study area were subjected to time series analysis by using Fast Fourier Transform. The results show the similarity between tidal and beach groundwater fluctuations with three dominant peaks appearing at the frequencies 0.042 h^{-1}, 0.039 h^{-1}, and 0.081h^{-1}. The period of these dominant cycles correspond exactly to 0.99 day (K1, lunar diurnal constituent), 1.07 day (O1, lunar diurnal constituent) and 0.52 day (M2, principal lunar semidiurnal constituent). The results also demonstrate the amplitude damping and phase shift for each dominant tidal component when they propagate inland. The cross-correlation series between tidal and beach groundwater fluctuations give an idea about a strong correlation at a delay of about 4 hour.

An extensive field observation of beach groundwater fluctuations on a cross-shore array has been conducted during 22-23 June 2005, during which beach groundwater salinity has also been measured. The measurement result clearly indicate that beach groundwater table at a point responded to the tidal fluctuation with a significant phase lag. A simple theoretical framework then be proposed to elucidate the nature of tidally induced seawater penetration into a particulate beach. The theoretical predictions pointed up the amplitude decayed exponentially with a linearly increasing time lag, when fluctuations propagate inland.

The measurement of beach groundwater salinity indicates the groundwater salinity to decreased with increasing distance away from shoreline. Obviously, a clear salt-fresh water interface as describe by the well-known Ghyben-Herzberg approximation, could not apply at Taniyagi Beach. It seems that the penetrating of saltwater is stopped at some point by the discharge of fresh water flow, resulting the mixing zone between salt and fresh water.

The effects of the storm surge induced by typhoon 0514 were also captured in the observation site at Taniyagi Beach. The tide peaked at 01:40 on 7 September 2005, with a storm surge of 0.8m or so. The groundwater fluctuation peaked at 05:36 on the same date, exhibiting some 4 hours lag in response.

Interestingly, the response of suction measurement at the same day conform the rapid rise in the beach groundwater. The sharp drop in the soil suction at a depth of 2.0m from the soil surface reflected the rapid rise in the groundwater table in response to the storm surge due to typhoon 0514. The suction measurements also clarify the effects of rainfall infiltration on the midnight of 6 September to the very early morning of 7 September 2005 were only affected the surface sand.