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Effects of a Changing Climate on Seasonal Variation in Natural Recharge of Unconfined Coastal Aquifers

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Irregular rainfall patterns throughout the year result in the discontinuous natural recharge of coastal aquifers, which has an effect on the size of freshwater lenses present in sandy deposits. The thickness of the freshwater lenses is important in the context of farmland salinization and coastal ecosystems survival. This study presents numerical models that simulate continuous and discontinuous recharge in sandy coastal aquifers and the thickness of resulting fresh water lenses under current and future climate scenarios. Temperature data for the period 1960-1990 from LOCCLIM FAO and from the IPCC SRES A1b scenario for 2070-2100, have been used to calculate the potential evapotranspiration. Potential recharge was defined as the difference between the precipitation and potential evapotranspiration in twelve locations around the world: Ameland (The Netherlands), Auckland and Wellington (New Zealand), Hong Kong, Ravenna (Italy), Mekong (Vietnam), Mumbai (India), New Jersey (USA), Nile Delta (Egypt), Kobe and Tokyo (Japan), and Singapore. These locations have shallow coastal aquifers along low lying coasts and comparable aquifer structure, which is the result of similar sediment supply and deposition in the Holocene as well as by the sea level changes from the last ice age to the present time.
Particular attention has been paid to temporal variations of natural recharge that can vary from continuous recharge throughout the year to discontinuous recharge. The most dramatic reduction in the magnitude of potential annual recharge by the end of this century will occur at lower latitudes (Mumbai, Singapore, Hong Kong and Mekong). The most pronounced change in length of the dry period occurs for Kobe (Japan) and Singapore even though the total annual amount of recharge remains practically the same.
The Influence of variable recharge on the size of freshwater lenses surrounded by saline water is simulated with the SEAWAT model. Models where the recharge is applied continuously throughout the year result in thicker freshwater lenses than models with the same amount of potential recharge applied discontinuously. This difference between the discontinuous and the continuous model is relatively small in areas where the total annual recharge is low (Wellington NZ, Ravenna IT, Ameland NL) but in places with Monsoon-dominated climate as Mumbai, the difference is large.
Under the IPCC A1b climate scenario, only Tokyo and Singapore appear to change from a continuous to a discontinuous recharge regime whereas in the other locations there is merely a change in the amount of annual recharge, mostly reducing the size of the freshwater lenses (Ameland, Mekong, Mumbai, Hong Kong and Ravenna). In low latitudes settings such as Mumbai, Mekong Delta, and Hong Kong, this change is more dramatic with large losses of freshwater. This study shows that it is important to consider seasonal variations in temperature and precipitation in water resources management in the coastal zone, especially in view of climatic change.