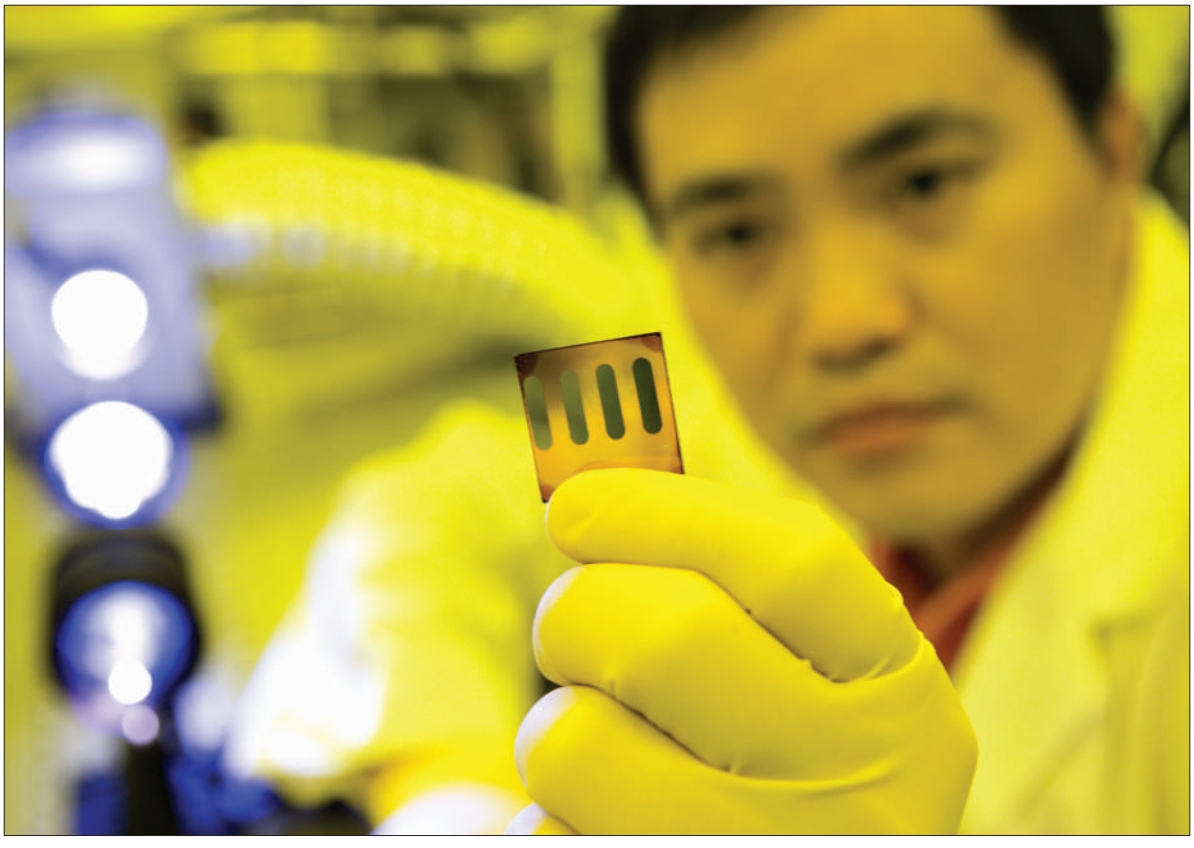

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Small Islands in the Pacific: Duel Between Freshwater and Sea Water

It is said that the first refugees of climate change will come from the Pacific. In the midst of this ocean's tropical regions are scattered 50,000 small islands, 8,000 of them inhabited. They are particularly vulnerable to the impacts of global warming. These effects include rising sea-water levels, drought and diminishing stocks of freshwater. Such water is essential for the life of the fauna and flora and for the human populations' food supplies. On the coral reef islands, freshwater occurs as underground reservoirs, as lenses in balance with the underlying sea water.

IRD scientists and their research partners have investigated the processes behind such lenses, the way they change and develops, their capacity and vulnerability. The team's geological, hydrogeological and geophysical surveys showed that the lens structure and internal processes depend strongly on the island's vegetation cover and topography. This study opens up ways towards assessing what will happen to this resource as a consequence of expected changes in the climate and sea level.

The balance between freshwater and salt water in coastal and island aquifers is unstable and the processes involved are difficult to characterize. With the objective of understanding the processes behind this lens formation on a coral island, IRD and its partners studied the structure and such parameters as the geometry of the reservoir and flow rates.

Terrain Untouched by Human Activity

The experimental sites, islands off Noumea in the South-West lagoon of New Caledonia, are remote from any human activity. The scientists used the geophysical imaging method, electrical resistivity tomography, to study the spatial distribution of the groundwater salinity, in particular on M'Ba island, 1,500 km east of Australia. With this imaging technique the groundwater conductivity can be measured along a vertical section and hence the salinity deduced. The data collected enabled the team to characterize the shape and structure of the underground freshwater reservoir, also to assess the rain-induced groundwater recharge, using a hydrological model based on IPCC climate data including information on cyclones.

Salt Concentration Rises in the Island's Centre

Contrary to the results anticipated, this salinity proved to be intensively concentrated in the middle of the island rather than on its edges, which are the usual zones of sea water-freshwater interaction. Complementary analyses derived from a hydrogeological model have revealed the importance of vegetation cover and the island's topography in the spatial distribution of the salinity in the groundwater reservoir, located 3 or 4 m below the ground surface, and the mechanisms of this island aquifer.

Plant transpiration causes the saline water to evaporate from the roots. This process concentrates salt in the freshwater lens at the island's centre, as the plant cover is denser and longer established there. For example, a coconut palm draws up 300 L of water per day. Conversely, in the recent coastal sand dunes, the vegetation is much more sparse and the groundwater salinity remains less concentrated. Moreover, the freshwater lens recharge induced by rain is minimal in the island's centre, again owing to the density of the vegetation and the greater degree of soil development. However, it is maximal in the sand dunes near the sea. This explains an accentuation of the phenomenon, with dilution of the underground water on the island margins and concentration of salt in the central areas.

The island's morphology and internal structure also have a strong influence on the variable groundwater recharge

rate along the island's transverse axis. This island was constructed by the piling-up of layers of material from sand-dominated reef formations, lying about 30 m above a complex substratum. It is geologically representative of many of the small islands or atolls in Noumea lagoon and, more generally, small coral reef islands of the Indo-Pacific region.

In conclusion, cross-validation of the geoelectrical models and the groundwater models is useful for 2D and 3D mapping of the salinity distribution of the island's groundwater aquifer. This analysis can help assess the water resources of the Pacific coral islands in the context of the search for indicators of vulnerability in the face of global climate change and bring significant evidence concerning future changes and developments in coral islands, which contributes to the survival and development of numerous terrestrial and marine species and of their inhabitants.

These investigations were conducted jointly by the teams of the research units LOCEAN (UMR IRD/Université Paris VI/CNRS/MNHN), CEREGE (UMR IRD/CNRS/Collège de France/Universités Aix-Marseille 1 and 3) and Université de la Réunion and Université d'Avignon, as part of the INTERFACE project subsidized by the French Agence Nationale de la Recherche (ANR) (programme Vulnérabilité, Milieux, Climats).

Jean-Christophe Comte, Olivier Banton, Jean-Lambert Join, Guy Cabioch. Evaluation of effective groundwater recharge of freshwater lens in small islands by the combined modeling of geoelectrical data and water heads. Water Resources Research, 2010; 46 (6): W06601 DOI: 10.1029/2009WR008058