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Rarotonga: groundwater-surface water interactions in sustainable water management

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Rarotonga is a picturesque volcanic island with a broad fringing reef. Over the past 20 years, its appearance remains the same, but now only dead coral frames and sea cucumbers populate large portions of the reef lagoons. This same time span coincides with a boom in the tourist industry on the island and construction of many beachside hotels. Without a centralized sewer system, both old and new residences rely on septic systems to manage effluent, where almost all septic systems are installed in sandy sediment no more than 1 km from the coast and generally within 200 m. Together with pig farming, septic systems contribute large quantities of nutrients into the lagoon that have supported algal blooms that overgrow corals, eventually destroying fish habitat and killing the corals. Both surface water and groundwater inputs into the lagoon contribute to this nutrient flux. We investigate the groundwater flowpaths into the Muri fringing reef on Rarotonga, Cook Islands. Electrical resistivity surveys in the lagoon indicate freshwater seeping well beyond a classically defined seepage face at the shore. Discrete plumes of fresher groundwater also occur in the alongshore direction, suggesting preferential flowpaths. On land, the shape of the local freshwater lens reflects the presence of variable geology controlling the freshwater-saltwater mixing zone. Despite spatial variability in the distribution of fresher groundwater, high frequency monitoring of groundwater levels suggest mainly upward and seawards discharge. We hypothesize that the presence of high elevation alluvial fans and terraces allows for groundwater recharge that is substantial enough to support discharge far into the reef, even in the absence of recharge in the high mountains or fracture flow directly to the reef. These long flowpaths from high elevation could flow under nutrient-rich local groundwater flows and may not contribute to the eutrophication of the lagoon. However, fresher groundwater plumes in the nearshore extend into the lagoon and may be local vectors for nutrient transport. Sustainable management and rehabilitation of the reef lagoon requires a sufficiently detailed understanding of multi-scale subsurface structure and groundwater flowpaths to prevent continued nutrient loading.

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