

# **Understanding Submarine Groundwater Discharge (SGD): Major Challenges, Limitations, and Recommendations for Sustainable Management**

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This study examines the underreported yet vital role of submarine groundwater discharge (SGD) as a sustainable water resource, particularly for tropical countries grappling with water scarcity. It also explores the influence of SGD on oceanic biogeochemical cycles, nutrients, trace metals, and human impacts. Through a detailed review of 1,628 publications from 2000 to the present, we analyze the fragmented global research on SGD. Our synthesis identifies diverse methodologies and highlights the challenges and limitations in estimating SGD fluxes. Key challenges include inconsistent sampling strategies, modeling uncertainties, spatio-temporal discharge variations, extreme weather impacts, and difficulties in assessing inaccessible regions such as mangroves and tidal flats. Limitations stem from inadequate coastal aquifer data, geological understanding, and historical hydrological records. We propose new methodologies for SGD quantification, informed by literature analysis. Our recommendations include targeted SGD assessments in high-discharge potential areas, the establishment of widespread monitoring networks, and the enforcement of stringent groundwater management policies by regional authorities. The insights provided in this paper are instrumental for policymakers and water conservationists in strategizing water management, pollution mitigation, and the judicious extraction of SGD, fostering sustainable practices in water-scarce regions.