Transport of solutes through hydraulically and chemically heterogeneous sediments of the Bengal Basin

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The sedimentary history of the Bengal Basin has determined the structure and pattern of an aquifer system more than 250, 000 km^2 in area and up to 16 km deep. Rivers carrying huge sediment loads from the Himalayas have deposited and eroded floodplain sediments through avulsion cycles; this combined with transgressions and regressions of sea level have produced complex stratigraphic sequences that make up a highly heterogeneous hydrogeologic system.

The sedimentary architecture plays a major role in determining groundwater flowpaths and subsurface transport of solutes. The depositional history also contributes to sediment chemistry, which can affect sorptive properties and other biogeochemical reactions. The effects of hydraulic and chemical heterogeneity in the Bengal Basin are considered generally and in two specific contexts: sustainability of arsenic-safe groundwater resources and groundwater salinization in the coastal zone.

Widespread contamination of shallow groundwater with As concentrations above world health standards occurs throughout much of the lower Bengal Basin, in Bangladesh and West Bengal, India. High concentrations are limited to the upper 100m in many areas; thus deep groundwater has been targeted as a mitigation option. The sustainability of deep resources depends on hydraulics and chemistry: both flowpaths and sorption may reduce vulnerability. Simulation of these protection mechanisms on a regional scale assuming basin-wide effective properties suggests a sustainable resource if properly managed. However, small-scale simulations that incorporate explicit heterogeneity in physical and chemical properties suggest that As migration may be highly variable, with short breakthrough times in some areas.

In the coastal zone, groundwater resources are threatened by salinization, which may become worse as sea level rises in the future. Currently, fresh groundwater exists at depth (>~200m) beneath a brackish zone. Mechanisms and timescales of salinization, both lateral and vertical, were investigated with variable-density numerical models. Subsurface salinity distributions, particularly in transient states, are highly dependent on heterogeneity in hydrogeologic properties as well as the history of sea level and storm surge inundations.

Geologic and hydrologic control of porewater chemistry and submarine groundwater discharge into Indian River Bay, Delaware

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Fluxes of nutrients transported by groundwater contribute to eutrophication in Indian River Bay, Delaware. Fresh and saline groundwater discharge rates and porewater salinity depend on system hydrology, mechanisms of groundwater-baywater exchange, and geologic heterogeneity. The interactions between these factors produce complex flowpaths and mixing that may affect nutrient bioavailability by causing biogeochemical transformations prior to discharge.

The hydrology, stratigraphy, subsurface salinity and N-species distributions, and submarine groundwater discharge (SGD) rates and patterns were characterized at Holts Landing State Park. A buried paleochannel and near-bottom confining beds, expected to control both flow and mixing in the subsurface, were located with offshore chirp seismic profiling and coring. Electrical resistivity surveys and vertical porewater salinity profiles to depths of up to 17m indicate that a zone of freshened groundwater extends hundreds of meters offshore. Onshore and offshore multi-level wells were sampled to obtain a 3D distribution of N species in the subsurface. SGD measurements from Lee-type seepage meters were collected to better understand discharge salinity, rates, and spatial and temporal SGD patterns. Measurements indicate that SGD is primarily saline, and that the lowest salinity groundwater discharges near the shoreline in the area away from the paleochannel feature and along the submerged paleochannel/interfluve boundary. Hydraulic head and permeability measurements in onshore and offshore wells provide information on site hydrology and temporal change. Data were incorporated into a groundwater flow model of the Indian River Bay watershed, which provides a larger-scale estimate of groundwater flowpaths and SGD fluxes and patterns along the entire bay shoreline.