area aquifers are saline at all depths. The coastal saline zone increases in width from 5-10 km in the northeast to 60 km in Mahanadi-Brahmani deltas. The well yields vary from 50 m³/hr to 270 m³/hr. Transmissivity values are in range of 106-825 m²/d. In contrast in the Godavari-Krishna deltas of Andhra coast groundwater is fresh only in the shallow water table zone generally within 20-25 m depth. In Tamil Nadu coast, groundwater is saline to brackish from a few kilometers to 40 km from the shore. A number of aquifer zones occur within a depth of 500 m, but often with salinity hazards. Tertiary Cuddalore sandstones form the most productive aquifers. Thick confined freshwater zones occur in this formation right on the coast in the depth range of 160-200 m at Portonovo, and 250-450 m at Karaikal. Tubewells yield 100-300 m³/hr. Transmissivity values are in the range of 1300-1700 m²/d. Pliocene and Quaternary aquifers occurring in shallow depths yield up to 50 m³/hr.

Detailed studies in Kaveri delta have shown that the confined Burdigalian Main Flowing zone recharges the shallow aquifers by upward leakage through semiconfining overlying formations. The high upward pressure of this zone prevents downward leakage of saline water from the overlying section. In Kerala, coastal salinity ingress is limited to 0.4 km from the shore. Tertiary Vaikom and Warkalli aquifers underlying the Quaternary alluvium form the most potential aquifers yielding up to 57 lps. Transmissivity values range from 22-3885 m²/d. However these aquifers are brackish in the southern parts of the coastal belt due to dissolved salts from the aquifer matrix.

In Gujarat, aquifers are affected both by seawater invasion through tidal creeks up to 4-6 km or more from the shore, and also by the inherent salinity of marine Tertiary formations. Alluvium comprising blown sand, miloillitic limestones and floodplain deposits varies in thickness from a mere 23 m near the coast to 149 m in the inland areas constituting multilayered aquifer system and yielding from less than 75 to 150 m³/hr. In Saurashtra coast, cavernous miloillitic limestones, 5-50 m thick, constitute the main aquifer yielding 50 m³/hr. The confined aquifers are all saline below 100-200 m depth.

Barring the saline aquifers, groundwater in the coastal areas is generally potable, and belongs to C1S1, C2S1, C3S2, and C3S1 irrigation classes. Groundwaters are usually of Ca-Mg-HCO$^-$, Na-HCO$^-$, Na-C1 or mixed types. Base exchange in the clays, sulphate reduction and seawater contamination influence groundwater quality. The chloride content varies from 14 to 18980 mg/l. Fresh Na-HCO$^-$ waters sometimes occur close to the coast, while saline Na-C1 waters occur far inland. High iron, fluoride, nitrate, sulphate occurring in pockets in the coastal areas of Orissa, West Bengal, Tamil Nadu and Gujarat, and high arsenic in parts of West Bengal render groundwater unfit for use.

Indiscriminate pumping has resulted in groundwater overexploitation and seawater ingress with salinisation of aquifers and landward movement of saline water-freshwater interface for several kilometers in Minjur area of Tamil Nadu, in parts of Pondicherry, and Saurashtra coast. Also groundwater-modelling studies in Haldia area indicate that the groundwater pumpage (80-110 MCM in northern area and 12 MCM in Haldia area) has reached its saturation limit, and further escalation in groundwater draft may trigger saline water invasion. Kolkata is also an example where excessive groundwater pumpage has created a cone of depression threatening saline water invasion from the aquifers in the south, and possible land subsidence estimated to be of the order of 3.33-13.78 mm/year. In parts of Greater Mumbai borewells yield saline or brackish water due to seawater ingress.

The basic problem in groundwater management is its development without disturbing the salt water/freshwater interface. This may be achieved by economical use of groundwater and limiting groundwater draft, through artificial recharge of overexploited aquifers, conjunctive use; as also adoption of optimal groundwater development strategies based on detailed surveys, exploration and water balance studies. Enactment of groundwater legislation to control groundwater extraction is need of the hour.

WEBSITE FOR SCHOOL TEACHERS

The Joint Earth Science Education Initiative Website – www.jesci.org – has recently been updated and contains more than 40 activities to help teachers of biology, chemistry and physics to teach Earth Science in more interesting, interactive and dynamic ways. This has been well received in UK and also has been made available in a CD.

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