CHAPTER 2

REVIEW OF LITERATURE

2.1 GENERAL

Hydrogeochemical characterization and solute transport studies lead to understanding of aquifer pollution in coastal aquifers. Such studies carried out by various researchers in the world are reviewed in this section. This chapter focuses on the local relations among groundwater chemistry, geology and solute transport.

2.2 HYDROCHEMISTRY

Geochemical studies of waters have been utilized to help define the hydrogeology of an area. For example, the Amazon River waters were examined geochemically and the controlling factors on the water chemistry were determined to be substrate lithology and soil geochemistry in the erosional regime (Konhauser et al 1994). The contribution of groundwater to the chemical character of stream and river waters was studied using water chemistry (Ferguson et al 1994; Williams et al 1990; Dethier 1988). Vitousek (1977) suggested that in humid climates the process of evaporation-crystallization is replaced by evapo-transpiration. Further, he explained that sulphate and chloride are controlled by precipitation and evapo-transpiration; sodium, silica, calcium and magnesium are controlled by mineral weathering, while nitrate and potassium are controlled by plant uptake.
Hudson and Golding (1997) reported that bicarbonate, silica, calcium and sodium are derived from the weathering of plagioclase, while magnesium and potassium are derived from the relatively less weatherable feldspars. Scheytt (1997) investigated seasonal and temporal variation patterns of groundwater chemistry and depth-wise chemical composition of groundwater at various locations. Near the water table, groundwater was mainly influenced by recharge of rainfall. Martinez and Bocanegra (2002) identified that cation exchange processes and calcite equilibrium are the important hydrogeochemical processes that control groundwater composition in the Mar del Plata aquifer, Argentina.

Elango et al (2003) identified carbonate weathering, silicate weathering and ion exchange processes to be responsible for groundwater chemical composition in a part of Kancheepuram District, Tamil Nadu, India. Thus, knowledge on hydrogeochemical processes that control groundwater chemical evolution could lead to improved understanding of hydrogeochemical characteristics of an aquifer. Elango (1992) had already studied the hydrogeochemical nature of the multi-layered aquifer of North Chennai, and had brought out the relation of groundwater recharge to flow mechanisms. Elango et al (1999) carried out extensive work on the hydrogeochemical nature of groundwater in an intensively irrigated region of Kancheepuram District, Tamil Nadu, South India. They also emphasized the need for regular monitoring of groundwater quality. Mohan et al (2000) attempted to assess the suitability and causes for deterioration of groundwater quality in the Naini industrial area of Allahabad District, Uttar Pradesh, by evaluating the hydrogeochemical nature of the groundwater. Cerling et al (1989) used cation exchange of $\text{Ca}^{2+}$ ions with $\text{Na}^+$ ions to explain the aqueous chemistry of waters draining shale bedrock regions. Clay mineral cation exchange properties also were studied in an effort to understand soil development in a montane area in New Zealand (Harrison et al 1990).
Agrochemicals are the main sources of nitrogen, and other organic and inorganic contaminants in the groundwater regime. Several authors have reported the presence of agrochemicals in soils (Muir and Baker 1978). Chandrasekharan et al (2007) studied the variability of soil–water quality due to the effect of tsunami in the coastal belt of Nagapattinam District, Tamil Nadu. Singh (2007) has recently studied the impact of the earthquake and tsunami on the groundwater regime at Neill Island (South Andaman).

2.3 MINOR IONS, HYDROGEN AND OXYGEN ISOTOPES

Moller et al (2007) have studied the characteristics of regional aquifers and their recharge areas with the help of changes in the concentrations of major, some minor and trace elements occurring in both surface and groundwater. Pillsbury and Byrne (2007) studied the spatial and temporal variations in the rivers with the help of major ions, CO$_2$-system chemistry and nutrients concentrations. Bianchini et al (2005) studied the hydrochemistry of the high-boron groundwater of the Cornia aquifer by interpretation of the concentration of major ions, selected minor and trace elements (B, Br, F and Li).

The hydrochemistry of minor elements - bromine (Br), boron (B), strontium (Sr), environmental stable isotopes (18O and 2H) together with major-ion chemistry (chloride, sodium, calcium) - have been used to constrain the sources, relative age, and processes of salinization in the continental terminal aquifer in the Saloum region (Faye et al, 2005). Valentino and Stanzione (2003) studied the source processes of the thermal waters from the Phlegraean fields by means of the study of selected minor and trace elements distribution. Kim et al (2003) studied the hydrogeochemical and isotopic evidence of groundwater salinization in a coastal aquifer: a case study in Jeju volcanic island, Korea. Zheng et al (2005) attempted to use deeper aquifers as
drinking water sources with the help of geochemical and hydrogeological contrasts between shallow and deeper aquifers in two villages of Araihaazar District, Bangladesh.

Isotopes of hydrogen and oxygen are used to determine processes related to water flow and sources. Researchers have determined the relative amount that groundwater contributes to stream flow in various environments and during different seasons (Sklash et al 1976; Sklash and Farvolden 1982). Maule et al (1994) examined soil waters near Edmonton, Alberta, Canada, and determined that waters from snow-melt contributed about 27% to the soil waters, whereas the groundwater contributed 44% to the soil water. Lateral flow of waters from nearby depressions may cause the snow-melt waters to pool before entering the soil, leading to the 27% snow-water portion. McCarthy et al (1992) used δD and δ¹⁸O values to show that the isotopically lighter Columbia River waters contribute 50% of the water pumped from municipal wells about 1 km away, near Portland, Oregon, in the USA.

Werner et al (1991) argued that the simplistic model of two waters, old water and new water, wherein the old water is being forced out by the new water, is too limited. They claimed that it is a difficult task to recognize different waters because the distinctive isotope values become muted very shortly after entering the soils of an area.

Changes in oxygen and hydrogen isotope composition of water from the Aswan High Dam Lake in Egypt were examined to determine the extent of evaporation (Aly et al 1993) and, in the Gaula River catchment, lake waters were found to have enriched δD and δ¹⁸O values relative to the surrounding streams and rivers due to evaporation (Bartarya et al 1995).
Dansgaard (1964) discussed altitudinal and latitudinal effects on the isotopic composition of precipitation over continents. Abundances of $^{18}$O and $\delta D$ decrease with increasing altitude on the windward side of mountains. Typical gradients for $\delta^{18}$O vary from -0.15% to -0.5‰ per 100 m, and for $\delta D$, -1.5‰ to 4‰ per 100 m (Yurtserver and Gat 1981). This is not likely to be a controlling factor for the $\delta D$ and $\delta^{18}$O values on the reserves because the reserve lies on the leeward side of the mountains. The D and $^{18}$O contents decrease with increasing length of storm path due to Rayleigh isotopic fractionation. The D and $^{18}$O contents also usually decrease with increasing latitude because of larger temperature gradients with distance. This process could affect isotope composition of waters on the reserve as the land lies far inland from any major body of water.

2.4 FLOW MODEL

Reynolds and Spruill (1995) showed that a groundwater model can be used for groundwater management studies by evaluating the effects of stresses on the aquifer system in North Carolina Coastal Plain, USA. Fernando and Gerardo (1999) used groundwater flow modeling technique to assess the impact of urbanization of Aguascalientes, Mexico. They also recommended the possible and best place for relocating the well field. Gnanasundar and Elango (2000) carried out regional simulation of the hydraulic head in the coastal sandy aquifer of southern Chennai, India.

2.5 SOLUTE TRANSPORT MODEL

Solute input-output studies had been undertaken using geochemical characteristics of water in sub-alpine and alpine areas of Colorado (Cleaves et al 1970). In a long-term weathering model, they determined that roughly 50% of the erosion occurring in the catchment could be accounted for by the
solute content of the waters. The erosion was predicted to be due to chemical solution of kaolinite, vermiculite, biotite and oligoclase. Mast et al (1990) looked at stream water solute levels and solute levels in precipitation, in a high-alpine setting, to determine the weathering processes affecting the area. They concluded that solute increase in the surface waters could be linked to bedrock weathering in the area through water-rock interactions. Attempts to determine the chemical changes that occur in an alpine-sub-alpine stream during spring snow-melt and runoff illustrated the irregular name of the solute inputs to the streams (Denning et al 1991). High dissolved organic carbon in soil lysimeters near the streams showed that the soil waters get flushed into the streams by the initial snow-melt, carrying with it an initial pulse of higher total Dissolved Solids (TDS) waters into the stream. Soil pore water chemistry has been used to trace groundwater movement, and to determine that the acidification of waters and soils are linked to particular temporal inputs from snow-melts and runoff (Arthur and Fahey 1993). Yakirevich et al (1998) carried out extensive studies on modeling the movement of solute in the Khan Yuins area of the Gaza Strip coastal aquifer, Israel. They showed an increase in chloride concentration with inward movement of the saline water with rapid development of the urban areas. Rao and Hathaway (1989) used the solute transport modeling technique to explain the changes in the chloride ion concentration of the fluid phase due to pumping.

However, there are no reports on the impact of tsunami on groundwater quality. Similarly there are no studies on the seasonal variation in groundwater quality after such major disasters. Hence, in the present study, such a work has been carried out in the Kalpakkam coastal region, Tamil Nadu, India.