This work is related to hydrogeological and hydrogeochemical studies in the lower Palar River basin, southern India, located 75 kms south of the Chennai city (formerly known as Madras). The objectives of the study were: to determine the response of the aquifer system to variations in rainfall; to identify the hydrogeochemical characteristics of the groundwater and geochemical processes; to develop a three-dimensional mathematical model to simulate the regional groundwater flow and solute; and to assess the behaviour of the aquifer system under different hydrogeological stresses in this area.

The study area (392 km²), experiences subtropical climate with an average rainfall of 1167 mm/year (average from 70 year rainfall data). Two rivers traverse the terrain, of which Palar is the major river and it bisects the area into two halves. There are numerous ponds/lakes, of which Madurantakam Lake is the largest. Geology of this area is characterised by charnockites and granitic gneiss of the Precambrian age and Recent alluvium. The alluvium is found along the present and palaeo channels, while the charnockites and granitic gneisses form the basement rock. The alluvium and weathered rock (charnockites and granitic gneiss) function as the aquifer system. The upper alluvial layer is characterised by alluvium of recent age and consists of sand, gravel, sandy clay, silt and clay. The lower layer consists of weathered charnockites and the granitic gneiss. Groundwater is found to occur in these layers in an unconfined condition.
Sampling and monitoring of groundwater level were carried out in 39 representative wells, for a period of 20 months from April 2000 to December 2002 from this area. The groundwater samples collected were analysed for in situ EC, pH, Eh and temperature using the portable instruments. Major cations such as Ca, Mg, Na and K and the anions such as HCO₃, CO₃, Cl and SO₄ were analysed in the laboratory. Characterisation of the subsurface was made using Triangulated Irregular Networking (TIN) method using the borehole module of the Groundwater Modelling Systems (GMS). TINs of this region were generated using the inverse distance weighted interpolation method based on the assumption that the interpolating surface should be influenced mostly by the nearby points and less by the more distant points. Geochemical reactions taking place in the aquifer system along the flow paths were modelled using the geochemical reactions modelling technique. Inverse modelling that produces mineral mass transfer and that can account for composition variations observed in the aqueous system was used in the present study. Inverse modelling software NETPATH, which is capable of calculating geochemical mass transfer was used to determine and quantify the rock-water interactions taking place in the study area. Hydrogeological/groundwater modelling was carried by solving the partial differential equation defining the general 3-dimensional groundwater flow by finite difference method. The computer software program MODFLOW developed by United States Geological Survey (USGS) was used of this purpose. The pre and post processor, developed by the United States Department of Defense, Groundwater Modelling Systems version 3.1 (GMS) was used to give input data and process the model output.
Hydrogeological investigation indicates that rainfall and lakes are the major source for recharge of groundwater in the study area. Maximum rainfall recharge rate of 35-40% was estimated in alluvial plains. Hydrogeochemical studies indicate that groundwater of the study area is dominated by Ca and HCO₃ ions. The order of dominance of the cations in the study area is Ca > Mg > Na > K and of the anions is HCO₃ > Cl > CO₃ > SO₄. Evaporation/evapotranspiration, cation exchange and silicate weathering are the important processes controlling the major ion chemistry of the study area. High concentration of HCO₃ in the study area is attributed to silicate weathering and recharge processes. The other important process identified includes the dissolution/precipitation of calcite, dolomite, sodium chloride and K-montmorollite.

A groundwater model was developed to simulate the groundwater flow and solute concentration in the study area. The model simulates groundwater flow and solute over an area of 392 km² discretised by 70 rows, 40 columns, and 2 layers. The study area is enveloped by topographic divide which is considered as a no flow boundary, except for the northwest side. It is bounded by Bay of Bengal in the east, considered as constant head boundary, while the northwestern boundary has a variable head. The model was calibrated in steady and transient state conditions. The model simulated groundwater flow in a transient state condition for a period of 12 years from 1991-2002, and solute concentration for a period of 20 months from April 2001 to December 2002. The model was used to forecast groundwater flow and solute concentration under various scenarios such as over pumping, less recharge, effect of the subsurface barrier and variations in rainfall concentration of solutes. The forecasted results indicate that this aquifer
system is stable at the present rate of pumping, excepting for a few locations along the coast where the groundwater head drops from 0.4 to 1.81 m below sea level during the dry seasons.

Thus, this research generated comprehensive primary data, which was used to characterize the hydrogeology and hydrochemistry that formed a basis to develop a hydrogeological model. The model developed can be used as an effective tool to sustainably manage this aquifer system. The model can also be effectively used to study the effect of any future industrial/agricultural requirements on the groundwater condition.