CHAPTER – IV

HYDROGEOLOGY

4.1. GENERAL

Hydrology is a science, which deals with water. It mainly deals precipitation, surface runoff, evaporation, infiltration, hydrological cycle and water balance. Hydrogeology is the science to study the subsurface water and associated geological formation, particularly the occurrence & movement of ground water with various geological formations. The amounts of precipitation, the percentage of infiltration are the important parameters to support the availability of water resource in a region. The occurrence of ground water in Thalaivasal block is mainly controlled by geology, geomorphology and secondary porosity such as joints and fractures.

4.2. RAINFALL

Precipitation is the major source of water for surface and subsurface ground water resource. The water resource in Thalaivasal block is mainly depends on the amount of rainfall received in particular year. The rainfall data for 22 years (1989 -2010) were collected from State Ground and Surface Water resource data centre at Chennai. Viraganur is the only rain gauge station located within the Thalaivasal block. However, the block is influenced by different level of precipitation, which can interpolate from the nearby rain gauge station, Hence in the present work, in addition to Viraganur rain gauge station, few more stations, such as Attur, Gangavalli, Perambalur and Kallakkurichi located nearby Thalaivasal block were considered. The annual average rainfall of Viraganur rain gauge station is about 696 mm, which represent for major part of the block. The Attur rain gauge station is located 17 km from Thalaivasal in NW direction. The Kallakkurichi rain gauge station located 28 km in NE direction. The Perambalur rain gauge station located 26 km in Southern direction. The Gangavalli rain gauge station located 15 km in SW direction. The annual
average rainfall of Attur, Kallakkurichi,Gangavalli and Perambalur are 807 mm, 896 mm, 599 mm and 859 mm respectively. The study area being received rainfall from four seasons, ie NE monsoon, SW monsoon, winter and summer seasons. The maximum amount of rainfall received from NE monsoon, next SW monsoon contributes significant amount of rainfall to the block, sometimes summer season contribute appreciable amount of rainfall (4 mm to 200 mm). The critical analysis of rainfall data is required to understand the availability of water resource condition in a region. For that, the collected rainfall data were plotted in the form of graphs and chart. The histogram plots of Viraganur rain gauge station were plotted as five year average rainfall for various seasons (Fig 4.1).

Except in the year's 2004 -2008 average, the rainfall during winter season is negligible. The five year average rainfalls vary from minimum of 139 mm and maximum 866 mm. It shows the entire block receiving less rainfall than district average or state annual average rainfall. The year 1999 and 2008 received very less rainfall and severe drought conditions were existed in the block.

4.2.1. Rainfall Trend

The moving average rainfall method is useful to understand the trend of rainfall over the period. In the present study, three years moving average rainfall method is adopted to predict the flourishing, normal & drought years in the block. The three years moving average is plotted for Viraganur raingauge station from 1991 to 2008 for about 18 years time period. From the plot, it is observed that the declining trend of rainfall pattern is noticed from 1999 to 2004. During this period, the rainfall fall below 400 mm (Fig 4.2). It is understood that the year 1999 to 2004 are consider as drought period. The year 1991 to 1998, 2005 to 2007 are normal years. The last 18 year rainfall data have indicated that there is no flourishing year of rainfall in the block.
Figure 4.1. The histogram plots of Viraganur rain gauge station plotted as five year average rainfall for various seasons.
Graphical Representation of 3 Years Moving Average Rainfall (1991-2008)
Raingauge Station - Viraganur

Rainfall in mm

Years


3 YEAR MOVING AVERAGE  Average

Figure 4.2. Three years moving average rainfall for Viraganur raingauge station
Further it is understand that, the rainfall pattern is changing above normal and below average condition once in seven years. Gangavalli is the next raingauge station located near to the block which receives an annual average rainfall of 599 mm, similar to Viraganur rain gauge station. Gangavalli also received maximum amount of rainfall during NE monsoon. The moving average annual rainfall plotted for every three years from 1989 to 2008 has indicated that during 1999 to 2003, this station received very low rainfall that is 100 mm (Fig 4.3). Once again the moving average rainfall plotted for 20 years period has indicated an alternate drought and normal rainfall condition once in four years (Fig 4.4).

The area of influence of rainfall by Attur raingauge station is also significant, since it is located about 17 km from Thalaivasal block from NW direction. The average annual rainfall of Attur raingauge station is 807 mm, which is higher than the other two stations. The five years annual average rainfall plotted for 20 years from 1989 to 2008 has indicated that more or less normal trend and about 25% deviation from the normal rainfall also have drought period observed during 1999 to 2004 (Fig 4.5 and Fig 4.6). However the moving average closely fit with normal rainfall condition.

The other two raingauge stations Kallakkurichi and Perambalur have less influence on depth of precipitation in Thalaivasal block. However, since these stations located around the block and in different direction, it is considered in overall assessment in the rainfall data analysis. The moving average rainfall plotted for three stations have also indicated higher depth of precipitation (Figures 4.7, 4.8, 4.9, 4.10), when compare to other stations. The moving average rainfall for the Thalaivasal block has shown in Figure 4.11, which indicates the average rainfall for 20 years is 700 mm and the drought period fall 1999 and 2000. The year 1995 to 1998 and 2005 to 2008 support just above normal rainfall (Fig 4.11).
Figure 4.3. The Histogram plots of Gangavalli rain gauge station plotted as five years average rainfall for various seasons
Graphical Representation of 3 Years Moving Average Rainfall (1991 - 2010)
Raingauge Station - Gangavalli

Figure 4.4. Three years moving average is plotted for Gangavalli raingauge station
Figure 4.5. The Histogram plots of Attur rain gauge station plotted as five year average rainfall for various seasons
Figure 4.6. Three years moving average is plotted for Attur raingauge station
Figure 4.7. The Histogram plots of Kallakkurichi rain gauge station plotted as five year average rainfall for various seasons.
Figure 4.8. Three years moving average rainfall is plotted for Kallakkurichi raingauge station
Figure 4.9. The Histogram plots of Perambalur rain gauge station plotted as five year average rainfall for various seasons
Figure 4.10. Three years moving average rainfall is plotted for Perambalur raingauge station
Figure 4.11. Three years moving average rainfall is plotted for entire Thalaivasal Block
4.3. WELL INVENTORY SURVEY

In the integrated hydrogeological study, field investigation is an important task to understand the subsurface lithology and water level condition. In addition to that, existing bore hole lithological data water level data and detailed well inventory survey (Plate –1) were carried out in the entire Thalaivasal block. Though the block covered by limited lithology, in charnockite and gneissic rock, hydrogeological condition is vary at different locations. Well inventory surveys were conducted at 50 dug well locations. It covers measurement of thickness of soil, weathered zone, fracture zone, depth to bed rocks and water level. In addition to that, bore hole lithological data available at State Ground Water Department were collected.

4.4. WATER LEVEL

The ground water in Thalaivasal block occur under unconfined to semiconfined aquifers system. The water level and fluctuation of water table condition has controlled by monsoon rainfall, recharge condition and nature of weathering. During well inventory survey, water levels were collected at different locations. The state Ground Water department has maintained eight observations wells at different parts of the blocks (Table -1). The water level for observations wells for 30 years from 1976 to 2006 were collected and utilized for further data analysis. The 30 years annual average water level for observation wells located within the block were plotted as graph (Fig 4.12). Overall, the shallow water level in the basin is about 4 m bgl and highest (deepest) water level reaches upto 20 m bgl. The average water level for entire block for 30 years is estimated that 8m bgl. The water level graph has indicated that the locations nearby Vashita nadhi has relatively shallow water level condition, however locations further in the north and south deeper water level condition observed such variations of and water level indicates that recharge contributed by river during flow condition.
### Table 4.1 List of observation wells maintained by State Surface and Ground Water Data Centre

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Well No.</th>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>53551</td>
<td>Unathur</td>
<td>11°40' 20&quot;</td>
<td>78°47'10&quot;</td>
</tr>
<tr>
<td>2.</td>
<td>53552</td>
<td>Puthur</td>
<td>11°37' 47&quot;</td>
<td>78°46'55&quot;</td>
</tr>
<tr>
<td>3.</td>
<td>53553</td>
<td>Thalaivasal</td>
<td>11°35' 00&quot;</td>
<td>78°45'30&quot;</td>
</tr>
<tr>
<td>4.</td>
<td>53554</td>
<td>Govindapalayam</td>
<td>11°31' 55&quot;</td>
<td>78°50'00&quot;</td>
</tr>
<tr>
<td>5.</td>
<td>53555</td>
<td>Aragalur</td>
<td>11°33' 35&quot;</td>
<td>78°47'10&quot;</td>
</tr>
<tr>
<td>6.</td>
<td>53556</td>
<td>Veeraganur</td>
<td>11°28' 22&quot;</td>
<td>78°46'46&quot;</td>
</tr>
<tr>
<td>7.</td>
<td>53557</td>
<td>Sarvoy</td>
<td>11°34' 05&quot;</td>
<td>78°43' 30&quot;</td>
</tr>
<tr>
<td>8.</td>
<td>53558</td>
<td>Kattukottai</td>
<td>11°36' 30&quot;</td>
<td>78°39' 40&quot;</td>
</tr>
</tbody>
</table>
Plate 4.1 Well Inventory Survey in Thalaivasal block
Figure 4.12 Graphical Representation of Annual Average Water level for Thalaivasal Block (1976 – 2006)
The average water level data for Thalaivasal block for thirty years (1976-2006) were plotted at respective control well location and water level contour map was generated in GIS environment (Fig 4.13). The water level contour map has shown that the minimum (shallow) water level of 7.2m bgl in the centre of the block near Thalaivasal and maximum (deeper) water of 13m bgl observed in the north eastern part of the block. Similarly in the southern part of the block water level is gradually increased from the centre of the block. The shallow water table condition closely observed on either side of the Vashista river. This is due to influence of river, which could recharge the aquifers during sufficient flow in the river. Shallow water level condition observed in the central part of the area around Thalaivasal, Aragalur, Sarvoy and Kattukottai. The average water level in the block is 9.6m bgl.

4.5 WATER LEVEL FLUCTUATION

The water level fluctuation is the variation of water level over the period of time. It indicates the ground water development and recharge condition in a basin. The short term and long term water level fluctuation in an area indicate the aquifer response to monsoon and drought condition. The short term fluctuations indicate variation in rainfall and local recharge condition in a basin. However, long term fluctuation in terms of continuous decline of water level indicates the severity of drought condition and also extraction of more ground water. Analysis of water level for long period could provide valuable information on the status of aquifer and possible to understand ground water development in an area. Based on existing ground water development, the Thalaivasal block already demarcated as dark area.

The water level fluctuation could be estimated from the difference between pre monsoon and post monsoon water level. In general, after the period of monsoon, the water level rises from depth to shallow condition. The higher the rises of water level indicate good recharge condition of an aquifer. The
variation of fluctuation between two longer periods also indicates the increase of ground development and decline of water table condition.

4.5.1 Pre monsoon Water Level

The Thalaivasal block experienced rainfall mostly from north eastern monsoon during October to December. Hence, normally the month of September is considered as pre monsoon month and measured water level during this month as pre monsoon water level. The water level reaches to the maximum depth below ground level depends upon the groundwater development in the block. The average pre monsoon water level plotted for 35 years from 1971 to 2006 for the Thalaivasal block. The 35 year average pre monsoon water level indicates maximum of 14 m bgl and minimum of 7 m bgl. The shallow water level condition once again observed at the central part of the block (Fig 4.14). Most of the shallow dug wells become dry during this period. The deeper water level in the entire block indicates the status of groundwater development and an urgent need of some remedial measures in the form of water management practices.

4.5.2 Post monsoon Water Level

Immediately after monsoon, the aquifer is getting recharged through rainfall and the water level is increased to sufficient level. Hence, water level in the month of January is considered as post monsoon water level. In Thalaivasal block, the post monsoon water level for 35 years from 1971 to 2006 is plotted and post monsoon water level contour map was generated (Fig 4.15). During post monsoon period, there is a significant improvement in the water table condition in the block. However, the increase of water level during post monsoon period is uncertain if monsoon is failure. From rainfall data analyses, we already inferred the frequent failure of monsoon. The shallow water table condition is observed in the centre part of block around 5.5 m bgl and the deeper water table condition (9.7 m bgl) noticed in the northeast end corner. Similarly the depth of water table gradually increased from centre to southwestern corner. The contour map clearly
depicts the good recharge condition in the centre of the block on either side of Vashista river during post monsoon period.

The average water level fluctuation for thirty five years (1971-2006) is plotted for eight control well location in the Thalaivasal block. The graph has clearly depicts the fluctuation upto 10m. In the last 35 years, only one or two year, the fluctuation is in positive mode, which may be contributed from unusual precipitation. The fluctuation is more prominent in the northern part of block. Overall, it indicates the extensive groundwater mining during and after monsoon. During drought, the condition might be worst, there may not be adequate water available to compensate the aquifer replenishment.

In addition to average water level fluctuation, individual water level fluctuation contour maps were also drawn for two end periods for the year 1971 and 2006. The water level fluctuation for the year 1971 has shown from 1.62m to 6m bgl. On the other hand, the water level fluctuation in the year 2006 has shown minimum of 3.08m to maximum of 14.4m bgl, which indicate the overall decline of water table condition in the block (Fig 4.16 and Fig 4.17).

4.6 GEOPHYSICAL RESISTIVITY STUDY

Geophysical resistivity data provides quality information on subsurface lithological condition to significant depth (upto 100m). The geophysical resistivity survey is the more reliable technique being adopted presently for ground water exploration. The crystalline hard rock terrain always in heterogeneous nature with varying in thickness of weathered condition. The close spatial vertical electrical sounding could provide precise information on thickness of weathered zone and fractured zone.
Figure 4.13 Annual average water levels for 35 years, Thalaivasal block
Figure 4.14 Pre monsoon water level in Thalaivasal block
Figure 4.15 Post monsoon water level in Thalaivasal block
Figure 4.16 Water level Fluctuation in Thalaivasal block (year 1971)
Figure 4.17 Water level Fluctuation in Thalaivasal block (year 2006)
In the present context, geophysical resistivity data were collected for more than 90 locations in the block from state Surface and Groundwater Data Centre. In general, the crystalline terrain in Tamil Nadu has four layer subsurface configurations such as top soil zone followed by weathered zone, fractured zone and massive rock. The resistivity data were interpreted through inverse slope method and estimated the thickness of weathered zone, fractured zone and depth of bed rock. The thickness values were plotted in the respective VES location and contour maps were generated for weathered zone and fractured formation and depth to bed rock.

The weathered zone thicknesses in the study area are ranging from 10m to 70m. However, in most of the areas, the weathered thickness extended only upto 30m. The highly weathered condition restricted to very few locations in the block. Since major portion the area covered by less than 10 m weathered condition, groundwater development for agriculture activities mostly through dug well irrigation. During field investigation, it is inferred that most of the dug wells excavated beyond 10m depth and extended upto massive bed rock at many places. Based on weathered zone thickness, the Thalaivasal block is divided into three zone as highly weathered, moderately weathered and less weathered zone (Fig 4.18). The villages located in the central part of the block, particularly near the Vasishtha nadi have highly weathered condition. The villages are Deviyakurichi, Thalaivasal, Pattuthurai, Veppampundi, Nattar Agharam and Pagadapadi.

The fractured zone estimated from geophysical resistivity survey and well investigation show it ranges from 10m to 90m. Again, the high thickness of fractured zone restricted to central part of the block, particularly near the Vasishtha nadi. Overall, the weathered zone and fractured zone follow same trend in the block. Wherever both layers are in appreciable thickness, it favours for borewell irrigation. The continuous usage of groundwater and decline of water table condition lead to failure of many dug wells and farmers force to install borewells. The weathering and fractured condition is significant in gneissic formation, however, in charnockite formation this
condition is very much restricted. The fractured zone thickness in the study area estimated through geophysical resistivity survey and well investigation is divided into less thickness of fractured zone, moderately thick and high thickness of fractured zone (Fig 4.19). The map has clearly indicated that the major part of the area is covered by less thickness of fractured zone. The weathered zone and fractured zone maps were useful in further ground water development or water management practices in the block.

The detailed well investigation and geophysical resistivity survey provide subsurface geological condition such as thickness of weathered zone, fractured zone in the block. These data provide the thickness of aquifer in the study area (Fig 4.20). Based on aquifer thickness, the area is divided into four categories as very high aquifer thickness, high aquifer thickness, moderately thick aquifer, low thickness of aquifer. Though major portion of the study area is covered by moderate thickness of aquifer, the yield is depending upon the rainfall and recharge condition.

4.7 GEOLOGY AND GROUNDWATER CONDITION

Granitic gneiss is the major rock types present in the block, mostly in the northern and southern part of the block. In total, about 305 sqkm area (70%) covered by gneissic rocks comprises of granitoid gneiss, granitic gneiss, biotite gneiss and hornblende biotite gneiss. The metamorphosed gneissic rocks foliated and weathered compare to charnockitic rocks. However, lineaments associated with joints and fractures control high weathered condition irrespective rock types. Both dugwells and bore wells catering groundwater requirement in gneissic terrain. Generally, the percentage of ground water development is more in this terrain. The average water level in this zone is 2 to 15m bgl. The recuperation of wells during winter is from 8 to 12 hours and in summer it ranges from 24 to 32 hours (IWS report, 2006).
The ground water development has reached maximum level at present. Further groundwater development in this region is difficult. Dug wells, bore wells and dug-cum bore wells catering groundwater to agricultural practices.

The central part of the block is mostly covered by charnockitic rocks. Approximately it covers 95 sqkm area and 24% of the total areal coverage. The weathered condition in charnockite is limited, mostly massive in nature and devoid of fractures and joints. Chanockitic formation at many places intruded by dolerite dykes and fragmented by deformation like fault and shearing. The depth of weathered zone ranges from 4m to 8m and extended to the maximum depth along lineament zone (upto 70m). The depth of wells in charnockite is in the range of 12m to 27m bgl. The water level is ranges from 2m to 10m bgl during winter and 12m to 23m bgl in the month of summer. The recuperation timing is almost similar to gneissic formation, 8 to 12 hours during winter and 24 to 36 hours in the summer period. The yield ranges from 10 to 30 lpm (IWS report, 2006). In charnockite formation also the groundwater development has reached maximum level and further development is not possible. The state groundwater department has already declared this block as dark area. It is the right time the geologist, water resource engineers and expert should work together for alternative water management practices include artificial recharge and conjunctive use. Though two main rivers flow in this block, there is no sufficient, alternate surface water resource available. The river flow is inadequate to compensate the present ground water development and requirement.
Figure 4.18 Weathered Zone Thickness in Thalaivasal block
Figure 4.19 Fracture Zone Thickness in Thalaivasal block
Figure 4.20 Aquifer Thickness in Thalaivasal block