CHAPTER 4

HYDROMETEOROLOGY

4.1 INTRODUCTION

The recharge potential of groundwater can be estimated with the help of a detailed study of the hydro-meteorological data. Rainfall that fall on the land is the major source for groundwater. The rainfall that falls on the land may infiltrate into the ground or may runoff as surface flow to the sea or may be evaporated or may be absorbed by plants and transpired in turn. The most important information which are of great significance for the climatological assessment of water resources of Madras being discussed in this chapter.

Madras city enjoys a tropical climate, based on the weather the area could be classified into four seasons.

1. Hot Weather : March to May
2. South West Monsoon : June to September
3. Post Monsoon or North East Monsoon : October to December
4. Cold Weather : January to February

The cold season usually begins in November and ends by the beginning of March. The coldest months of the year in the area are January and February during which time the nights are longer than the days, the extremes in temperature ranges between 18.1°C and 25.9°C. By the end of March the
temperature begins to move with an upward trend and attains a peak during the end of April and goes on till the end of May. This period is the hottest and driest time of the year. The extremes in temperature recorded during this period is somewhere between 13.9°C and 45°C.

4.2 RAINFALL

In Madras the pattern of precipitation is of the tropical monsoon type in which the North East monsoon accounts for the large amount of rains. Rainfall is the major source for the groundwater recharge here and the north east monsoon which occurs during the months of October, November and December accounts for about 2/3rd of the total rainfall of the area.

The average annual monthly rainfall recorded from four rain gauge stations are shown in the table 4.1 and the normal rainfall available for individual stations are given in figures 4.1, 4.2 & 4.3. Rainfall brought due to the south west monsoon is almost negligible compared to the rains brought by the North East Monsoon. During the north-east monsoon the amount of rainfall is about 70 cms. Most of the precipitation occurs due to cyclones caused due to the depression in the Bay of Bengal which often causes serious floods. It is interesting to note that during the 50 years from 1930 to 1980, thirty cyclonic storms from the Bay of Bengal crossed the coast within 250 kilometres radius of Madras. During these periods serious floods have occurred in Madras city and neighbourhood areas on four occasions in 1946, 1952, 1957 and 1976. Thunderstorms which occur mainly during April to October and the pronounced sea breeze provides some uniformly warm and moist climate. The average annual rainfall of Madras city is of the order of about 1396.6 mms.
### Average Monthly and Annual Rainfall of Madras City

<table>
<thead>
<tr>
<th>Months</th>
<th>Nungambakkam</th>
<th>Thiruvotriyur</th>
<th>Meenambakkam</th>
<th>Egmore</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>32.77</td>
<td>27.1</td>
<td>26.91</td>
<td>15.6</td>
</tr>
<tr>
<td>February</td>
<td>19.81</td>
<td>17.21</td>
<td>15.78</td>
<td>17.1</td>
</tr>
<tr>
<td>March</td>
<td>3.7</td>
<td>3.56</td>
<td>2.77</td>
<td>3.1</td>
</tr>
<tr>
<td>April</td>
<td>4.57</td>
<td>2.19</td>
<td>7.2</td>
<td>2.3</td>
</tr>
<tr>
<td>May</td>
<td>38.22</td>
<td>24.68</td>
<td>36.11</td>
<td>37.66</td>
</tr>
<tr>
<td>June</td>
<td>86.74</td>
<td>44.17</td>
<td>64.20</td>
<td>60.50</td>
</tr>
<tr>
<td>July</td>
<td>104.64</td>
<td>79.74</td>
<td>126.26</td>
<td>102.75</td>
</tr>
<tr>
<td>August</td>
<td>146.51</td>
<td>105.2</td>
<td>146.64</td>
<td>127.12</td>
</tr>
<tr>
<td>September</td>
<td>128.5</td>
<td>106.08</td>
<td>147.59</td>
<td>118.65</td>
</tr>
<tr>
<td>October</td>
<td>468.65</td>
<td>326.5</td>
<td>305.95</td>
<td>380.45</td>
</tr>
<tr>
<td>November</td>
<td>351.22</td>
<td>201.79</td>
<td>388.89</td>
<td>307.25</td>
</tr>
<tr>
<td>December</td>
<td>200.19</td>
<td>309.75</td>
<td>168.89</td>
<td>142.39</td>
</tr>
<tr>
<td>Annual</td>
<td>1385.52</td>
<td>1248.17</td>
<td>1437.29</td>
<td>1315.44</td>
</tr>
</tbody>
</table>

Table 4.1
MONTHLY AVERAGE RAIN FALL - MEENAMBAKKAM
(20 YEARS)

Fig. 4.1
MONTHLY AVERAGE RAIN FALL - THIRUVOTRIYUR
(20 YEARS)

Fig 4.2
MONTHLY AVERAGE RAIN FALL - NUNGAMBAKKAM
(20 YEARS)

Fig. 4.3
Rainfall average taken for twenty years show that Nungambakkam has had the maximum rainfall of about 137.91 cms. and the lowest is being experienced by Egmore at the order of 83.98 cms in North Madras. Station receiving heavy rainfall is Nungambakkam.

The following is the list of contribution of rainfall by various seasons.

<table>
<thead>
<tr>
<th>SEASON</th>
<th>RAINFALL IN CMS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cold Season</td>
<td>15.45</td>
</tr>
<tr>
<td>b. Hot Season</td>
<td>34.05</td>
</tr>
<tr>
<td>c. South West Monsoon</td>
<td>115.04</td>
</tr>
<tr>
<td>d. North East Monsoon</td>
<td>280.97</td>
</tr>
</tbody>
</table>

### 4.2.1 Requirement of additional rain-gauges

An attempt has been made to assess the requirement of the number of rain gauges in this coastal zone.

The coefficient of variation in rainfall of the 4 stations has been calculated and is as per the following calculations.

1. Total Rainfall \((T)\)
   \[
   T = 132.12 + 83.98 + 119.77 + 109.62 = 445.49
   \]

2. Mean \((M) = T/4\)
   \[
   M = 445.49/4 = 111.37
   \]
3. Sum of Squares (SS)

\[ SS = 132.12 \times 132.12 + 83.98 \times 83.98 + 119.97 \times 119.97 + 109.62 \times 109.62 \]

\[ = 17,455.69 + 7,052.64 + 14,344.85 + 12,016.54 \]

\[ = 50,898.72 \]

4. Mean of \( T^2 \)

\[ = T^2/4 = 198461.34/4 = 48615.335 \]

5. \( S^2 = (SS - T^2/4) / (4 - 1) \)

\[ = (50,869.72 - 48615.335) / 3 \]

\[ = 751.46 \]

6. Coefficient of Variation (Cv)

\[ = 100 \times 751.46 / 111.37 \]

\[ = 24.61 \text{ Percentage Error (P)} \]

Additional rain gauges, \( N = \frac{Cv^2}{P} \)

\[ = 605.65 / 10 = 60.56 \]

Optimum number of rain gauges required for this area is 10.

No. of additional rain-gauges to be installed : 6.

From the above calculations it is inferred that six additional rain-gauges are required for this terrain.
4.3 TEMPERATURE

As per the data collected the city experiences a very high temperature during the summer months i.e. between April and May. During this part of the year the mercury soars upto 41.2°C. and the minimum temperature is accounted during January which is of the order of 18.1°C.

If the south-west monsoon is favourable then the temperature is brought down at a very rapid rate. If the south-west monsoon fails, then the other source of relief from the sweltering heat is the sea breeze which usually sets in at sometime past noon.

4.4 OTHER CLIMATOLOGICAL FACTORS

4.4.1 Humidity

Humidity of a given air mass may be defined as the number of grams of water present in a cubic meter of air. At any given temperature, air can hold a maximum amount of moisture which is the saturation humidity. This is proportional to the temperature of air.

The percent ratio of the absolute humidity to the saturation humidity for the temperature of the air mass is the relative humidity for an air mass. Evaporation ceases to occur as the humidity becomes 100%.

The relative humidity in Madras city is high during the months of November, December and January when it is 83%, 84% and 83% respectively and it touches the lower mark during the month of June when it reads 58%.
Table 4.2 gives an idea of the relative humidity and the vapour pressure. The annual mean humidity has been calculated as 74%.

4.4.2 Potential evapo-transpiration

Going by Table 4.2 which shows the potential evapo-transpiration it is seen that the potential evapo-transpiration is maximum during the months of April, May and June when it crosses the 200 mark and touches the lower side during the months of November and December (105). The mean monthly evapo-transpiration has been worked out to be 168.44 mm.

4.4.3 Wind speed

The velocity of the wind is found to be maximum during the month of June when it is about 16.4 kmph and is low during the month of January, February and October (9.13 kmph). The annual average velocity of this area is 11.8 kmph.

4.4.4 Cloud amount

The clouds were found to be maximum during the month of July and minimum during January and February as shown in Table 4.2.

Low clouds are maximum during the months of November and December and minimum during the months of July and August.
4.5 RAINFALL VOLUMES

\[ \text{RF} \times \text{area} = \text{Total volume of water coming to the surface} \]

(assuming 10% of RF recharge)

\[ 1.396 \text{ m} \times 172420000 \text{ m}^3 = 240.69832 \text{ Mm}^3 \]

10% of 240.69832 Mm\(^3\) = 24.069832 Mm\(^3\)

RF is Rainfall

Therefore 24.069832 Mm\(^3\) water will be filtering into the ground.
Table 4.2  Climatological data of Madras City and its environs

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Mean Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature °C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Max</td>
<td>29</td>
<td>31</td>
<td>32.7</td>
<td>34.9</td>
<td>37.6</td>
<td>37</td>
<td>35</td>
<td>35</td>
<td>33.9</td>
<td>32</td>
<td>29</td>
<td>28.2</td>
<td>32.9</td>
</tr>
<tr>
<td>Min</td>
<td>20</td>
<td>21</td>
<td>23.1</td>
<td>26</td>
<td>27.8</td>
<td>28</td>
<td>26</td>
<td>26</td>
<td>25.4</td>
<td>24</td>
<td>23</td>
<td>21</td>
<td>24.3</td>
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<tr>
<td><strong>Relative Humidity %</strong></td>
<td>83</td>
<td>67</td>
<td>77</td>
<td>72</td>
<td>63</td>
<td>58</td>
<td>65</td>
<td>69</td>
<td>73</td>
<td>81</td>
<td>83</td>
<td>84</td>
<td>74</td>
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<tr>
<td><strong>Cloud Amount</strong></td>
<td>3.6</td>
<td>3.4</td>
<td>2.7</td>
<td>4.2</td>
<td>4.5</td>
<td>5.8</td>
<td>6.6</td>
<td>6.1</td>
<td>5.6</td>
<td>5.3</td>
<td>5.9</td>
<td>4.6</td>
<td>4.8</td>
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<td><strong>Oktas of Sky</strong></td>
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<tr>
<td><strong>Wind speed kmph</strong></td>
<td>9</td>
<td>9.2</td>
<td>10.2</td>
<td>10.5</td>
<td>13</td>
<td>16</td>
<td>15</td>
<td>14</td>
<td>11.1</td>
<td>9.2</td>
<td>12</td>
<td>12.6</td>
<td>11.8</td>
</tr>
<tr>
<td><strong>Potential Evapo-</strong></td>
<td>128.2</td>
<td>140.5</td>
<td>185.5</td>
<td>204.3</td>
<td>248.3</td>
<td>234.8</td>
<td>199.8</td>
<td>177.8</td>
<td>162.0</td>
<td>128.7</td>
<td>105.5</td>
<td>105.9</td>
<td>168.44</td>
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<tr>
<td><strong>transpiration mm</strong></td>
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<td></td>
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</tbody>
</table>

Source: Indian Meteorological Department