CHAPTER III

3. THE EXPERIMENTS

3.1 INTRODUCTION

Much of the work described in this thesis was carried out under a research project financed by the Department of Science and Technology, Government of India. The primary objective of the project was to understand the behaviour of atmospheric electrical parameters over the highly radioactive region along the Kerala coast. However, measurements were carried out at sites with low levels of radioactivity also. In addition, measurements were carried out in the campus of our institution, using the instruments developed for the project. These measurements have helped in determining the effect of some of the meteorological parameters like temperature, rainfall, winds, etc. The results are presented in this thesis. The influence of certain environmental parameters like pollution have not been studied during this investigation.

As part of the study, observations were carried out at different places at the surface. In addition, a few surveys were carried out at the surface and up to an altitude of about 660 m using an aircraft. A brief description of the physiographical and meteorological characteristics of the region where the study was conducted, the sites where observations were made, the kind of environment at each site, data reduction and analysis techniques used, survey routes, etc. is given in this chapter.
3.1.1 The study region

The study described in this thesis was carried out in the south-western region of India, mainly in the state of Kerala, with some measurements extending beyond the southern border into the adjoining state of Tamil Nadu. Kerala is a small state confined to a narrow region between the Western Ghats on the east and the Arabian sea on the west. The physiography of the state is shown in Figure 3.1. The land area of the state can be divided into three regions, namely, the low land consisting of the coastal areas and adjoining lakes and wetlands, the high land consisting of the Western Ghat region, and the midland between them. The state has a high density of population, with the highest densities in the coastal region. Blessed by good rainfall during the more than six months of the year, the state is also densely covered with vegetation.

Since the width of the state is rather small, the Western Ghats have a strong influence on the climate of the state. Being oriented almost perpendicular to the flow of the monsoon winds, the Ghats act as an obstruction to the clouds and thus bring copious rainfall to the state.

In the state, the year may be divided into three main seasons from the climatological point of view. These are: (i) the south-west monsoon season, from June to mid-October, (ii) the north-west monsoon season, from mid-October to February, and (iii) the hot, or summer, season from March to May. The third season is marked by relatively high temperatures and high humidity. The mean maximum temperature
Figure 3.1 Map showing physiography of Kerala State.
is generally the highest in March, around 33°C, and is higher in the northern parts. The diurnal range in temperature is lowest in July and August, and highest in January. The total rainfall received per year increases from about 1800 mm in the south to about 3800 mm in the north. In the southern parts, about half of this is obtained during the months of June, July and August. The fraction increases towards the north. During the north-east monsoon, the southern parts receive around 25% of the annual total rainfall, the fraction decreasing towards the north (IMD, 1986).

The monsoon, therefore, has a dominant influence on the climate of this state. The monsoon is a south-easterly wind system that develops over the Indian ocean south of the Equator and crosses over to the northern hemisphere over the Arabian Sea. The wind then turns and becomes south-westerly, and strikes the Indian sub-continent, bringing plentiful rain. The wind system normally reaches the coast of Kerala on the 1st of June. This brings a sudden transition in the weather conditions in this region. The hot, sunny days of the months of April and May are suddenly replaced by cold, rainy days. Almost completely overcast skies, heavy and continuous rainfall and continuous strong winds are characteristic of the month of June, especially for a coastal station in Kerala. Since the weather has a significant influence on atmospheric electrical parameters, these factors have been kept in mind during the interpretation of the results.

One of the unique features in this region of the country is the rich placer deposit of the radioactive mineral monazite along the south western coast of south India. Figure 3.2 shows a map of the region
Figure 3.2 Map of the southern part of Kerala State and the adjoining regions of Tamil Nadu showing the distribution of radioactivity, in terms of the intensity of terrestrial radiation.
(adapted from Sankaran et al., 1986) where the terrestrial radiation levels for this region are marked. The region along the coast from around Chavara southwards is seen to have high values. This is due to the high concentration of thorium in the sands in this region. Estimates of the concentration of thorium in the beach sands in the southern part of Kerala (Prakash, et al., 1990) show that it varies from about 200 ppm to more than 2000 ppm, with a mean value of about 550 ppm. The range of average content of thorium in igneous and sedimentary rocks is considered to be 4 to 15 ppm (Junge, 1963, p 213). The lowest concentrations of radioactive substances are found in extremely alkaline igneous rocks, and the highest in acidic igneous rocks, with the values for sedimentary rocks somewhere in-between (Israel, 1971, p 185). These coastal sands, therefore, contain about 100 times the global average level of radioactivity. This was therefore one region which was selected for the study. Since the deposits are found mainly in the coastal sands, it was decided to make observations at another coastal site that does not have any radioactivity so that effects common to coastal areas could be eliminated. Such a site can be obtained towards the north of Chavara. As explained below, a suitable site was obtained at Ambalapuzha. An inland non-radioactive site also was chosen for observations so that the difference between continental and marine environments could be discerned. The radioactivity levels are lower in the midlands than in the coastal region, but the lowest values are seen in a patch almost straight to the east of Chavara. A site was found at Kottarakara, about 25 km east of Chavara, which falls at one corner of this patch. Apart from these sites, some observations were also carried out in the campus of our institute at Trivandrum.
3.2 MEASUREMENTS AT THE SURFACE

During the present investigation, measurements were carried out at four sites at the surface, and jeep-borne and air-borne surveys were carried out. This section gives a brief description of the sites selected, and the operation and maintenance of the instruments.

3.2.1 Monitoring sites

For monitoring atmospheric electrical parameters at the surface, sites had to be identified where it would be possible to install and run the instruments conveniently. The requirements were that the place should have convenient access so that the equipment could be carried in a vehicle, power should be available for running the instruments, sufficient security should be available for the instruments, and some amount of open space should be present so that the instrument would not have to sit under trees or other vegetation. These conditions are not easily met in a thickly populated and vegetated state like Kerala, especially when the site has to be located within a small specified region, as in the present case.

For the station within the radioactive region, a convenient site was found at Chavara (8° 59' N, 76° 31' E), a place that has a very high concentration of monazite sands. The site was near a factory of the Indian Rare Earths (IRE) where the sand mined from the region is mechanically separated to extract monazite and other useful minerals. A lighthouse belonging to the Department of Lighthouses and Lightships, Government of India, exists near the factory and close to the seashore,
which can be reached through a muddy jeepable road. The place is well protected, and some open space is available for installing the sensor. A small building was available where the power supply and control and recording instruments could be kept. Power disruption was minimal since the lighthouse had its own generator that would take over within a few minutes in case of power failure. The proximity of the IRE factory did not cause problems because it generated very little pollution. The nearest main road is the National Highway (NH47) about 1 km east of the lighthouse, so that pollution due to automobile exhausts is also small at this site. The coast line is protected by a sea wall that was about 30 m to the west of the place where the sensor was situated. Being so close to the sea created problems during the monsoon season due to excessive corrosion, especially in the sensor.

The second station was established at Ambalapuzha (9° 23' N, 76° 46' E), in the premises of a building of the Kerala State Fisheries Department. This was situated on the Ambalapuzha beach. The sea was about 100 m from the building. Due to safety reasons, the instrument could not be installed outside. The sensor was kept inside a room in the ground floor of the building, but care was taken to ensure that there was free passage of air through the room at all times by keeping the windows open. The sensor was occasionally kept outside for short durations in order to compare the values obtained outside with those obtained inside. The two sets of values were in good agreement with each other. No significant difference was noticed. The building had the open beach to its west, with fishermen's huts on the eastern and southern sides. A road leading from the Highway about 1 km to the
east terminated in front of the building. A similar building was situated on the opposite side of the road, with more huts behind it.

The third station was located at Kottarakara (9° N, 76° 46' E), about 25 km to the east of Chavara, in the campus of the Kallada Irrigation Project office of the Kerala State Irrigation Department. The sensors (Gerdien condenser and field mill) were kept on the terrace of their dormitory building, and the rest of the system was kept inside one of the rooms. The dormitory is a two-storied building and it stands on the slope of a small hillock close to the town. At this site, the instruments were kept at a height of around 10 m from the ground. Moreover, the site is different from the other two in that it is close to a small town. These factors would affect the conductivity values obtained. This has been kept in mind while interpreting the data.

Measurements were also made at the campus of the Centre for Earth Science Studies (CESS). Here, in addition to conductivity, rainfall also was measured using a self-recording rain gauge certified by the India Meteorological Department. The CESS campus is situated at Akkulam in the outskirts of Trivandrum city. The Centre is situated in its own land of about 18 ha in the Ulloor Panchayat, in a region where population density is low and there is virtually no industrial activity. There is no major highway nearby. The area thus has very little pollution. The sensor was kept on top of a single storied building, and the rest of the system inside. The rain gauge also was kept near the sensor since a suitable open area was not available on the ground. The terrace, however, provided a relatively large open space without any obstructions nearby. This arrangement was more or less sufficient for
the present purpose since the precise value of rainfall was not of much interest, but only its variation. The locations of the monitoring stations are marked in a map in Figure 3.3.

3.2.2 Operation and maintenance

The monitoring stations were manned by technicians trained in their operation and maintenance. Since the data were recorded on chart paper, the technician was required to mark time on the chart twice a day, in the morning and in the evening. He was also required to ensure that the instrument functioned normally. A log book was provided at each station in which the technician was required to note down the values of certain parameters that could be read from the digital panel meter (DPM) on the system console. These included the driving voltage levels and the output voltage levels at different stages in the Gerdien condenser and field mill circuitry, the input voltages to the recorders, and the power supply voltages. This provided a very useful check on the system performance, and also was of considerable help on trouble shooting. Periodic cleaning of the sensor, lubrication of the fan in the sensor, ensuring that the recorder functioned smoothly, noting the periods when power failed, and noting down in the log book his observations about general weather conditions like thunderstorm activity, rainfall, cloudiness, etc. were also part of the duties of the technician. In case of any problem that he was not able to tackle, he was required to immediately inform the investigator. In addition, the investigators visited the stations at periodic intervals to ensure that the instruments were running smoothly.
Figure 3.3  Map showing the locations of the monitoring stations.
3.2.3 Data reduction and analysis

The data were recorded on chart paper using a strip chart recorder running at a speed of 20 mm per hour. The chart rolls were brought to Trivandrum every month, along with the log book, by the technician, who also reported on the performance of the station. The log book and the chart record together give a clear picture of the functioning of the station with regard to accuracy and stability. For reducing the data, time marks were put for each hour of the day by interpolating between the time marks put by the technician. While doing this, care was taken to ensure that the intervals are more or less uniform for all hours of the day. If there had been any power failure during night time that the technician had failed to note, then the time interval would not match with the distance on the chart paper. Periods when the time marks and the distance on the chart paper do not match within reasonable limits have been excluded during data reduction. Data have been lost also during periods when the record was noisy due to heavy rain or some other extraneous interference, or during periods when the recorder did not function properly. Data for short durations were lost also when the maintenance of the instrument was being carried out. These are limited to about half an hour on each occasion. Figure 3.4 shows a sample portion from a chart.

The readings were taken for each hour of the day. For a given hour, the readings were taken for the period between half an hour before the time mark and half an hour after. For instance, the output recorded between 0030 hr and 0130 hr was noted as the values for the time 0100 hr. Since the period of the driving voltage waveform was 50.
Figure 3.4 Sample portion of a day's record of conductivity.
minutes, normally there would be one positive value and one negative value for each hour of the day. The change over from one voltage to zero, or vice versa, need not coincide with the midway mark between two time marks. Therefore, the output for each polarity of driving voltage was ascribed to the hour in which the larger part of it fell. An average value for the period of the particular driving voltage (about 20 minutes) was noted down as the reading for the corresponding hour. But once in a while, three readings, one of one polarity and two of the other, would be present for one hour. In such cases, for the polarity for which two readings were present, an average was taken.

The readings were converted into conductivity values by multiplying with the proper conversion factor. The conversion factors were determined from the calibration of the system. The polar conductivity values were separately tabulated for each month. From this, the monthly mean for each hour of the day and the daily average of the hourly values were computed. The standard deviation also was determined for each average value. For each polar conductivity, an average value was derived from the daily means for each month.

3.3 JEEP-BORNE AND AIR-BORNE SURVEYS

The data from the monitoring stations at the surface were useful for understanding the temporal variation of the atmospheric electrical parameters and studying the nature of of the influence of the radioactive deposits. It was also desired to study the horizontal and vertical extent of the influence. For this, air-borne surveys were carried out over the region of study. A Pushpak trainer aircraft of the Kerala
Aviation Training Centre (KATC), Trivandrum, was used for the purpose. The survey routes were chosen such that they would cover the sites where the monitoring stations were set up. Thus one survey was done from Trivandrum to Alleppey and back along the coast, which went over the sites of the monitoring stations at Chavara and Ambalapuzha. A second survey was carried out from Trivandrum to Kottarakara, from there to Chavara and about one kilometre beyond the coast over the sea, and back along the same route. A third survey went southward from Trivandrum to Manavalakurichy, in Tamil Nadu, and some distance beyond almost up to Kanyakumari, along the coast and back. This was done because this region also has significant deposits of monazite, especially in the areas around Manavalakurichy. Data were recorded on magnetic tapes and later transferred onto chart paper. The details regarding the aerial surveys are given in Chapter 5.

The instrument developed for the aerial surveys was tested in some surveys at ground level where the instrument was carried in a jeep. Of these, only one survey gave good continuous data. The results from these are also presented in Chapter 5.