4

THE ENVIRONMENT IN THE AJWA RESERVOIR

Section - A : Physical Characteristics linked with Primary Production.

(a) Location : Geographical position

(b) Climatological data

(c) Morphometry

(d) Edaphic and geological factors

(e) Water level

(f) Transparency

(g) Thermometry at Stations A and B.

(h) Hydrogen ion concentration (pH)

(a) Location : Geographical position :

The city of Baroda draws its water supply from a storage tank or reservoir which is located at the north east of Baroda, near a village called "Ajwa"

about twenty four kilometers away from the city at 22°-18' north latitude. The reservoir is, therefore, called the "Ajwa" Lake; it is also known as "Sayaji Sarovar" named after Sir Sayajirao Gaekwad, the late ruler of the erstwhile Baroda State. The reservoir is situated about a few kilometers from the foot of the famous Pavagadh hill, the most familiar hill of Gujarat, situated in Western Panchmahals district. The reservoir was first formed by damming the river Surya, with a drainage basin of 91.17 sq.km (35.2 sq.miles) and its storage capacity was 36.81 million cubic meters with the full storage level (F.S.L.), at R.L. 62.4 meters prior to 1900. Next the Vishwamitri project was completed in 1900 and it added 38.33 sq.km of catchment area. With the introduction of this feeder, the F.S.L. of Ajwa reservoir was raised to the prest R.L. 63.3 m. Even after the construction of this feeder project, it was not possible to raise the water level to R.L. 63.3 in bad monsoon years. Therefore, another feeder tank, known as Pratap Singh reservoir with catchment area of 71.58 km was constructed later. Thus, today,

3 the catchment area of the Ajwa reservoir is 203.6 sq.km and F.S.L. is at 63.3 m when it has a storage capacity of 48.1 million cubic meters. The reservoir is also provided with a waste weir 240 m long on its north and a valve tower with inlets at R.L. 56.4 m and R.L. 59.4 m at the deepest portion of the reservoir for drawing off water for purification works at Nimeta about 8 km away from Ajwa on the main trunk road to Baroda.

(b) Climatological data :

(Tables A and B in Appendix)

The data relating to air temperature, humidity, wind velocity, rainfall and hours of bright sunshine for 1969 and 1970 respectively are shown in Appendix Tables A and B.

They represent the data recorded daily at the meteorological observatory located at the campus of M.S. University of Baroda. The reservoir is, however,

situated about 24 km away from the campus and no meteorological station is available anywhere adjoining the reservoir. The nearest observatory from which the data is available is that at the campus and data from this observatory have been used for the purpose of the present study.

Seasons in area of study.

Baroda (Long 73° 13' E; Lat. 22° 18'N) is about 31 to 40 meters above sea level and is surrounded by flat country.The following classification of the weather in the area is based on the meteorological data collected between 1957 and 1965 by the Meteorological Observatory, Faculty of Science, M.S. University of Baroda, Baroda.

Summer (March to May). The atmospheric temperature at any time does not drop below 9°C. The daily maximum temperature is always above 28°C and may go as high as 47°C. The maximum range of relative humidity is 13% to 97%. The rainfall is scarce and usually not more than 15 mm.

Monsoon (Wet Summer). (1) Early monsoon (June). The air temperature never rises above 44°C. The relative humidity ranges from 55% to 100%. A monthly rainfall may range from 0 to 232 mm.

(2) Mid monsoon (July to September). The air temperature at any time is between 20°C and 41°C. The relative humidity ranges between 85% to 100%. A monthly total of rainfall is always above 4 mm and may be as high as 630 mm.

(3) Late monsoon (October). October is also considered as a transitional period between monsoon and Winter. The air temperature at any time is between 13°C to 45°C. The relative humidity may range from 89% to 99% and the total rainfall ranges from 0 to 111 mm.

Winter (November to February). The daily minimum temperature is always below 25°C and may on certain days, be as low as 3°C. The daily maximum temperature never goes above 40°C. The relative humidity is on the whole moderate and at no time drops below 22%. The sky is usually clear and it

6 rarely rains (Naik & Razak, 1967)

The weather during the period of study is summerised in Table 1.

(i) Atmospheric temperature (°C) :

The annual range and average values for the monthly mean maximum and minimum mean values are shown below :

Table - 1

Annual range and average temperature of air (°C)

year	Annual range		Annual average	
	Mean maximum	Mean minimum	Mean maximum	Mean minimum
1969	42.1	14.3	33.3	23.2
1970	41.8	12.6	29.6	23.1

The seasonal values for the monthly mean maximum and minimum temperatures are given under in Table-2.

Table - 2

Average seasonal values of atmospheric temperature, March 1969 through October 1970

Seasons	1969-1970 Mean maximum °C	Mean minimum °C
Summer		
(March 1969-May 1969)	39.8	23.9
Monsoon (Wet Summer)		
i) Early monsoon (June)	31.7	25.2
ii) Mid monsoon (July to Sept.)	31.5	25.1
iii) Late monsoon (Oct.1969)	37.2	23.5
Winter		
(Nov.1969 - Feb.1970)	24.6	14.3
Summer		
(March 1970-May 1970)	37.4	23.2
Monsoon		
i) Early monsoon (June 1970)	31.5	24.8
ii) Mid monsoon (July-Sept.1970)	31.2	24.7
iii) Late monsoon (Oct.1970)	31.6	23.5

The maximum temperature is reached in April or May and minimum in January. There is a gradual increase of mean maximum temperature from January to April or May, and there is a gradual fall from May onwards till a little lower temperature is reached in August largely due to rains. There is again a gradual fall until the second minimum is reached in December. The mean minimum values also show the same trend but with a slight difference compared with the mean maximum values. To begin with, there is a gradual rise in temperature from January until the maximum is reached in June; then, there is a gradual fall until the lowest temperature is reached in December.

(ii) Hours of bright sunshine :

The maximum daily average varied from 11.20 hours in May in 1969 to 10.93 hours in May in 1970. The lowest figure of 2.04 hours was observed in August, 1969. Corresponding value for August 1970 was 3-00 hours. The values for the four seasons are shown in Table-3.

Table - 3

Observed hours of bright sunshine

Seasons	March 1969-October 1970 Hours per day	
	Lowest	Highest
Summer		
(March 1969-May 1969)	9.2	9.6
Monsoon (Wet Summer)		
i) Early monsoon (June)		9.1
ii) Mid monsoon (July-Sept.)	2.0	10.1
iii) Late monsoon (Oct.1969)		8.0
Winter		
(Nov.1969-Feb.1970)	8.3	9.7
Summer		
(March 1970-May 1970)	9.7	11.6
Monsoon		
i) Early monsoon (June 1970)		5.7
ii) Mid monsoon (July-Sept.1970)	2.6	6.9
iii) Late monsoon (Oct.1970)		10.2

(iii) Rain fall (mm).

The records of rainfall in the catchment area extending over a period of 64 years (1890 to 1953) show that the rainfall was below 250 mm (10 inches) in two years, below 375 mm (15 inches) in four years, below 626 mm (25 inches) in nine years, and 900 mm(40 inches) in 35 years. The average rainfall for 64 years' period was 1100 mm (44 inches) according to Modak (1955).

The total annual rainfall for 1969 was 1096.6 mm and for 1970 it was 1341.6 mm. The number of raining days was 62 in 1969 and 85 in 1970.

(c) Morphometry : (Fig. 2)

The reservoir is dammed on one side only and the length of the dam or embankment is 5.47 km (3.4 miles). It's maximum length at full tank level (R.L. 211) is 6.52 km (4.05 miles). Its breadth is 5.34 km (3.26 miles). The shore line circumference is 24.72 km (13.5 miles). The mean breadth is 2.1 km (1.305 miles) and depth is 3.4 m (11.32 ft.), the maximum depth being 9.0 m (30 ft.).

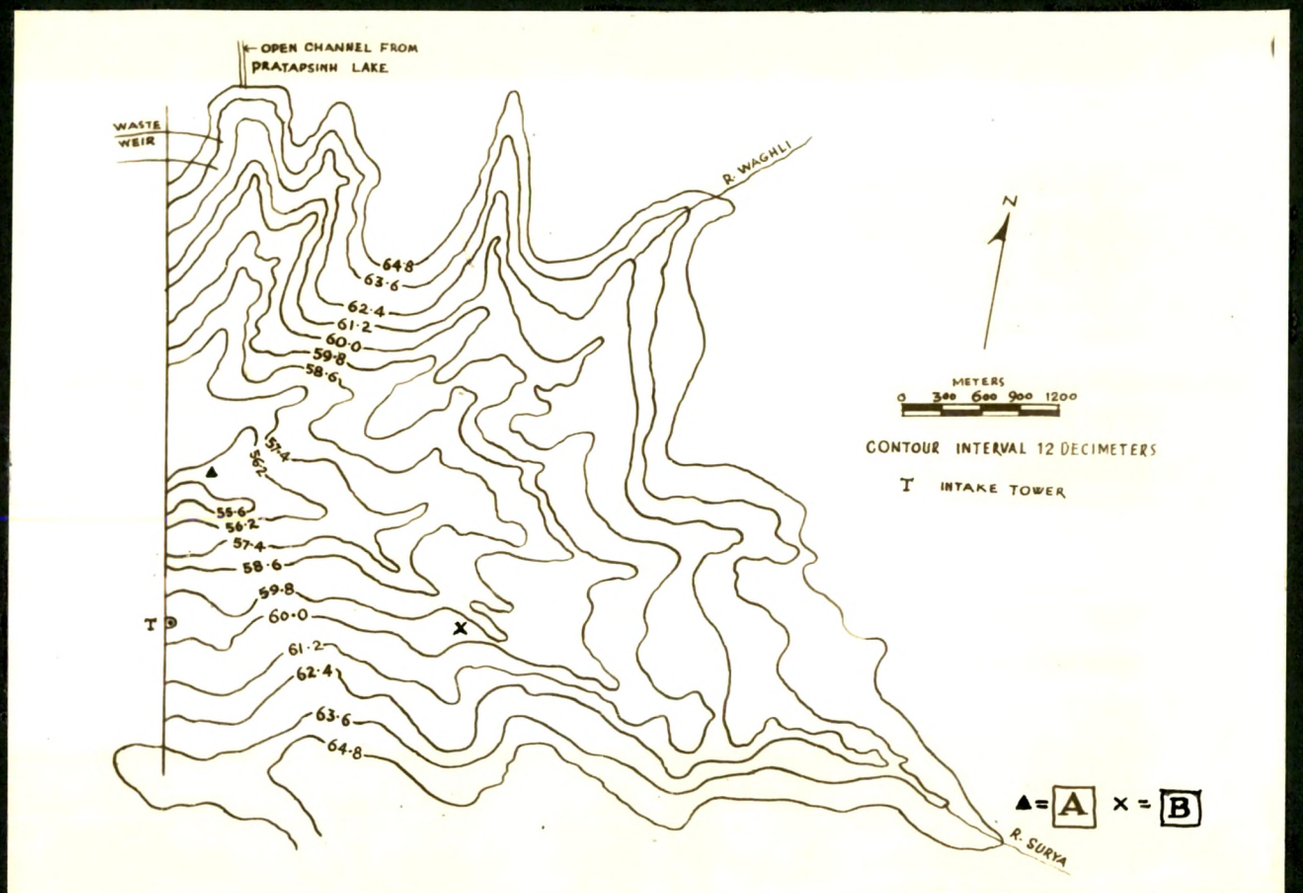

Figure 2 Morphometric map of Sayaji (Ajwa) Sarovar

(d) Edaphic and Geological Factors :

The main catchment area of the reservoir is composed of reserve forests consisting of trees. Cultivated lands and plantations are negligible. The feeder streams carry a lot of silt during the monsoon season making the water in the reservoir turbid for nearly six months in the year i.e. from July to October.

The regional geology of the area around the Ajwa reservoir can be summarised as follows :

Alluvial deposits - recent and sub-recent
Basalts of Deccan trap - Cutacco - Eocine
Sandstone of Bagh beds - Cretaceous
(Jayangaudar, 1964)

(e) Water level :

Ordinarily the level of water depends upon climatic conditions especially rainfall and temperature of the locality in which the reservoir is situated and on the draw-off for the town water supply. The

raining season for this region is the south-west monsoon season i.e. July to September, when the reservoir gets filled with the river and rain water from the water-shed. The water levels on the days of sample collection are shown in Appendix Table B. The maximum and minimum levels and the seasonal changes during 1969 and 1970 are shown in Table No.4.

Table - 4

Level of water during 1969 and 1970

Year	Maximum (m)	Month	Maximum (m)	Month
1969	8.77	September	4.10	June
1970	9.04	October	6.90	June

The water level decreased gradually from January to June or July when the lowest level was reached. Thereafter, on account of rains the level rose up abruptly to the maximum in September or October and later continued to decrease in successive months. The shallow depths of water resulting from

the decrease in water level encourage the development of aquatic vegetation in very large areas in the reservoir every year.

(f) Transparency (Sacchi's Depth).

In September the transparency was as low as 47 cm due to inflow of turbid rain waters. In the successive months it increased til March. Then it was slightly reduced due to higher algal growth. The maximum transparency (250 cm) was recorded in October 1970.

(g) Thermometry : (Tables No.D and H Appendix)

Temperature of water is an important attribute which has to be taken into account in productivity studies. The temperature data collected at Station A in the deepest portion of the reservoir is considered to represent the mean temperature conditions of the entire reservoir during the period under discussion. The data at Station B represents the temperature of water in the area with maximum macrophytes.

STATION A

Temperature of the Surface Water

It can be seen from Figures 3 and 4 and Tables 5,6 and 7 that the highest temperature at the surface of water was recorded in May. April and June were almost as hot as May.There was a slight fall in the temperature in the mid monsoon (July, August and September); but in October (i.e. late monsoon), there was once again a rise in temperatures. An abrupt fall in the temperature was recorded in November and it reached the lowest in January. December was also generally cold (temperatures being closer to that of January). Thereafter temperature rose till the maximum was reached in May.The temperature variations in the water closely correspond with that of the atmospheric temperature.

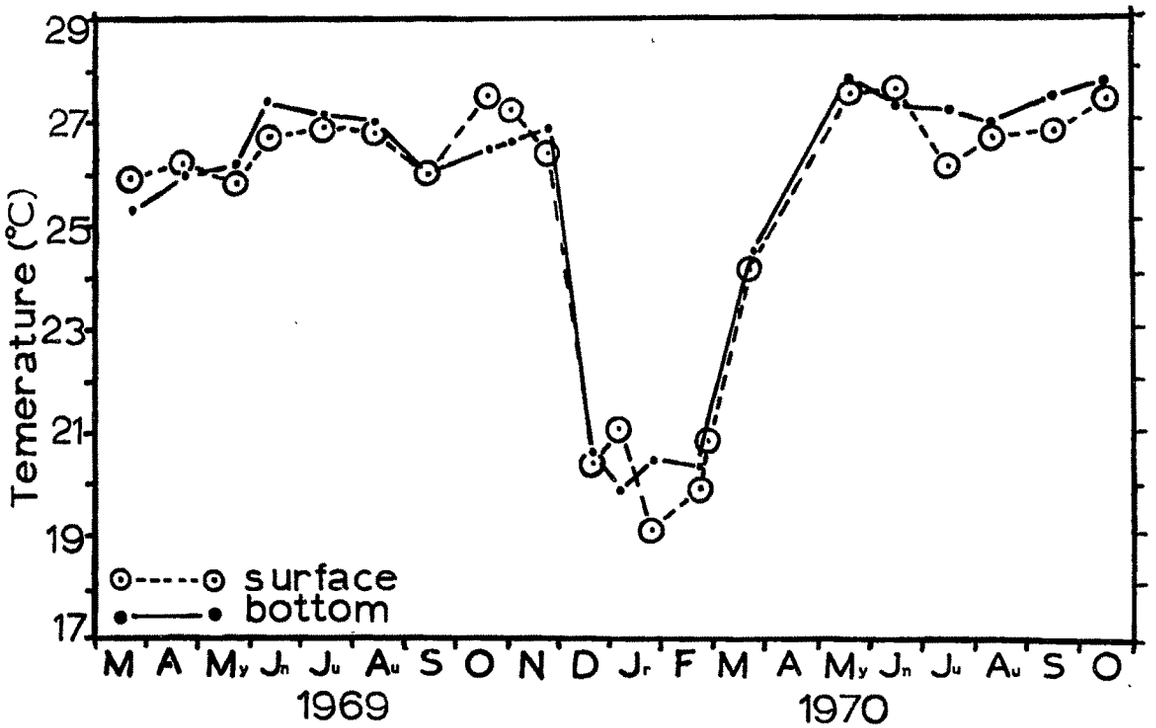

Figure 3 Temperature of surface and bottom layers of water at 0600 hours in Ajwa Reservoir. (Station A)

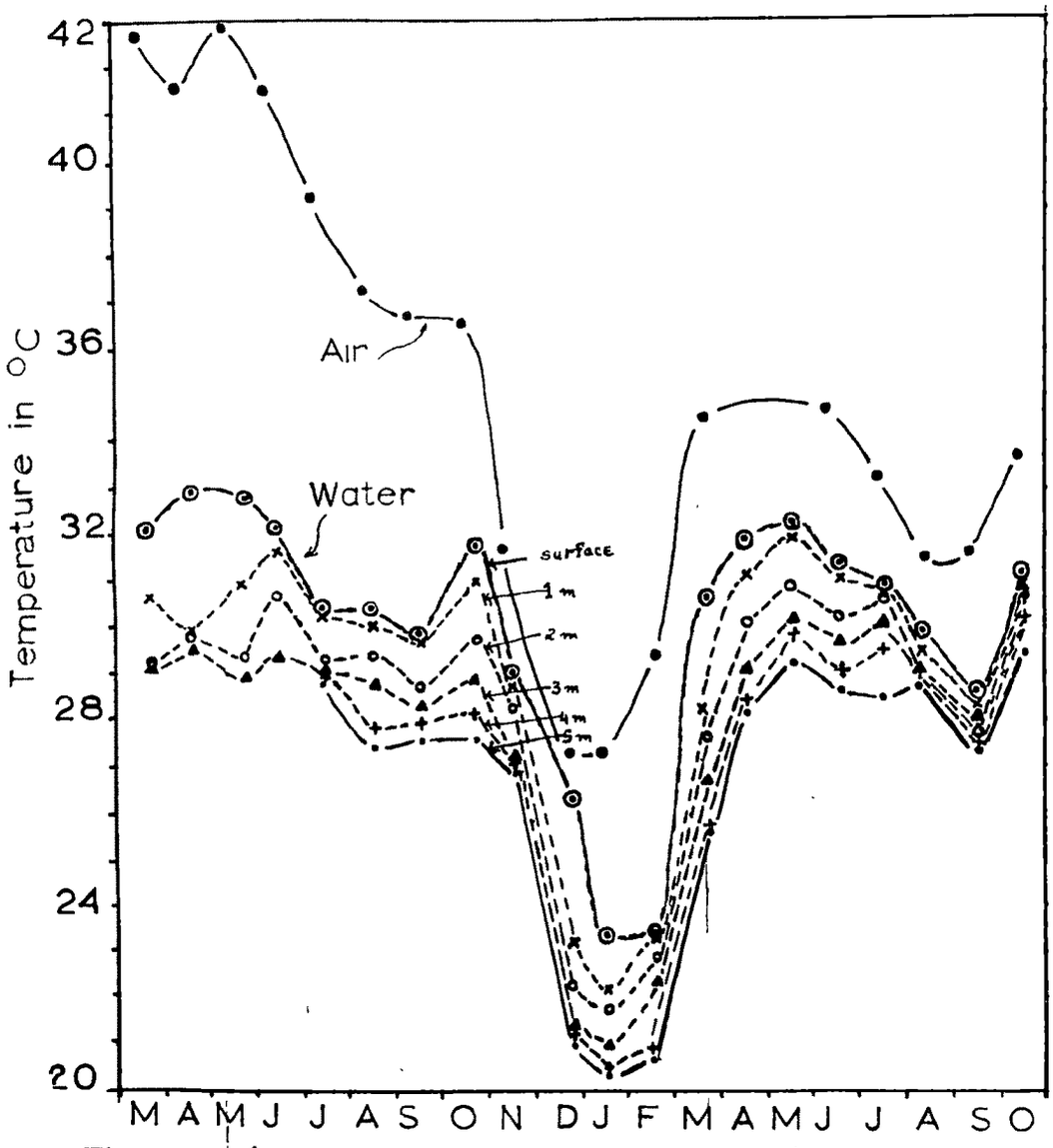

Figure 4

Temperature of air and water (0-5m depth) at 1600 hours (Station A)

Table - 5

Temperature of surface water in °C

STATION- A

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Early morning	1969	-	-	26.8	27.2	27.5	27.7	26.9	26.8	26.0	27.5	26.4	20.6
	1970	19.1	19.9	26.6	27.7	27.6	27.6	26.4	27.1	26.0	27.4	-	-
Afternoon	1969	-	-	32.2	32.7	32.8	32.8	30.4	30.4	29.8	31.8	29.0	26.3
	1970	23.0	23.4	30.6	31.9	32.3	31.3	30.9	29.9	28.6	31.1	-	-
*Early night (1st half of night)	1969	-	-	27.2	28.9	30.2	28.9	27.9	28.8	27.5	29.9	27.3	24.7
	1970	22.0	21.1	27.3	@28.9	30.8	28.9	28.6	28.3	27.2	29.8	-	-
+Laternight (2nd half of night)	1969	-	-	26.9	27.4	28.2	27.3	27.1	27.5	26.0	28.2	26.6	21.4
	1970	21.3	21.0	26.3	-	-	-	-	-	-	-	-	-

* 2200 hours
\+ 0200 hours
@ April to October 1970
only midnight temperature recorded

The temperature of the surface water and its seasonal variations are summerised in tabular statement below :

Table - 6

Maximum and Minimum Temperature (monthly average in °C)

in 1969-70
STATION - A

Time of collection	1969 Value	1969 Month	1970 Value	1970 Month	1969 Value	1969 Month	1970 Value	1970 Month
	FIRST MAXIMUM				SECOND MAXIMUM			
Early morning	27.7	June	27.6	June	27.5	Oct.	27.4	Oct.
After-noon	32.8	May	32.3	May	31.8	Oct.	31.1	Oct.
1st half of night	30.2	May	31.2	May	29.9	Oct.	30.4	Oct.
2nd half of night	28.2	May	28.9	May	28.2	Oct.	28.2	Oct.
	FIRST MINIMUM				SECOND MINIMUM			
Early morning	26.0	Sept.	19.1	Jan.	20.6	Dec.	26.0	Sept.
After-noon	29.8	Sept.	23.0	Jan.	26.3	Dec.	28.6	Sept.
1st half of night	27.5	Sept.	22.0	Jan.	24.7	Dec.	27.5	Sept.
2nd half of night	26.6	Sept.	21.3	Jan.	21.4	Dec.	26.6	Sept.

The seasonal variations in the temperature are shown in Table-7.

Table - 7

Seasonal variation in temperature (°C) of surface water during 1969 and 1970

STATION-A

Seasons	Early morning	After-noon	1st half of night	2nd half of night
Summer (March1969-May 1969)	27.2	32.6	28.8	27.5
Monsoon(Wet Summer)				
i) Early monsoon (June)	27.7	32.1	28.9	27.3
ii) Mid monsoon (jult-Sept.)	26.6	30.2	28.1	27.1
iii)Late monsoon (Oct.1969)	27.5	31.8	29.9	28.2
Winter (Nov.1969-Feb.1970)	22.1	25.7	24.4	23.4
Summer (March-May 1970)	27.1	31.6	29.3	27.5
Monsoon				
i) Early monsoon (June 1970)	27.6	31.4	29.6	28.2
ii) Mid monsoon (July-Sept.1970)	26.5	29.8	28.5	27.2
iii) Late monsoon (Oct.1970)	27.4	31.1	30.4	28.2

Early morning series 1969 : (Figure 3)

The highest temperature recorded was 27.7°C and it was reached in June; thereafter there was a fall in the monsoon season when the lower temperature of 26.0 was reached in September; and later there was a slight rise until October. Then, during the post-monsoon there was a gradual fall until the lowest temperature of the year 20.6°C was reached in December.

Early morning series 1970 :

During the cold weather the lowest temperature of 19.1 °C was recorded in January.Then there was a rise in the temperature in the hot weather until the highest of 27.6°C was reached in June; thereafter during monsoon season the second lower was reached in September and then a rise in October only to be followed by a decline in temperature.

Afternoon series 1969 : (Figure 4)

During the hot weather the highest temperature

19 of 32.8°C was reach in May followed by a rapid fall. But in the monsoon there was a rise of temperature until the second peak of 31.8°C was reached in October. Thereafter there was a gradual fall in the post-monsoon.

Afternoon series 1970 :

The lowest temperature of 23.0°C was recorded in January. The rise in the temperature was gradual, and it reached the maximum of 32.3°C in May. Thereafter there was a slight fall in temperature in monsoon. But later it increased to 31.1°C in October.

Night series 1969-70 :

The temperatures of the first and the second halves of the night also showed two maxima and two minima during the study.

Night series 1970 :

The highest temperatures of 31.2 in May 28.9 °C also in May were reached in first and second halves of night respectively. Then there was a fall.

Night series 1970 :

The lowest temperature was 22.0 and 21.3 °C in January which was followed by a rise till May when the highest temperature was 31.2 and 28.9 °C respectively. The second peak of 30.4 and 28.2 °C was in October.

Temperature of bottom layer

The temperature at the bottom layer of water showed a similar trend to that of the surface water.

Table - 8

Temperature of bottom layer of water in °C

STATION - A

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Early morning	1969	-	-	26.3	27.0	27.0	27.3	26.3	26.7	26.0	26.6	26.4	20.6
	1970	19.9	20.1	24.6	27.5	28.1	27.3	27.0	26.4	26.2	26.8	-	-
Afternoon	1969	-	-	29.1	29.5	28.9	29.4	28.7	27.5	27.6	27.6	27.0	21.0
	1970	20.4	20.7	25.8	28.2	29.8	28.7	28.4	29.1	27.4	29.3	-	-
1st half of night	1969	-	-	26.7	27.4	27.9	28.0	28.0	27.8	27.2	27.2	26.9	20.9
	1970	19.9	20.7	25.4	*27.6	28.7	28.6	27.5	27.8	26.7	28.7	-	-
2nd half of night	1969	-	-	25.6	27.1	27.5	27.3	26.5	26.9	26.4	26.9	25.6	20.7
	1970	19.9	20.4	25.0	-	-	-	-	-	-	-	-	-

* April to Oct. 1970. Midnight temperature.

Seasonal
Seasonal variations.

The maximum and minimum values are shown in Table-9.

Table - 9

Maximum and Minimum Temperature in 1969-70

STATION - A

°C

Time of collection	1969 Value	1969 Month	1970 Value	1970 Month	1969 Value	1969 Month	1970 Value	1970 Month
	FIRST MAXIMUM				SECOND MAXIMUM			
Early morning	27.3	June	28.1	May	26.6	Oct.	26.8	Oct.
After-noon	29.4	June	29.8	May	27.6	Oct.	29.3	Oct.
1st half of night	28.0	June	28.9	May	26.9	Oct.	28.9	Oct.
2nd half of night	27.3	June	28.5	May	26.9	Oct.	27.9	Oct.
	FIRST MINIMUM				SECOND MINIMUM			
Early morning	26.0	Sept.	19.9	Jan.	20.6	Dec.	26.2	Sept.
After-noon	27.6	Sept.	20.4	Jan.	21.0	Dec.	27.4	Sept.
1st half of night	27.2	Sept.	19.9	Jan.	20.9	Dec.	26.2	Sept.
2nd half of night	26.4	Sept.	19.9	Jan.	20.7	Dec.	26.8	Sept.

23 There were two maxima and two minima. The maxima for the early morning series varied between 26.6°C and 28.1 °C and for the afternoon series between27.6°C and 29.8°C; for the first half of the night between 28.0°C and 29.0°C and for the second half of the night between 26.9°C and 28.5°C. The seasonal variations are given in Table-10.

Early morning series 1969 : (Figure 3)

The average summer temperature was 26.8°C, monsoon temperature was lower and then once again a rise until it reached the second maximum of 26.6°C in October.

Early morning series : 1970 :

The lowest temperature was 19.9°C in January which was followed by rise in temperature and the highest of the hot weather was 28.1°C in May. Thereafter there was a fall and the second minimum was 26.2°C in September; then a rise to be followed by a decline in temperature in the post-monsoon.

Table - 10

Seasonal Variations in temperature (°C) of bottom layer of water during 1969 and 1970 (STATION - A)

Seasons	Early morning	After-noon	1st half of night	2nd hlf of night
Summer (March-May 1969)	26.8	29.2	27.3	26.4
Monsoon (Wet Summer)				
i) Early monsoon (June)	27.3	29.4	28.0	27.3
ii) Mid monsoon (Jult to Sept.)	26.4	28.4	27.4	26.6
iii) Late monsoon (Oct.1969)	26.6	27.6	26.9	26.9
Winter (Nov.1969-Feb.1970)	22.1	22.8	22.6	22.4
Summer (March-May 1970)	26.8	27.8	27.2	26.8
Monsoon				
i) Early monsoon (June 1970)	27.3	28.7	28.4	27.8
ii) Mid monsoon (July-Sept.1970)	26.5	28.6	27.8	26.9
iii) Late monsoon (Oct.1970)	26.8	29.3	28.9	27.7

Afternoon series 1969 : (Figure 4)

The highest temperature was 29.4 in June followed by a rapid fall in September to 27.6 °C. But in late monsoon there was slight rise of temperature until the second peak 27.6 was reached in October. Thereafter there was a fall in the post-monsoon.

Afternoon series 1970 :

The lowest temperature of 19.9°C was recorded in January. The rise through February, March and April was gradual and it reached the maximum of 29.8°C in May. The second minimum was in September which was followed by decline in the temperature in the post-monsoon.

Night series 1969-70 :

The night temperature of the bottom layer also showed a similar trend in the seasonal variations as at the surface.

STATION - B

The temperature at surface and bottom layers of water at station B have been tabulated below, (Table II). The variations in the temperature are similar to Station-A.

The temperature of the surface water and its seasonal variations are summerised in Table-12.

The seasonal variations are shown in Table-13.

Early morning series 1969 : (Figure 5)

In the month of October, the temperature recorded was 26.9°C. Thereafter, there was a rapid fall and the lowest temperature was 20.1°C in December.

Early morning series 1970)

During the cold weather the lowest temperature of 19.4°C was recorded in January. Thereafter there was a rise in the temperature in the hot weather until

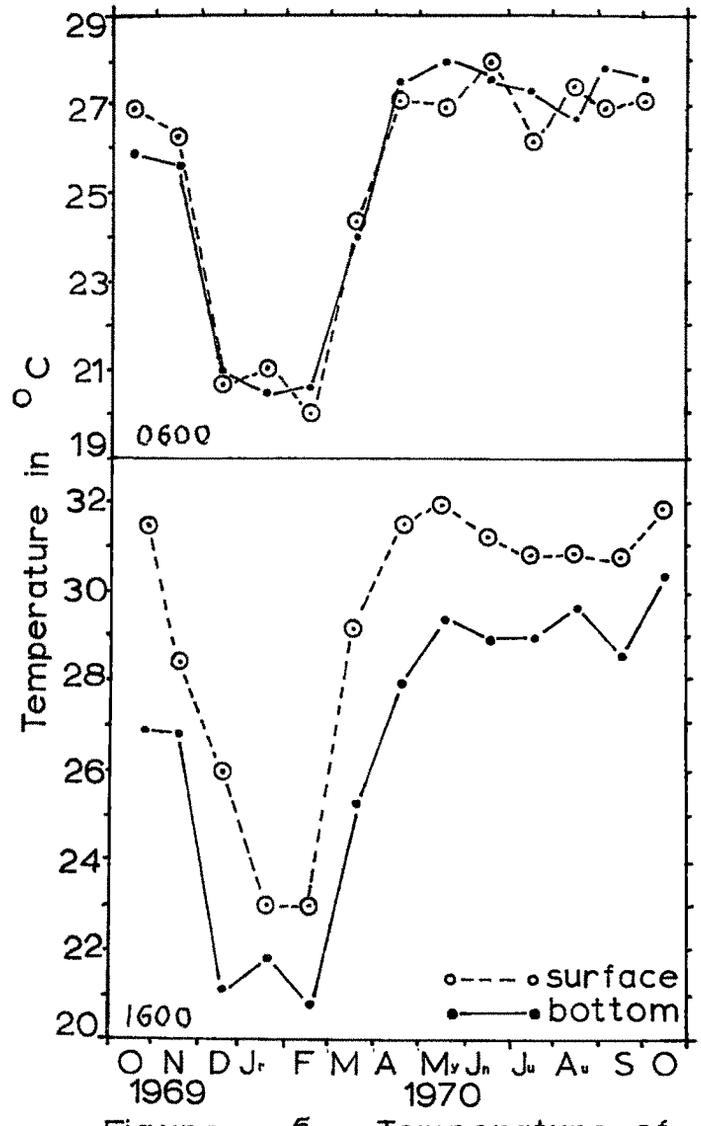

Figure 5 Temperature of surface and bottom layers of water in Ajwa Reservoir (Station B).

Table - 11

Temperature of Surface and bottom layers of water

STATION - B

°C

		1969			1970									
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Early morning	Surface	26.9	26.1	20.1	19.4	20.0	25.2	27.1	27.0	27.3	26.1	26.9	26.3	27.2
	Bottom	25.9	26.2	20.2	19.6	20.3	24.4	27.4	27.0	27.4	26.5	27.1	26.2	27.0
Afternoon	Surface	31.6	28.9	26.0	23.1	23.2	29.3	31.5	32.1	31.3	30.7	30.1	28.9	31.2
	Bottom	27.0	27.0	21.2	20.7	21.1	25.3	28.0	29.4	28.5	28.3	28.7	27.9	29.4
Early night (1st half of night)	Surface	31.0	27.4	24.9	22.3	22.0	26.7	*28.9	30.3	28.9	28.6	28.5	28.9	30.0
	Bottom	26.7	26.8	20.7	20.5	20.8	25.3	27.5	28.6	28.0	27.5	27.5	27.4	28.8
Laternight (2nd half of night)	Surface	27.9	26.6	21.7	21.3	21.4	26.0	-	-	-	-	-	-	-
	Bottom	26.3	26.6	20.6	20.0	20.6	24.8	-	-	-	-	-	-	-

* April to October 1970 Midnight Temperature.

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Table - 12

Maximum and Minimum temperature in 1969-1970

°C

Time of collection	1969 Value	1969 Month	1970 Value	1970 Month	1969 Value	1969 Month	1970 Value	1970 Month
	FIRST MAXIMUM				SECOND MAXIMUM			
Early morning	-	-	27.3	June	26.9	Oct.	27.2	Oct.
Afternoon	-	-	32.1	May	31.6	Oct.	31.2	Oct.
1st half of night	-	-	30.7	May	30.1	Oct.	30.5	Oct.
2nd half of night	-	-	28.2	May	27.9	Oct.	27.3	Oct.
	FIRST MINIMUM				SECOND MINIMUM			
Early morning	-	-	19.4	Jan.	20.1	Dec.	26.1	July
Afternoon	-	-	23.1	Jan.	26.0	Dec.	28.9	Sept.
1sthalf of night	-	-	22.0	Feb.	24.9	Dec.	28.5	Sept.
2nd half of night	-	-	21.3	Jan.	21.7	Dec.	26.7	Sept.

Table - 13

Seasonal variation in temperature of surface water

1969-70

°C

Season	Early morning	After-noon	1st half of night	2nd half of night
Late monsoon (October 1969)	26.9	31.6	30.1	27.9
Winter (Nov.1969-Feb.1970)	22.5	25.5	24.4	23.1
Summer(wet summer) (March-May 1970)	26.6	31.0	28.7	27.5
Monsoon				
i) Early monsoon (June 1970)	27.3	31.3	29.6	28.2
ii) Mid monsoon (July-Sept.1970)	26.4	29.9	28.9	27.6
iii) Late monsoon (Oct.1970)	27.2	32.2	30.5	28.6

the highest of 27.3 °C was reached in June. July temperature was 26.1 which was the second minimum and then there was rise in the temperature in October which was 27.2 °C, the second maximum.

Afternoon series 1969 : (Figure 5)

The temperature in October was 31.6°C which was followed by an abrupt fall to 26.0°C in December.

Afternoon series 1970 :

The lowest temperature of 23.1°C of the cold season was reached in January.Then there was a gradual rise till it reached the maximum of 32.1 in May.Then there was a slight fall in the temperature; once again the second maximum of 31.2°C was reached in October.

Temperature of bottom layer and its seasonal variations :

The maximum and minimum values are shown in Table-14.

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TABLE - 14

Maximum and Minimum Temperature in 1969-1970

°C

Time of collection	1969 Value	Month	1970 Value	Month	1969 Value	Month	1970 Value	Month
	FIRST MAXIMUM				SECOND MAXIMUM			
Early morning	-	-	27.0	May	25.9	Oct.	27.2	Oct.
After-noon	-	-	29.4	May	27.0	Oct.	31.2	Oct.
Night	-	-	28.7	May	26.7	Oct.	29.2	Oct.
	FIRST MINIMUM				SECOND MINIMUM			
Early morning	20.2	Dec.	20.7	Jan.	-	-	26.2	Sept.
After-noon	21.2	Dec.	21.0	Jan.	-	-	27.9	Sept.
Night	20.7	Dec.	20.9	Jan.	-	-	27.6	Sept.

The seasonal variation is given in Table-15.

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Table - 15

Seasonal variations in temperature (°C) of bottom layer of water during 1969-70 (STATION-B)

Seasons	Early morning	After-noon	1st half of night	2nd half of night
Late monsoon (October 1969)	25.9	27.0	26.7	26.3
Winter (Nov.1969-Feb.1970)	21.6	24.6	22.7	22.6
Summer (March-May 1970)	26.9	27.6	26.9	26.3
Monsoon				
i) Early monsoon (June 1970)	27.4	28.5	28.1	27.7
ii) Mid monsoon (July-Sept.1970)	26.6	28.3	27.8	27.0
iii) Late monsoon (Oct.1970)	27.0	29.4	29.2	27.7

The differences of the temperatures of the bottom layers at Stations A and B were negligible and the seasonal variations also showed the similar trend.

Table - 16

Surface and bottom temperatures (°C) and their differences in the early morning (STATION-A)

Months	Surface	Bottom	Difference	Surface	Bottom	Difference
January	-	-	-	20.2	19.9	0.3
February	-	-	-	19.1	19.5	0.4
March	26.8	26.3	0.5	26.0	25.1	0.9
April	27.2	27.0	0.2	27.7	27.5	0.2
May	27.5	27.0	0.5	27.6	28.1	0.5
June	27.7	27.3	0.4	27.6	27.3	0.3
July	26.9	26.3	0.6	26.4	27.0	0.6
August	26.8	26.7	0.1	27.1	26.4	0.7
September	26.0	26.0	0.0	26.0	26.2	0.2
October	27.5	26.6	0.9	27.4	26.8	0.6
November	26.6	26.6	0.0			
December	20.6	20.6	0.0			

Table - 17

Surface and bottom temperature (°C) and their differences in the afternoon (STATION-A)

Months	Surface	Bottom	Difference	Surface	Bottom	Difference
January	-	-	-	23.0	20.7	2.3
February	-	-	-	23.4	20.7	2.3
March	32.2	29.1	3.1	30.6	25.8	4.8
April	32.9	29.5	3.4	31.9	28.2	3.7
May	32.8	28.9	3.9	32.3	29.3	3.0
June	32.1	29.4	2.7	31.4	28.7	2.7
July	30.4	28.7	1.7	30.9	28.4	2.5
August	30.4	27.5	2.9	29.9	29.1	0.8
September	29.8	27.6	2.2	28.6	27.4	1.2
October	31.8	27.6	4.2	31.1	29.3	1.8
November	29.0	27.0	2.0	-	-	-
December	26.3	21.0	5.3	-	-	-

5

Thermal stratification.

(a) The early morning series and afternoon series of temperature measurements taken on the same day every month in the vertical direction at Station-A for 1969 and 1970 are considered for the purpose of studying the thermal stratification.

In Table-16 the surface and bottom temperatures and their differences are shown for the early morning series. This data show that the differences between surface and bottom temperatures in the early morning ranged between 0.0°C and 0.9°C. In some months there was practically no difference at all. In other words the condition in the reservoir was isothermal in the early hours for the whole year. It would appear that there was complete circulation or turnover of the water in the reservoir taking place every day, through out the year, and hence the isothermal condition in the early morning hours.

(b) The afternoon series of surface and bottom temperatures are shown in Table-17. Almost all through out year there was greater (compared to

56 the early morning series) difference in the temperatures between the surface and bottom layers, indicating the existence of a well defined thermal stratification. Thus there was well defined daily thermal stratification and the circulation or turn-over before the early morning hours through out the year in the water of Ajwa Reservoir. Also the entire reservoir gets heated up during the course of the day especially in the afternoon as a result of which the bottom temperature also rise and show seasonal variations similar to the atmospheric temperature. These changes affect the biological productivity in the reservoir, as will be seen later.

(h) Hydrogen ion concentration (pH) :

Determinations of pH were made in the surface samples drawn in the early morning and afternoon hours (detailed in Chapter-3). The maximum pH varied between 8.3 and 8.5 and the minimum between 8.1 and 8.2 in the early morning samples. In the case of the afternoon samples, the maximum was 8.8 and the minimum

varied between 8.2 and 8.1.

The results of the monthly variations are shown below for one year (1969-70) for the surface water, (Table 18).

Table - 18

pH of water on the dates of collection

Date -month		Early morning	After-noon	Diffe-rence
1969				
March	- 24	8.3	8.6	0.3
April	- 21	8.3	8.6	0.3
May	- 25	8.5	8.8	0.3
June	- 13	8.2	8.8	0.6
July	- 14	8.2	8.6	0.4
August	- 15	8.4	8.3	0.1
September	- 15	8.2	8.2	0.0
October	- 22	8.2	8.3	0.1
November	- 26	8.1	8.3	0.2
December	- 27	8.1	8.3	0.2
1970				
January	- 7	8.3	8.4	0.1
February	- 10	8.2	8.1	0.1

The pH values were comparatively higher during the period March to July. Comparing the early morning and afternoon values, it is found that the afternoon values are more alkaline and the increase in alkalinity has to be attributed to photosynthesis.

SECTION B : The Chemical Environment and Nutrient Supply linked with primary production.

(a) General Characteristics of the water :

i) Hardness

ii) Chloride

iii) Dissolved gases

1) Free CO_2

2) Dissolved oxygen at Stations A and B and

3) Percentage saturation values of Oxygen and Stations A and B.

(b) Ions involved in plant nutrition :

i) Inorganic forms of nitrogen

ii) Phosphate (PO_4)

iii) Silicate (SiO_2)

iv) Iron

v) Calcium, Sodium and Potassium.

(a) General Characteristics of the Water :

In this section an attempt is made to indicate the relative abundance of the major ionic constituents and their seasonal variations in the Ajwa reservoir.

(i) The hardness in Ajwa was mainly due to bicarbonates and to some extent carbonates of calcium and magnesium (ii) Chlorides: The figures for hardness and chloride for 1969-70 are shown in Table 19 for one year.

Table-19

Hardness and Chlorides in Surface sample

Date	Parts per million Hardness	Chloride	Water level (actual depth in meters)
1969			
March - 24	156	62	7.06
April - 21	160	70	6.72
May - 25	170	75	5.73
June - 13	176	76	4.10
July - 14	160	73	4.63
Aug. - 15	150	48	6.20
Sept. - 15	140	40	8.77
Oct. - 23	143	43	8.67
Nov. - 26	145	48	8.40
Dec. - 27	148	50	8.19
1970			
Jan. - 7	146	50	7.91
Feb. - 10	148	50	7.81

In respect of hardness, the value varied from a minimum of 140 in September to a maximum of 176 in June. There was a gradual increase from March to June when the maximum was reached. Thereafter, there was a gradual decline until September when the minimum was reached and then again there was a gradual rise in values.

Taylor (1958) has classified waters as "soft" and "hard" (depending on the hardness which was mainly due to bicarbonates and to some extent carbonates of calcium and magnesium) as detailed below :

Less than 50 ppm	Soft
From 50 to 100 ppm	Moderately soft
From 100 to 150 ppm	Slightly hard
More than 150 and less than 250 ppm	Moderately hard
More than 250 and less than 350 ppm	Hard
More than 350 ppm	Very hard

According to the above classification, the waters of the Ajwa reservoir range between slightly hard and moderately hard.

The seasonal variation in the values of hardness is also found to vary inversely with the reservoir level, indicating that changes in concentration of solutes due to evaporation were responsible for this variation.

(ii) Chloride (See Table 19)

The values were found to vary from a minimum of 40 ppm in September to a maximum of 76 ppm in June. The contents were found to increase from March to June and thereafter to decrease until September. Thereafter there was a gradual rise again till June.

(iii) Dissolved gases.

(1) Free CO_2 : Carbon dioxide was not found at any time during the period of investigation.

(2) Dissolved oxygen. The results of oxygen determinations are expressed in milligrams per litre and also in terms of percentage saturation which was calculated from the table given in 'Standard Methods' (1965). The results are presented in following tables.

STATION A

The oxygen content at surface and bottom layers of water are shown in tables 20 and 23 .

The dissolved oxygen is dependent on following physical and biological factors.

(i) Air and consequently water temperature.

(ii) Exchange of gases between air and water at the interface.

(iii) Wind velocity and consequently turbulence.

(iv) Solar energy radiant on the surface and its penetration into deeper layers affected by turbidity of water.

(v) Amount of photosynthetic cover.

(vi) Amount of total (animal, plant and bectarial) respiration.

(a) The oxygen content in the surface layer and its seasonal variations (Tables 21 and 22)

Table - 20

Oxygen content (mg/1) in surface layers of water

STATION A

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Early morning	1969	-	-	6.3	6.6	6.0	5.6	6.6	7.0	7.0	4.9	4.7	6.0
	1970	4.0	5.1	4.4	5.5	5.3	5.4	4.3	4.9	5.2	6.0	-	-
Afternoon	1969	-	-	8.1	7.8	7.6	7.0	7.6	8.0	8.1	5.6	5.4	7.2
	1970	5.4	6.4	6.0	7.4	7.8	7.0	5.9	6.3	6.5	7.0	-	-
1st half of night	1969	-	-	6.8	7.2	6.7	6.4	7.0	7.3	7.4	5.2	5.0	6.5
	1970	4.9	5.9	5.5	*6.4	5.9	6.2	4.9	5.5	5.6	6.6	-	-
2nd half of night	1969	-	-	6.2	6.9	6.6	5.8	6.0	7.0	7.0	4.9	4.9	6.2
	1970	4.3	5.4	4.6	-	-	-	-	-	-	-	-	-

* April to October
only mid night rates.

(i) The maximum and minimum values.

Table - 21

The maximum and minimum values of oxygen in the surface water

	Maximum				Minimum			
	1969		1970		1969		1970	
	Value	Month	Value	Month	Value	Month	Value	Month
Early morning	7.0	Aug.	6.0	Oct.	3.7	Nov.	4.0	Jan.
After-noon	8.4	Sept.	7.8	May	5.6	Nov.	5.9	July

It would be seen from the above that the maximum value for oxygen is reached in August and September in 1969 and April & May 1970 and minimum value in Nov.1969 and in January & July in 1970.

(ii) Seasonal variations.

The data on seasonal variation in oxygen content are shown in Table-22.

Table - 22

The seasonal variation in the oxygen (mg/l) content in the surface layer during 1969 and 1970 (STATION A)

Seasons	Early morning	After-noon	1st half of night	2nd half of night
Summer				
(March-May 1969)	6.3	7.9	7.0	6.7
Moonsoon (Wet summer)				
i) Early monsoon (June 1969)	5.6	7.4	6.4	5.8
ii) Mid monsoon (July-Sept.1969)	6.9	7.9	7.2	6.9
iii) Late moonsoon (Oct.1969)	4.9	5.6	5.2	4.9
Winter	4.6	6.1	5.7	5.1
(Nov.1969-Feb.1970) Summer (March-May 1970)	4.9	6.8	6.9	5.8
Monsoon				
i) Early moonsoon (June 1970)	5.4	7.0	7.0	6.2
ii) Mid monsoon (July-Sept.1970)	4.9	5.15	5.9	4.9
iii) Late monsoon (Oct. 1970)	6.0	7.0	6.9	6.6

From a study of the above it is seen that both the highest and lowest value are reached in the hot weather and monsoon seasons.

Table - 23

Oxygen content (mg/l) in bottom layer of water

STATION A

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Early morning	1969	-	-	5.0	6.0	5.1	4.9	5.8	6.0	6.0	4.0	3.6	5.3
	1970	3.6	4.4	3.6	4.4	4.6	4.6	3.3	3.9	4.1	5.1	-	-
Afternoon	1969	-	-	6.0	6.4	6.0	5.6	6.1	6.3	6.2	4.1	3.8	5.7
	1970	3.9	4.7	3.9	4.6	5.7	5.5	4.0	4.5	4.9	5.5	-	-
1st half of night	1969	-	-	5.0	6.0	5.3	5.2	5.9	6.3	6.1	4.1	3.8	5.4
	1970	3.6	4.4	3.9	*4.5	4.7	5.0	3.5	4.2	4.2	5.3	-	-
2nd half of night	1969	-	-	4.8	5.8	5.1	5.0	5.9	5.9	6.0	4.1	3.6	5.3
	1970	3.5	4.4	3.8	-	-	-	-	-	-	-	-	-

* April to October only midnight values.

(b) Oxygen content of the bottom layer and its seasonal variation.

The results are shown in Table-23.

Table - 24

The maximum and the minimum values of oxygen during 1969-70

Time of collection	Maximum				Minimum			
	1969		1970		1969		1970	
	Value	Month	Value	Month	Value	Month	Value	Month
Early morning	6.0	Aug.	5.7	May	3.2	Nov.	3.3	July
After-noon	6.4	Apr.	4.7	Feb.	3.6	Nov.	4.0	July

It would be seen from the above that the oxygen content in the bottom layer was found to be maximum in August and April in 1969 and in May & February in 1970 and minimum in November, in 1969 and July 1970.

Seasonal variation in oxygen concentration in bottom layer, given in Table-25.

Table - 25

The seasonal variation in the oxygen content in the bottom layer during 1969-70 (STATION A).

Seasons	Early morning	After-noon	1st half of night	2nd half of night
Summer (March-May 1969)	5.3	6.2	5.4	5.2
Monsoon (Wet summer)				
i) Early monsoon (June 1969)	4.9	5.6	5.6	5.0
ii) Mid monsoon (July-Sept.1969)	5.95	6.2	6.2	5.9
iii) Late monsoon (Oct.1969)	4.0	4.1	4.1	4.1
Winter (Nov.1969-Feb.1970)	4.65	5.05	4.75	4.65
Summer (March-May 1970)	4.30	5.00	4.70	4.35
Monsoon				
i) Early monsoon (June 1970)	4.60	5.3	5.0	4.8
ii) Mid monsoon (July-Sept.1970)				
iii) Late monsoon (Oct1970)	5.1	5.3	4.05	5.1

From the above it would be seen that the bottom layer was never totally deficient in oxygen at any time during the period of investigation.

Vertical Distribution of Oxygen :

(a) Early morning series :

The oxygen values for the surface and bottom layers with their differences are shown in Table-26.

Table - 26

Oxygen (mg/l) in surface and bottom layers of water and their differences in the early morning. (STATION A)

1969-70

Months	Surface	Bottom	Difference	Surface	Bottom	Difference
January	-	-	-	4.5	3.7	0.8
February	-	-	-	5.1	4.4	0.7
March	6.3	5.0	1.3	4.4	3.6	0.8
April	6.6	6.0	0.6	5.5	4.4	1.1
May	6.0	5.1	0.9	5.3	4.6	0.7
June	5.6	4.9	0.7	5.4	4.6	0.8
July	6.6	5.8	0.8	4.3	3.3	1.0
August	7.0	6.0	1.0	4.9	3.9	1.0
September	7.0	6.0	1.0	5.2	4.1	1.1
October	4.9	4.0	0.9	6.0	5.1	0.9
November	3.7	3.2	0.5	-	-	-
December	6.0	5.3	0.7	-	-	-

In all the cases (except in March 1969) there was no appreciable decrease in the concentration. Such a distribution has been called 'Orthrograde' by Aberg and Rodhe (1949 cf. Hutchinson,1957,p.603), and it is not 'Clinograde'.

(b) Afternoon series :

The results of the oxygen concentration in surface and bottom layers are shown in Table-27.

Table-27

Oxygen (mg/l) in surface and bottom layers of water and their difference in the afternoon. (STATION A)

Months	1969			1970		
	Surface	Bottom	Difference	Surface	Bottom	Difference
January	-	-	-	6.7	4.3	2.4
February	-	-	-	6.6	4.7	1.9
March	8.4	6.2	2.2	6.3	4.0	2.3
April	7.9	6.5	1.4	7.4	4.6	2.8
May	7.8	6.0	1.8	7.8	5.7	2.1
June	7.5	5.5	2.0	7.0	5.6	1.4
July	7.8	6.2	1.6	5.9	4.0	1.9
August	8.1	6.4	1.7	6.4	4.6	1.8
September	8.4	6.2	2.2	6.6	4.9	1.7
October	5.8	4.1	1.7	7.1	5.5	1.6
November	5.8	3.6	2.2	-	-	-
December	7.4	5.7	1.7	-	-	-

14 In this series there were appreciable differences in the oxygen content between the surface and bottom samples. Large differences of 2.2 mg/l in March and September of 1969 and 2.8 mg/l in April of 1970 were recorded. Hutchinson (1957, p.607) states "Following in part the scheme of Thienemann (1928) the agents of deoxygenation may be classified as (i) animal respiration; (ii) plant respiration at night, or when the respiring organisms have sedimented below the compensation point; (iii) bacterial respiration in the decomposition of sedimentary organic matter, and (iv) purely chemical oxidation of organic matter in solution, either produced in or brought into the Lake". In Ajwa reservoir, animal respiration appeared to be the main factor responsible for appreciable quantity of deoxygenation in the bottom layers. Also the reservoir is full of carp fishes, some of which always feed upon bottom sediments. They may disturb the bottom deposits which may also have consumed a part of the oxygen dissolved in the bottom layer. At no time there was a catastrophic oxygen deficiency in the bottom layers.

The increased amounts of oxygen in the surface

layer is attributed to surface aeration and/or photosynthesis.

Percentage Saturation of Oxygen :

It is useful to know the amount of dissolved oxygen in the water when saturated with atmospheric oxygen.The ratio of the two contents usually expressed as 'percentage saturation' can throw light on previous physical and biological history of the sample.The ratio also controls the rate at which oxygen is taken up from the air (Mortimer 1956). So, the values for percentage saturation were calculated and are discussed below :

The percentage saturation values for the surface and bottom layers are shown in Table-28, and 36.

Ruthner (1926 cf. Welch 1935, p.170) has stated that the respiration of aquatic organisms depends not only on the dissolved O_2 content but also in a significant measure upon the temperature of the surrounding water, and that in lakes showing a decline of the dissolved oxygen in deeper waters in summer or winter, the temperature must be considered in determining the

Table - 28

Percentage Saturation of Oxygen in surface and bottom layers of water

STATION A

SURFACE

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Early morning	1969	-	-	76.9	81.5	79.7	70.9	81.5	87.7	85.4	60.5	56.6	73.2
	1970	45.6	56.1	55.1	61.3	67.3	67.5	55.1	61.3	62.5	74.9	-	-
Afternoon	1969	-	-	110.5	106.8	106.9	101.3	103.1	106.6	106.4	78.4	72.3	93.7
	1970	71.4	75.1	82.8	99.1	105.1	92.2	77.5	83.1	83.5	91.1	-	-

BOTTOM

Early morning	1969	-	-	60.9	73.2	62.9	60.5	70.7	74.1	73.8	50.0	42.5	66.2
	1970	39.5	48.7	42.9	52.4	65.1	61.7	47.4	48.8	50.0	62.9	-	-
Afternoon	1969	-	-	79.1	83.3	83.1	70.5	77.6	80.0	77.5	50.2	45.6	63.3
	1970	45.3	52.2	51.3	57.3	71.2	69.0	50.0	57.1	62.5	67.1	-	-

Table - 29

Oxygen content in surface and bottom layers of water

STATION B

		1969			1970									
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Early Morning	Surface	5.2	4.4	5.2	4.8	6.1	5.2	5.8	5.9	6.1	6.1	5.9	5.4	5.5
	Bottom	4.4	3.6	4.4	4.1	5.4	5.0	5.0	5.0	5.4	5.2	5.0	4.1	4.9
Afternoon	Surface	6.8	6.3	7.4	6.8	7.4	7.5	6.9	6.9	7.2	7.4	7.4	7.0	8.0
	Bottom	4.9	4.0	5.2	4.5	5.9	5.6	5.9	5.6	6.0	6.1	5.6	5.2	5.9
1st half of night	Surface	6.2	5.7	6.2	5.8	6.7	6.5	*6.2	6.2	6.4	6.4	6.4	6.2	7.1
	Bottom	4.8	3.8	5.1	4.3	5.5	5.4	5.1	5.4	5.7	5.5	5.3	4.8	5.4
2nd half of night	Surface	5.4	4.7	5.4	5.1	6.3	5.5	-	-	-	-	-	-	-
	Bottom	4.5	3.6	4.6	4.1	5.5	5.1	-	-	-	-	-	-	-

* April to October only mid night values.

17 respiratory values of the dissolved oxygen present. He also states that the practice of expressing the results of dissolved oxygen in percentage of saturation in misleading.

STATION - B

(a) The oxygen content in surface and bottom layers of water are summarised in Table-29.

The oxygen content in the surface layer and its seasonal variations :

The oxygen content at Station B also showed similar variations as in Station A. Comparing the differences in the oxygen content in surface and bottom layers of water in the morning series, the differences in the afternoon series is larger. The deoxygenating agents have been discussed previously.

(i) The maximum and minimum values : (Table-30)

Table - 30

The maximum and minimum values of oxygen during 1969-70.

	Maximum				Minimum			
	1969		1970		1969		1970	
	Value	Month	Value	Month	Value	Month	Value	Month
Early morning	5.2	Oct.	6.1	June	4.1	Nov.	5.4	Sept
After-noon	7.1	Oct.	8.2	Oct.	6.5	Nov.	6.9	Apr.

19 It would be seen from above that the maximum values for oxygen was reached in October and minimum reached in November, or Sept. or April.

(ii) Seasonal variations.

The data are shown in Table-31.

Table-31

Seasonal variation in Oxygen (mg/l) in surface layer at STATION B

Seasons	Early morning	After-noon
Late monsoon (Oct.1969)	5.2	7.1
Winter (Nov.1969-Feb.1970)	5.1	7.3
Summer (March-May 1970)	5.6	7.2
Monsoon		
i) Early monsoon (June 1970)	6.1	7.4
ii)Mid monsoon (July-Sept.1970)	5.8	7.5
iii) Late monsoon(Oct.1970)	5.5	8.2

From the study of the above table it is seen that both the highest and the lowest values are reached in October and in November the values being 8.2 and 5.1 mg/l respectively.

(b) Oxygen content of the bottom layer and its seasonal variations :

(i) The maximum and minimum values.

Table - 32

The maximum and minimum values of oxygen during 1969-70

Time of collection	Maximum				Minimum			
	1969		1970		1969		1970	
	Value	Month	Value	Month	Value	Month	Value	Month
Early morning	4.4	Oct.	5.4	June	3.0	Nov.	3.9	Jan.
After-noon	5.2	Dec.	6.1	July	3.5	Nov.	4.5	Jan.

It would be seen from the above that the maximum value for oxygen is reached in July and minimum values in November and in January.

(ii) Seasonal variations :

The data are shown in Table-33.

Table - 33

Seasonal variation in Oxygen (mg/l) in Bottom layer at STATION B

Seasons	Early morning	After-noon
Late monsoon (Oct. 1969)	4.4	5.0
Winter (Nov.1969-Feb.1970)	4.3	4.9
Summer (March-May 1970)	5.0	5.7
Monsoon		
i) Early monsoon (June 1970)	5.4	6.0
ii) Mid monsoon (July-Sept.1970)	4.7	5.8
iii) Late monsoon (Oct.1970)	4.9	6.1

From a study of above it is seen that both the highest and the lowest values are reached in October and November.

Vertical distribution of Oxygen :

(a) Early morning series.

The oxygen values for surface and bottom layers with their difference are shown in Table-34.

Table - 34

Vertical distribution of oxygen during 1969-70

STATION - B (Early morning)

Month	Surface	Bottom	Difference
October	5.2	4.4	0.8
November	4.2	3.3	0.9
December	5.2	4.4	0.8
January	4.8	4.0	0.8
February	6.1	5.4	0.7
March	5.2	5.0	0.2
April	5.8	5.0	0.8
May	5.9	5.0	0.9
June	6.1	5.4	0.7
July	6.1	5.2	0.9
August	5.9	5.0	0.9
September	5.4	4.9	0.5
October	5.5	4.9	0.6

Afternoon series. The oxygen values for surface and bottom layers with their differences are given in Table-35.

Table - 35

Vertical distribution of oxygen during 1969-70

STATION - B (Afternoon)

Month	Surface	Bottom	Difference
October	7.1	5.0	2.1
November	6.5	3.8	2.7
December	7.8	5.3	2.5
January	7.2	4.6	2.6
February	7.6	6.0	1.6
March	7.6	5.6	2.0
April	7.0	5.9	1.1
May	7.0	5.7	1.3
June	7.4	6.0	1.4
July	7.6	6.2	1.4
August	7.6	5.7	1.9
September	7.2	5.4	1.8
October	8.2	6.1	2.1

Station B also showed daily thermal stratification in the afternoon similar to that of Station A.

Table - 36

Percent saturation of Oxygen in surface and bottom layers of water

STATION B

	1969			1970									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
SURFACE													
Early morning	64.2	56.3	56.4	52.3	66.3	61.3	71.6	72.1	76.4	74.3	72.1	65.1	67.2
Afternoon	94.3	81.3	95.1	93.7	94.8	96.1	92.8	93.3	90.3	100.0	96.1	95.2	107.8
BOTTOM													
Early morning	53.7	40.2	47.8	45.3	59.1	57.5	63.3	60.8	66.6	63.4	62.7	50.0	61.7
Afternoon	62.7	46.3	58.8	51.1	66.6	68.7	74.1	71.8	75.3	76.6	71.3	67.5	71.8

(b) Ions involved in plant nutrition :

(1) Inorganic forms of nitrogen.

Nitrogenous compounds occur in varying amounts in lake water, depending upon the nature of the water-shed, the amount of pollution, and the abundance of planktonic life in them. They occur in two forms: organic and inorganic nitrogens. Organic nitrogen is parly in suspension and partly in solution. Suspended organic nitrogen is derived from the billions of bacterial cells, phyto and zoo-plankton and other floating organic materials in the water. These can be removed from water easily by centrifuging or filtration. The soluble organic nitrogen (in true and colloidal solution) results form (a) the decomposition of dead organic matter by bacterial action and (b) excretions of aquatic animals.

The inorganic forms of nitrogen consist of ammonium salts, nitrites and nitrates. Free ammonia, or ammonium salts result from decomposition of organic matter by saprophytic bacteria. Nitrites are derived from free ammonia and its salts and become nitrates by

the action of nitrifying bacteria. Free nitrogen and ammonia can be formed also by the action of denitrifying bacteria on nitrites and nitrates. Therefore, the total quantity of inorganic nitrogenous compounds will depend upon the proportion of nitrifying to the denitrifying bacteria in the later.

Estimations of free ammonia, nitrites and nitrates were made regularly on the surface samples every month. All the three forms of nitrogen were found to be absent in the Ajwa reservoir.

Ruttner (1931) who examined the tropical lakes of Sumatra, Jawa and Bali found that ammoniacal nitrogen was in largest amounts in the bottom layers and 'nil' in the surface layers. Hutchinson et al.(1932) found nitrites in traces in all the pans and lakes of South Africa. Beadle (1950) found trace or none at all of nitrites and nitrates in the Rift Valley lakes of East Africa. In the lakes of the English lake district, Pearsall (1930) cound not detect ammonia in the surface layer at any season.

(ii) Orthophosphate (PO_4)

This was not detected in the surface layers of the early morning or afternoon series of samples collected every month during 1969-70. Sreenivasan (1964) did not find the soluble phosphatates in the Bhavanisagar reservoir, Madras. Einsele (1938) has explained that under oxidising conditions phosphate is precipitated in the presence of irons as insoluble ferric phosphate on the mud-surface and that appears to be the reason for its absence in the Ajwa reservoir.

(iii) Silicates (SiO_2)

Silicon is almost universally present in some more or less reactive form in all natural waters (Hutchinson, 1957). According to him, the data suggest that greater silicate concentration can occur in tropical than in temperate regions; and that the movement of silica, like that of phosphate but to a lesser degree is determined by the state of oxidation of the iron present, at the mud-surface interface, though very little is known definitely about this.

Silica was estimated regularly at the surface layers in the early morning and afternoon collections. The results are shown below in Table 37.

The silica content in the surface layers was found to range from 0.1 to 0.20 mg/l.

Table - 37

Silica content (SiO_2) in mg/l in the surface water of the Ajwa reservoir during 1969-70

	Early morning	After-noon
1969		
March - 24	0.10	0.10
April - 21	0.10	0.10
May - 25	0.10	0.10
June - 13	0.10	0.14
July - 14	0.13	0.10
August - 15	0.20	0.14
September - 15	0.20	0.13
October - 22	0.10	0.10
November - 26	0.13	0.13
December - 27	0.15	0.15
1970		
January - 7	0.15	0.15
February - 10	0.10	0.10

9 (iv) Iron :

Iron was estimated qualitatively only. It was not found in the surface water at any time during the period of investigation.

(v) Calcium, sodium and potassium:

The results of examination of the surface water for the four constituents are shown in Table-38.

Table - 38

Ca, Na and K contents in mg/l.

	Calcium	Sodium	Pottassium
1969			
March - 24	11.40	54.60	2.35
April - 21	13.50	56.81	2.30
May - 25	13.62	57.48	2.64
June - 13	13.80	58.84	3.00
July - 14	12.10	54.68	2.75
August - 15	7.40	51.64	3.78
September - 15	6.48	46.68	3.90
October - 22	9.88	50.94	3.78
November - 26	11.98	58.66	1.64
December - 27			
1970			
January - 7	9.4	51.28	1.42
February - 10	10.3	52.40	2.36

50 SECTION C : Biological conditions linked with primary production.

(a) Net phytoplankton at Station A.

i) A list of the phytoplanktonic organisms.

ii) Percentage composition of the algal and animal groups of organisms.

iii) Quantative grouping of the organisms.

iv) Periodicity of the most dominant organism.

(b) The larger aquatic vegetation at Station B.

i) Rooted and submerged hydrophytes in descending order of abundance.

ii) Vertical distribution of plants.

iii) Horizontal distribution of plants.

iv) Standing crop.

(c) Periphyton at Station B.

i) Bio-mass

31 (a) Net phytoplankton at Station A.

(i) List of the phytoplankton organisms found in the netplankton during the period of investigation is given below :

Chlorophyta.

1. Cosmarium depressum Nag.
2. Cosmarium contractum Kirchn.
3. Pediastrum simplex Meyen.

Chrysophyta.

4. Botryococcus braunii.

Bacillariophyceae.

5. Surirella tenera var nervosa AS.
6. Synedra ulna (Nitz) Ehr.

Cyanophyta.

7. Anacystis cyana (Kutz) Dr. & Daily.

(ii) Percentage composition of the different algal groups.

It is shown in a Table-39.

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Table - 39

Percent composition of algal groups

Name of the algal group	No.of species in each group	% of the total
1. Chlorophyta	3	43.0
2. Chrysophyta	1	14.3
3. Bacillariophyceae	2	28.6
4. Cyanophyta	1	14.3
Total	7	100.2

From the above it will be seen that the development or phytoplankton organisms is comparatively poor, the total number of organisms being only 7. Of these chlorophyta constitutes 43%; Bacillariophyceae 28.6% and Chryosophyta and cyanophyta constituting 14.3% each.

(iii) Quantitative grouping of the organisms.

Of the seven forms reported in the plankton catches, the only two organisms which were not only constant but also attained fairly large numbers at one time or another were Pediastrum simplex Meyen and Botryococcus braunii, Surirella tenera var nervosa A.S. was only seen in fairly large numbers occasionally. The

Table - 40

Periodicity of Phytoplankton organisms (in 5 ml sample of the Catch) at Station - A in the Ajwa Reservoir (numbers per ml)

Name of the organisms	Mar. 24	Apr. 21	May 25	June 13	July 14	Aug. 15	Sept. 15	Oct. 23	Nov. 26	Dec. 27
					1969					
1. Cosmarium depressum Nag	-	-	5	-	10	-	20	-	-	-
2. Cosmarium contractum Kirchn	5	25	-	-	-	-	10	5	5	-
3. Podiastrum simplex Meyen	45	55	60	200	280	50	70	-	10	20
4. Botryococcusbraunii	5	-	10	65	160	110	180	40	-	-
5. Surirella tenera var. nervosa A.S.	5	10	-	80	-	-	-	40	100	100
6. Synedra ulna (Nitz) Ehr.	-	-	5	10	-	-	25	-	-	50
7. Anacystis cyana (Kutz) Dr. & Daily	10	10	120	-	-	5	-	-	-	-

	Jan. 27	Feb. 19	Mar. 23	Apr. 16	May. 16	June 14	July 15	Aug. 9	Sept. 16	Oct. 16
					1970					
1. Cosmarium depressum Nag	15	10	-	-	50	50	100	10	-	-
2. Cosmarium contractum Kirchn.	-	-	-	15	-	-	-	10	50	-
3. Pediastrum simplex, Meyen	45	55	60	100	250	200	250	150	100	100
4. Botryococcus braunii	-	-	50	110	100	150	150	50	-	5
5. Surirella tenera var. nervosa A.S.	50	10	10	120	40	40	-	-	5	-
6. Syndra ulna (Nitz) Ehr.	10	5	-	-	-	25	-	-	10	-
7. Anacystis cyana (Kutz) Dr. &Daily	5	10	100	-	-	-	-	-	-	-

rest of the 7 were found rare or very rare or stray.

(iv) Periodicity of the most dominant organism.

The only organism which was most dominant was Pediastrum simplex Meyen, and it was found in abundance during the monsoon season. In other seasons it was common or stray, (Table 40).

(b) The larger aquatic vegetation at station B.

(i) Rooted and submerged hydrophytes in descending order of abundance.

(a) Hydrocharitaceae: Vallisneria spiralis, Hydrilla verticellata.

(b) Naiadaceae: Naias flexilis, Naias marina var muricata, Naias major.

(c) Potamogetonaceae: Potamogeton indicus.

(d) Lentilariaceae: Utricularia stellaris.

Vallisneria was seen flowering in November and December and its pollen grains were seen floating in abundance on the water surface during those months.

(ii) Vertical distribution of plants.

As a general rule the distribution and quantity of submerged hydrophytes are influenced by the transparency of water, character of the bottom deposits and the quantity of nutrients in the water. The submerged hydrophytes compete with the free floating phytoplankton for light and nutrients. The increase of phytoplankton in the upper layers of water results on the one hand, in a rapid decrease in transparency and on the other in the depletion of nutrients of biological significance. In the case of the Ajwa reservoir, phytoplankton is very poor and hydrophytes are seen in abundance.

On a rough survey of the reservoir during April and May when the reservoir level was the lowest, it was found that about 0.8 % of Najas flexis, 2.3 % of Potamogeton indicus, and about 63.25 % of Vallisneria spiralis were seen in 1 to 3 m and 3 to 5 metre depths but in lesser numbers at the letter depths. No attempt was made to determine the compensation depth.

(iii) Horizontal distribution of plants.

In the Ajwa reservoir, transparency of

water as measured by the disappearance of the Secchi's disc was found to vary between 55 cm and 108 cm in 1969 and between 47 cm and 250 cm in 1970 at Station A. The compensation depth in the Ajwa reservoir may be considered to vary between 1 m to 5 m if the conclusion of Hogetsu and Ichimura (1954) is accepted. (See Discussion). The occurence of hydrophytes upto 3 meter depth in the Ajwa reservoir, on the above basis, can then be explained. The three dominant plants are seen at all depths from shore to the depth of 3 m in the reservoir.

(iv) The Standing crop.

By the methods mentioned under "Materials and Methods", the standing crops in the summer season of April and May, 1970 were computed. The results are shown in a tabular form in Table-41.

The area of the plant zone in the Ajwa reservoir is nearly 1200 hectares. The wet weight of the plants per hectare comes to be 16,550 kg. In lake Mendota and in Green lake, U.S.A. Ricket (1922, 1924) found 17,788 and 15,880 kg per hectare of wet weight respectively.

Table - 41

Estimated total weights of the dominant higher aquatic plants in the Ajwa reservoir in April and May 1970

Species	Weight in kg wet	Dry*	Percentage
1. Vallisneria spiralis	12,500,000	1,250,000	63.0
2. Potamogeton indicus	4,500,000	450,000	22.7
3. Naias flexilis	1,660,000	166,000	0.8
4. Hydrilla verticellata	700,000	70,000	0.4
5. Others	500,000	50,000	0.2
Total	19,860,000	1,986,000	

* Calculated as 10% of the fresh weight.

Vallisneria spiralis constituted 63% and Potamogeton 23% of the total. The other plants were less than 1% each.

(c) Periphyton at Station B :

(i) Bio-mass of the Periphyton.

In a majority of studies artificial substrates have been suspended in the pelagic regions of standing bodies of water. About 300 slides were suspended in the midst of aquatic vegetation in order to obtain the same or similar types of organisms which are likely to colonise the stem and leaves of hydrophytes. A few slides at a time were taken periodically and estimated for biomass as well as for identification of periphytic organisms. Tables 42 and 43 show in several ways the biological growth of organisms found attached to slides hung near the surface and at 2.5 m depth (Fig. 6) illustrates the growth in the two situations. The growth at 2.5 m is greater than at surface and is found to be maximum in July. There is a gradual rise in deposition from November until the maximum is reached in July; and thereafter there is a decrease. The maximum cummulative growth recorded is 40.29 g/m^2 of glass surface in surface layer and 55.18 g/m^2 of glass surface at 2.5 m depth of water.

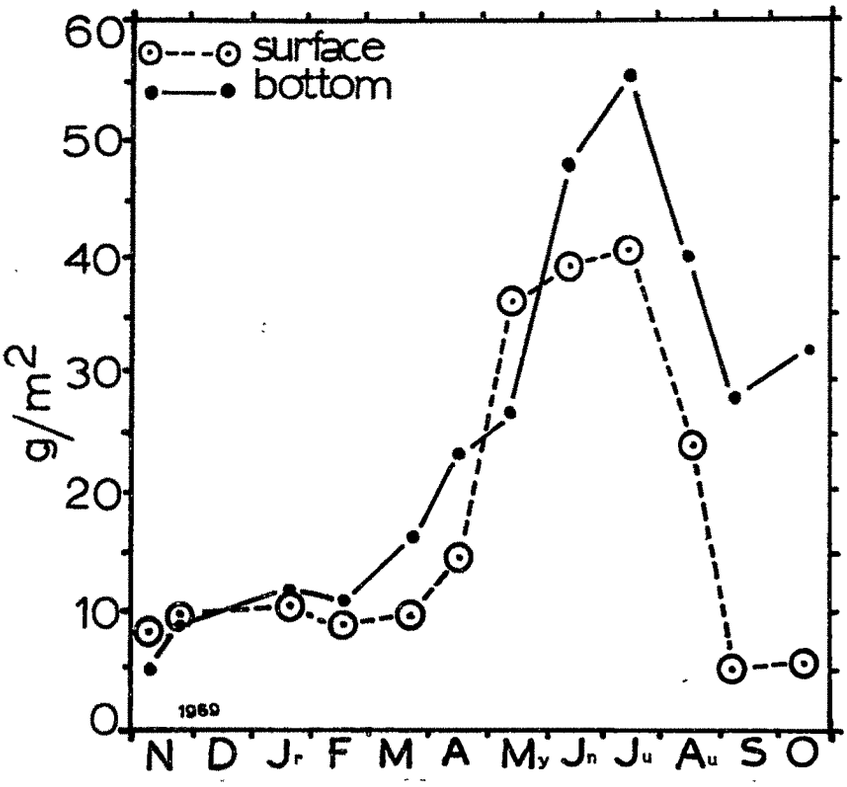

Figure 6 Periphyton biomass on sampling dates.

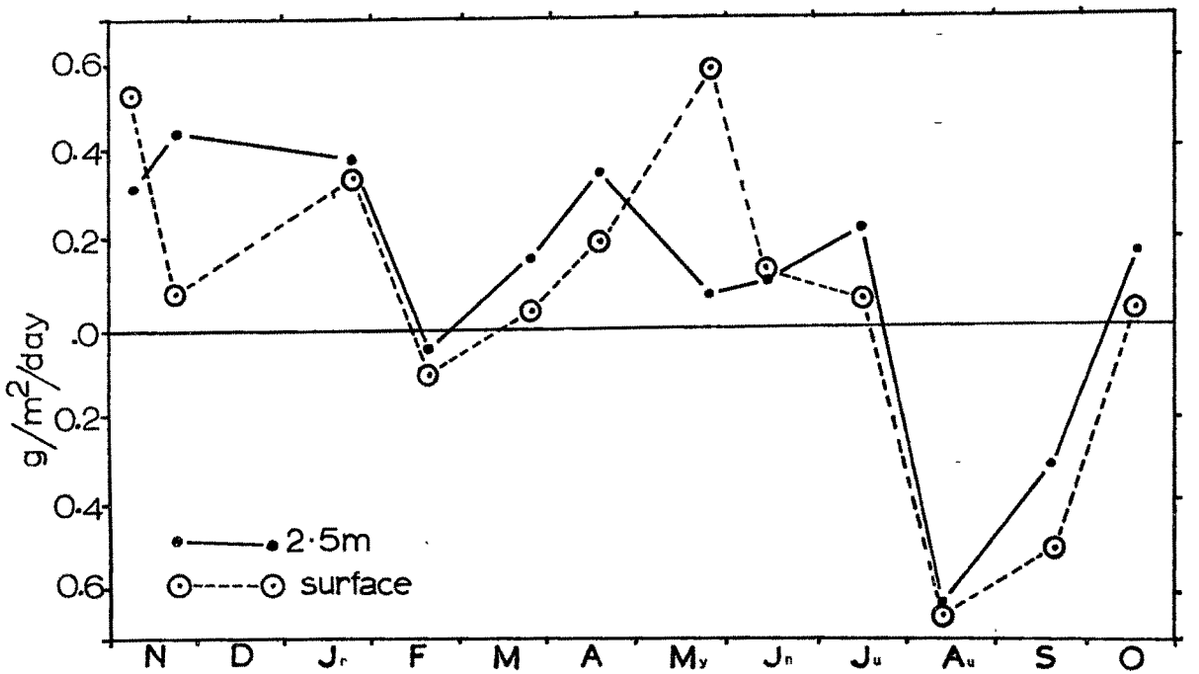

Figure 7 Changes in the biomass of periphyton in Ajwa Reservoir. ⊙---⊙ surface , ●——● 2.5 m.

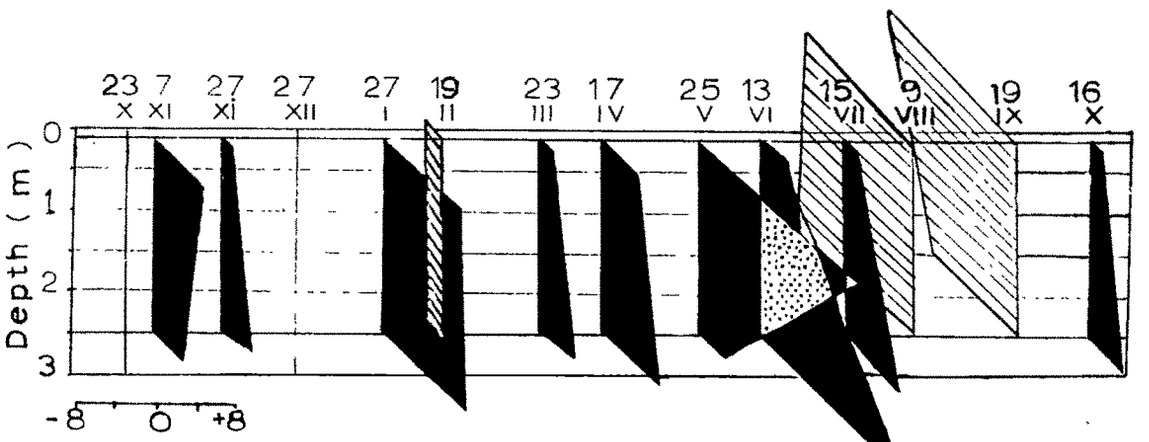

Figure 8
Increments (directed to the right) and losses (directed to the left) of periphyton. gm/sq.m of dry weight

Table - 42

Periphyton growth (in gram) on slides hung at surface at Station-B in the Ajwa Reservoir at Baroda

Date 1969-1970	No. of days hung	Growth on 38.4 cm^2 area			Growth in g/m^2			Increase or decrease Actual	Increase or decrease g/m^2/day	% Dry wt. or organic matter
		Net*	Ash	Organic	Net	Ash	Organic			
October - 23	Slides were first hung in Station-B									
November - 7	15	0.0304	0.0058	0.0246	7.920	1.505	6.415	+ 7.929	+ 0.528	80.9
November - 27	34	0.0362	0.0076	0.0286	9.430	1.978	7.452	+ 1.510	+ 0.079	79.0
December - 27	Slides were lost and hung afresh									
January - 27	31	0.0414	0.0083	0.0331	10.780	2.154	8.626	+10.780	+ 0.348	81.9
February - 19	54	0.0322	0.0067	0.0251	8.433	1.896	6.537	- 2.347	- 0.102	77.5
March - 24	87	0.0372	0.0067	0.0305	9.687	1.744	7.943	+ 1.254	+ 0.038	82.0
April - 17	111	0.0551	0.0110	0.0441	14.360	2.870	11.490	+ 4.673	+ 0.193	80.4
May - 25	149	0.1392	0.0251	0.1142	36.250	6.500	29.750	+21.890	+ 0.573	82.1
June - 13	168	0.1493	0.0300	0.1194	38.890	7.770	31.120	+ 2.640	+ 0.139	80.0
July - 15	199	0.1547	0.0325	0.1222	40.290	8.810	31.480	+ 1.400	+ 0.067	78.1
August - 9	224	0.0920	0.0189	0.0736	23.970	3.790	19.280	-16.320	-0.652	80.2
September- 19	262	0.0185	0.0035	0.0149	4.810	0.940	3.870	-19.160	- 0.503	80.5
October - 16	289	0.0217	0.0042	0.0172	5.659	1.108	4.551	+ 0.849	+ 0.031	80.7

* Gain in dry weight.

Table - 43

Periphyton growth (in gram) on Slides hung at 2.5 m depth at Station-B in the Ajwa Reservoir at Baroda

Date 1969-70	No.of days hung	Growth on 38.4 cm^2 area			Growth in g/m^2			increase or decrease		% Dry wt. or organic matter
		Net*	Ash	Organic	Net*	Ash	Organic	Actual	g/m^2/day	
October - 23	Slides were hung at 2.5 m depth.									
November - 7	15	0.0181	0.0036	0.0145	4.722	00.945	3.777	+ 4.722	+ 0.315	80.0
November - 27	34	0.0322	0.0064	0.0258	8.389	1.694	6.695	+ 3.667	+ 0.441	80.0
December - 27	Slides were lost and fresh slides were hung.									
January - 27	31	0.0460	0.0092	0.0368	11.980	2.397	9.583	+11.980	+ 0.387	80.0
February - 19	54	0.0420	0.0079	0.0341	10.930	2.048	8.882	- 1.050	- 0.046	85.3
March - 24	87	0.0626	0.0125	0.0500	16.300	3.280	13.020	+ 5.370	+ 0.163	79.9
April - 17	111	0.0933	0.0186	0.0750	24.360	4.820	19.540	+ 8.060	+ 0.336	80.2
May - 25	149	0.1053	0.0211	0.0843	27.440	5.460	21.980	+ 3.080	+ 0.078	80.0
June - 13	168	0.1843	0.0369	0.1474	47.990	9.600	38.390	+20.550	+ 1.081	80.0
July - 15	199	0.2118	0.0424	0.1695	55.180	11.030	44.150	+ 7.190	+ 0.231	80.0
August - 9	224	0.1524	0.0305	0.1219	39.680	7.930	31.750	-15.500	- 0.620	80.0
September- 19	262	0.1080	0.0204	0.0876	28.160	5.313	22.847	-11.520	- 0.306	80.0
October - 16	289	0.1250	0.0252	0.0998	32.560	6.830	25.730	+ 4.400	+ 0.163	81.1

* Gain in dry weight.