INTRODUCTION

The study of hydrobiology* is of direct use to mankind in connection with water supply and fisheries. In both cases, the major biological problem is concerned with productivity but with the important difference that water supply in general requires a reduction of productivity in order to avoid algal and other organisms which are likely to cause difficulties in pre-treatment, filtration, odour and taste troubles, while fisheries require an increase in productivity of all organisms of the fish food cycle. In either case, i.e., for decreasing or increasing biological productivity of inland waters, it is necessary to know the production of life which centres round the plankton in relation to the water and deep deposits (Worthington 1939).

Although fundamental studies of natural lakes of the world have been carried on for more than a century (Welch 1935) Hutchinson 1957), the knowledge thus gained has not been applied either to the design, construction, or the management of raw water storage reservoirs, which serve as the source of water supply to large and medium sized municipalities

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* " In the past and to some extent at present certain terms have been used loosely as more or less equivalent to the term limnology, viz. hydrobiology, freshwater biology, aquatic biology, aquatic ecology and aquatic synecology" (Welch 1935 p 10). In this paper, the term hydrobiology is used in the sence of "biological productivity of inland waters and with all the causal influences which determine it" (Welch 1935).

in India. These reservoirs are nothing but small artificial lakes (created by human agencies) which are directly connected to conventional water treatment plants. The most important event occurring in these small bodies of water is a seasonal thermal-density-viscosity phenomenon " which is so profound and far reaching in its influence that it forms directly and indirectly the substructure upon which the whole biological framework rests, particularly in the temperate zone" (Welch 1935). It is, therefore, essential to determine the effects of thermal stratification on the economic purification of raw water drawn from storage reservoirs in India.

Problems connected with thermal-density-stratification in reservoirs of moderate depth are many. Generally, the establishment of a thermally stratified system results in temporary isolation of an uppermost layer of nearly uniform temperature called the epilimnion from a colder, stagnating bottom layer, called the hypolimnion, by a zone of sharp temperature change between them known as the thermocline, " the layer of varying thickness wherein the fall of temperature equals or exceeds 1.0°C per metre". The resultant biological changes in the three different zones are fundamental for a proper understanding of the reservoir biota. The upper zone is often supersaturated with oxygen and abundant algal growths which occur in it can cause difficulties in filtration, and also give rise to tastes and odours in the water supply. The bottom layer, on the other hand, gradually becomes deficient in dissolved oxygen and eventually an anaerobic condition may be established. Then, it becomes a zone in which the water may have an offensive odour, may be rich in carbon dioxide, ammonia and H_2S, in soluble forms of nitrogen and phosphorous and in iron which has diffused out from the bottom mud, where dead plankton and organic debris which settle at the bottom from above undergo putrefaction and are converted into soluble substances (Mortimer 1941, 1942).

The change from a thermally stratified system to a homothermal state and vice versa, affects the vertical distribution of certain microscopic plant and animal organisms; and sometimes leads to the reservoir water having increased turbidity, ammonia content, and chlorine demand. According to Greenshields (1961) the catastrophic breakdown of stratification on a number of occasions had seriously affected the supply of potable water and more than once threatened the health of a large number of consumers in London. Water Engineers are, therefore, seriously concerned with the numbers of algae at given depths, namely, those at which water is abstracted for water supply. The circulation of the water should reduce the great surface blooms as well as reduce the danger of water rich in reduced substances from the bottom reaching the supply pipes.

Again the development of algal blooms in raw water storage reservoirs is, at times, influenced either by the onset or by the destruction of thermal-density stratification. In some cases according to Ridley (1962) cyclonic weather seems to encourage the proliferation of certain algae, possibly by the transport of nutrient substances of biological importance into the epilimnion from the hypolimnion. Water Work Engineers, therefore, as users of large open storage reservoirs as sources of water supply are directly concerned with the bio-chemical and biological conditions arising from thermal-density-viscosity stratification, because the partial or complete destruction of thermal density gradients is often of great significance to subsequent purification processes, particularly filtration and disinfection (Thompson 1954).

Even in such an advanced country like England there was no application of the fundamental hydrobiological principles either to the design or to the use of storage reserviors until the early thirtees of this century. From 1935 a system of hydrobiological surveys to facilitate the management of raw water storage reservoirs of the London city water supply was initiated by Gardiner (1939). Since then, the thermal, biochemical, and plankton studies of the raw water storage reservoirs in Southern England have been vigorously pursued. Taylor (1955) has given an idea of the activities of Metropolitan Water Board, London, in providing a satisfactory water supply for domestic purposes, particularly from the stand-point of the effect of the raw water storage reservoirs on the quality of the final product. The latest work on the subject is by Ridley (1962, 1964) which is of far reaching significance. He has studied the role of internal seiches in storage reservoirs and how their amplitude and periodicity can in certain circumstances, result in rapid and undesirable changes in the biological and biochemical quality of the water being drawn from shore outlets. Greenshields (1961) has stated that he has been able to solve the problem of water supply for the next twenty-five years or so for London as a result of original limnological studies on the Metropolitan storage reservoirs over the past decade.

So, water works authorities in India should be interested to know whether storage reservoirs attached to their water works will be thermally stratified or not in summer as in the lakes of the temperate region. If thermal stratification does take place, then, it is essential to know its effects on the economic purification of water. What steps can be taken to minimise the problems arising out of thermal stratification?

Hydrobiological studies on raw water storage reservoirs will enable us to know the total stock of living microscopic and macroscopic plants and animals. In order to avoid an increase in the existing stock, what is the annual crop that must be removed? An answer to these problems will help the Water Works Engineer in deciding from what levels to draw water at different times of the day and during the year and how far it is desirable to stock raw water storage reservoirs with fish and to encourage angling (Worthington 1939).

Although there are a large number of multi-purpose raw water storage reservoirs scattered all over India, only a few of them have been studied. Ganapati (1951,1955,1957,1959) and Srinivasan (1964 a ~~b~~) have studied almost all the South Indian reservoirs from the view-point of fisheries; and practically none of the North-Indian reservoirs has been investigated. Also, no reservoir attached to a Water Works has been studied from the view-point of the Water Works Engineer. An opportunity was provided to the author of this thesis to examine the conditions of existence in the water works system of a medium sized municipality which has been in continuous operation since 1951. The Baroda Borough Municipality sought advice for controlling algal growths (in the Ajwa reservoir, the source of water supply for Baroda), which they thought were, perhaps, responsible for short filter runs in the rapid sand filters at the Nimeta Water Works. This opportunity was availed to make a two-year detailed hydrobiological study not only on the Ajwa reservoir but also of the Nimeta Water Works where the raw water is being purified by pretreatment and rapid mechanical sand filtration. The results of these studies form the subject matter of the two main papers discussed below from the view point of the Water Works Engineer and they are entitled :

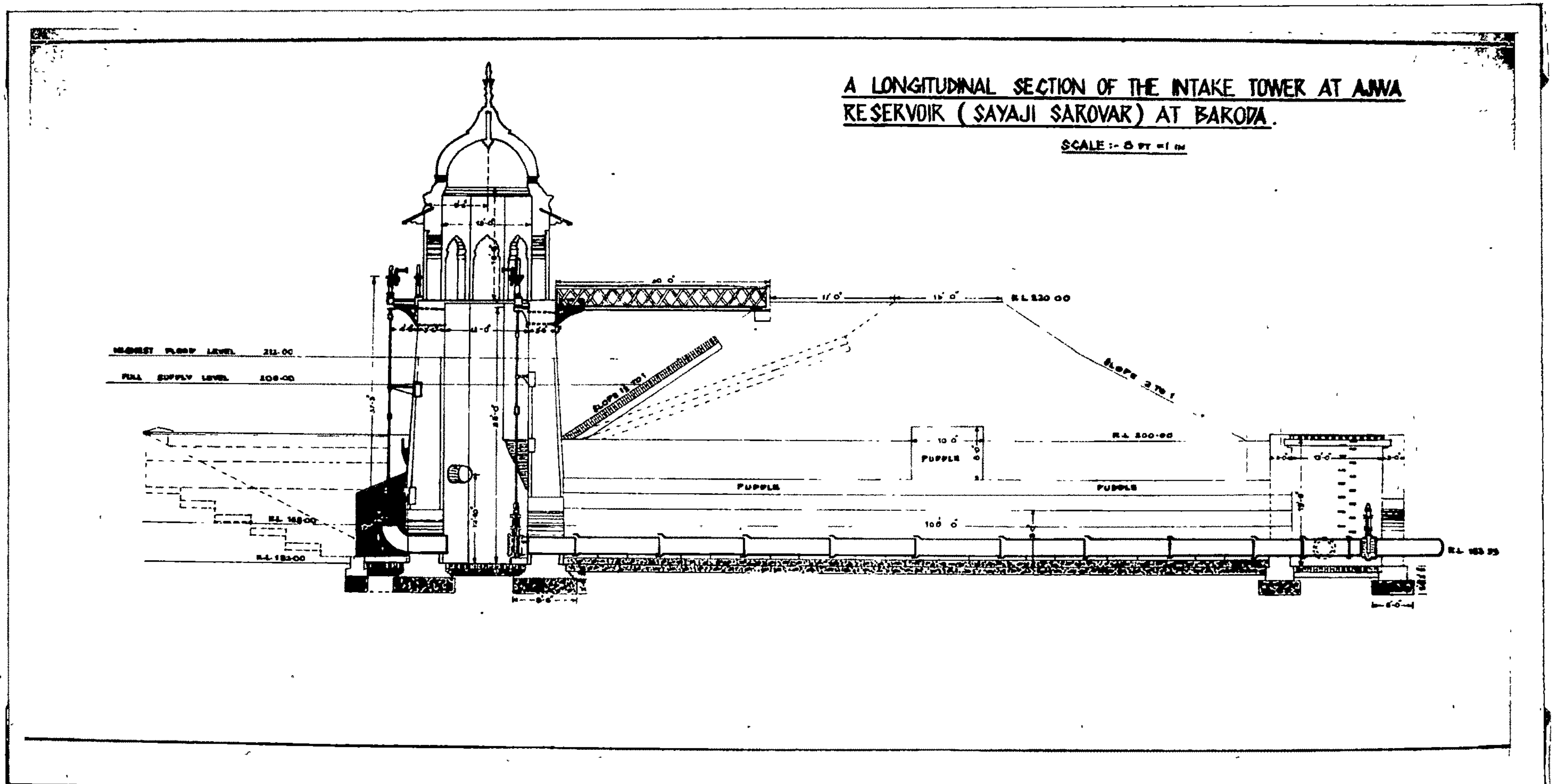

Fig. 1. A longitudinal Section of the Intake Tower at the Ajwa reservoir.

Section A: Hydrobiological studies on the Ajwa Reservoir at Baroda and Section B: Biology of the Nimeta Water Works at Baroda.

2. CLIMATOLOGICAL DATA

(Tables I & II Appendix)

The data relating to the atmospheric temperature, humidity, wind velocity, rainfall, hours of bright sunshine are showin in Tables I & II (Appendix) for 1963 and 1964 respectively. They represent the data collected everyday within the Baroda University campus. But the reservoir is situated about 15 miles away from the University. Since no meteorological data are available anywhere adjoining the Ajwa reservoir, the only data available for Baroda, is from the University, which have been used for our purpose.

The four seasons in Western India are : cold weather period consisting of December, January and February, hot weather period comprising March to June, the monsoon season from July to September and the post-monsoon season of October and November. The characteristics of the four weather periods during 1963 and 1964 are summarised below:

a) Atmospheric temperature (C): The annual range and average values for the monthly mean maximum and mean minimum values are given below:

TABLE NO. 1

	ANNUAL RANGE		ANNUAL AVERAGE	
Year	Mean maximum	Mean minimum	Mean maximum	Mean minimum
1963	30.9-41.6	13.6-27.5	35.1	21.5
1964	29.1-41.0	10.4-27.1	35.1	20.4

The seasonal range and average values for the monthly mean maximum and minimum values are given under

TABLE NO. 2

1 9 6 3

	R A N G E		A V E R A G E	
Seasons	Mean maximum	Mean minimum	Mean maximum	Mean minimum
Cold weather	31.1-35.7	13.6-15.4	32.7	14.8
Hot weather	37.3-41.6	19.5-27.5	39.1	24.3
Monsoon season	33.4-30.9	25.8-23.7	32.3	24.8
Post monsoon	35.8-33.9	22.1-19.0	32.5	20.0

TABLE NO.2
(Contd.)

1 9 6 4

Seasons	RANGE Mean maximum	Mean minimum	AVERAGE Mean maximum	Mean minimum
Cold weather	29.4-33.7	10.4-13.6	31.6	12.2
Hot weather	38.0-41.0	19.3-27.1	39.6	24.2
Monsoon season	31.3-33.5	25.4-24.6	32.2	25.1
Post-monsoon	36.2-34.4	21.0-15.4	35.3	18.2

It will be evident from the above that the maximum temperature is reached in April or May and the minimum in January. It is also seen that there is a gradual increase of mean maximum temperature from January to April or May, and from May onwards there is a fall till the lowest temperature is reached in August; and again there is an increase till the second lower maximum is reached in October and again there is a gradual fall until the second higher minimum is reached in December. But the mean minimum values also show the same trend but with slight changes to the mean maximum values. Beginning from January there is to begin with a gradual rise in temperature until the maximum is reached in June, then there is a gradual fall until the lowest temperature is reached in December.

b) Hours of bright Sunshine per day: The maximum daily average varied from 10.9 hours in 1964 to 11.2 hours in 1963, and it was reached in May in both the years. The lowest figure of 3.0 hours in 1963 and 3.5 hours in 1964 was shown in August in both the years. The values for the four seasons are shown below:

TABLE NO. 3

Seasons	1963 (Hours per day)	1964 (Hours per day)
Cold weather	8.6 - 9.5	9.2 - 9.8
Hot weather	9.0 - 11.2	8.0 - 10.9
Monsoon season	3.0 - 6.6	3.5 - 6.7
Post-monsoon	9.5 - 8.6	10.2 - 9.6

c) Rainfall (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 10"(250mm) in two years, below 15"(375mm) in four years, below 25"(626mm) in nine years and below 40"(900mm) in 35 years; and the average fall for the 64 years period was 44" (1100) according to Modak (1955).

The total annual rainfall for 1963 was 1045.1mm and for 1964 was 804.5mm. Monthly maximum fall was recorded in August in 1963 and in July in 1964. The number of days when rainfall recorded was 42 in 1963 and 46 in 1964.

MATERIALS AND METHODS

(a) Materials: For Section A of the main paper dealing with the hydrobiology of the Ajwa reservoir, which serves as the source of water supply to the town of Baroda, a survey of the physico-chemical, bacteriological and biological conditions of the surface water in the reservoir was undertaken from April 1963 to December 1964. This survey carried out once in a month for three days included also specially the measurement of the vertical distribution of temperature and dissolved oxygen at different depths from the surface to the bottom in the reservoir; and pH, alkalinity and oxygen absorbed at 27° C. of samples drawn from the surface and bottom only. Also every month sampling was done both at about 5.0 a.m. in the early morning hours before sunrise and at about 4.0 p.m. in the afternoon in order to find out the nature of the thermal-density-gradient- whether it was diurnal, seasonal or periodic.

The definitions of epilimnion, thermocline and hypolimnion are based upon conditions in continental lakes where the range of temperature is higher, and therefore, stability greater. The annual heat budget as defined and calculated by Birge (1915) has been used in this paper for the two years, but taking into account the lowest temperature recorded for the reservoir. The heat stored up in the reservoir has also been calculated by the method suggested by Munster-Strom (1931) for the heat budget from 10m. layer. Here, it is the number of calories necessary to warm a column of unit base and height equal to the " reduced depth " of the layer from the selected minimum to the summer temperature of the layer. The " reduced depth " is obtained by dividing the volume of the layer by the area of the surface of the whole lake.

The seasonal variations of plankton, the nature of the aquatic vegetation and its relation to the potential fertility of the aquatic soil, the vertical distribution of plankton in the early morning hours and in the afternoon were also investigated. Data relating to the biochemical and biological quality of the water being drawn from a fixed depth in the reservoir for purification at Nimeta Water Works were also obtained.

Section B of the main paper deals with the biology of the Nimeta Water Works. The biological quality of the raw water reaching the water works, the sedimented water and the filtered water drawn from each of the six rapid sand filters was also investigated for the same period of about two years.

Finally the remedial measures that should be taken both at the reservoir and at the Water Works for supplying a " safe " and aesthetically satisfactory water to the town are also discussed.

b) <u>Methods of Collection</u>:

i) Sampling routine: " No fixed routine can be

Fig. 2. Sample collection from a boat in the Ajwa reservoir.

prescribed for sampling; this must be determined by the circumstances peculiar to each source of water. As a general principle, however, it is suggested that examinations should be abbreviated as much as possible commensurate with the information sought, so that the maximum number of samples can be examined." (Manual of British Water Supply Practice 1954, p 631). As the Ajwa reservoir and Nimeta Water Works are situated at about 80 miles away from the main laboratory at Ahmedabad, the places were visited only once a month for three days. Perhaps, it may be argued that such infrequent samplings may not give accurate information on biological productivity in the reservoir. But atleast a general pattern might emerge in the absence of any information. By staying for three days at a time in the field and doing everything that was considered necessary for solving the problem, it was possible to obtain sufficient data for arriving at definite conclusions.

Two touring outfits containing all bottles for collection of samples, apparatus, glasswares, chemicals and standard solutions for the important tests in the field were taken in two specially designed boxes carefully packed along with a microscope and plankton net of silk bolting cloth.

ii) Sampling point: All collections and observations were made from a boat in the Ajwa reservoir. About 100 ft. away from the draw-off tower in the deepest part of the reservoir, a 3" galvanised iron pipe measuring about 40 ft. in length was fixed to mark the spot for sample collection.

iii) Collection of samples: was made from the surface and from different depths in the reservoir. First, surface samples were drawn for bacteriological, then chemical and lastly for biological tests. Samples from different depths were drawn for temperature, dissolved oxygen and for sodium, potassium and calcium estimations. Samples from the surface and bottom alone were taken for pH, oxygen absorbed and biological examinations.

iv) Method of collection: Samples from the surface were taken a few centimeters below the surface; a vertical series of samples was obtained from different depths by means of a two litre Friedinger bottle and the water temperature was noted by means of a thermometer calibrated to a tenth of a degree, after the bottle was hauled up but before running off the contents to several bottles carefully by means of a rubber tubing fitted to the nozzle and taking the usual precautions to exclude air. Samples were obtained from 0, 5, 10, 15 and 20 feet, the last depth was about one foot above the mud. The meteorological conditions in the Ajwa reservoir on the days of sample collection are shown in Table No. III (Appendix).

v) Bacteriological samples: of 250 ml capacity were collected first taking the usual precautions from the surface in sterile, clear glass bottles having ground stoppers which were protected with a piece of sterile brown paper tied round the neck of the bottles. The bottles were not opened until before the samples were carefully taken and the stopper replaced immediately after collection. Samples were inoculated into media tubes within the six hours of collection and incubated at the University laboratory before they were transferred to the main laboratory at Ahmedabad for further incubation.

vi) <u>Samples for chemical analysis</u>: a litre of the sample was collected in chemically clean bottles made of good quality (neutral) glass, practically colourless and fitted with ground glass stoppers. The bottles were rinsed out atleast three times before they were filled completely and the stopper securely fastened. Special samples for the estimation of potassium, sodium and calcium by flame photometry were collected in 100 ml polyethylene bottles and in two separate N.M.F.S. 250 ml glass stoppered bottles, one for the estimation of dissolved oxygen and the other for the determination of free CO_2 carbonates, bicarbonates and pH in the field.

vii) <u>Biological</u>: The question of plankton collection has been carefully examined by Lund and Talling (1957). They have pointed out the usefulness of plankton net even if the organisms are present in very small numbers, when quantitative estimations by other methods would be impossible. ~~Rennie (1956) is against the use of the net for quantitative purposes. But~~ Rawson (1953, 1955, 1956) has used it for quantitative sampling for establishing fundamental relationship between lake morpho-

Fig. 3. Plankton collection from a boat in the Ajwa reservoir.

morphometry and production. Since Lund and Talling (1957) and Rawson (1953, 1955, 1956) have recommended the use of plankton net, it was considered suitable for our purpose also. So, it has been used in these studies.

Plankton collection from the surface was made by means of a plankton net of silk bolting cloth 75 cm long, 15 cm in diameter and containing 77 threads to a centimetre. The net was attached to one end of a 20 ft. long rope and the other end was tied to a post in the boat. The boat was rowed by men slowly and steadily between two fixed points i.e. the intake tower and the second landing place at a distance of about 3000 ft. from the tower. The time taken for rowing this distance was 30 minutes on each occassion. The net was towed very gently to reduce displacement of water from the mouth of the net. The net plankton was carefully washed, and transferred to a specimen tube to make a volume of 15 ml and later preserved after a microscopic examination in the field laboratory by the addition of enough formalin to make a 4% solution. The sediments were later measured after centrifuging and made up to a known volume depending upon the density of the organisms in the sediments.

In addition to the surface, haul, plankton from the surface and bottom layers alone was collected for quantitative comparison in the two situations in the following manner. Fifty litres of water each from the surface and from the bottom layers from the usual place of sample collection were carefully strained independently in the plankton net which was held in a bucketfull of water and the catches were separately preserved.

The water level in the reservoir was read from the scale attached to the intake tower. The exact depth at the place of sample collection was noted every time by letting down a heavy weight attached to a long calibrated rope. The colour of water was noted as it appeared to the naked eye. A record of every sample collected was made and every bottle numbered by pasting a label so that the information on label provided identification of the sample at a later time. Date, hour, location, weather conditions, water level, colour of water etc., were recorded in a separate field note book.

C. Methods of examination:

i) Bacteriological: Examination for coliforms, E. Coli Type I and Faecal streptococci was done according to the British technique as detailed in publication No. 71, 1939, Medical Reports by the British Ministry of Health.

ii) Chemical: pH, dissolved gasses, orthophosphates, hardness (EDTA), carbonates, bicarbonates, dissolved oxygen, silicates, nitrates, nitrites, ammoniacal nitrogen (direct nesslerisation) and oxygen absorbed were determined within an hour of sample collection in the field laboratory. Dissolved oxygen was fixed in the boat immediately after collection and later estimated in the field laboratory.

Excepting oxygen absorbed test, all other tests were done according to the " Standard Methods " (1960). pH was determined using a Hellige comparator provided with permanent colour discs, using the indicators phenol red or cresol red. Percentage saturation of dissolved oxygen values were calculated from the table prepared by G.C. Whipple and M.C.Whipple from measurements of C.J.J. Fox as given in the " Standard Methods".

iii) <u>Biological</u>: According to Lund and Talling (1957) counting of plankton has three great advantages over other methods. Algae are observed each time a count is made. Estimations of populations whose density is so small can be measured with equal accuracy; and it enables small numbers of specific algae to be distinguished from others. So, numerical estimation of the organisms was made by the " drop-sedimentation" method as detailed in the American " Standard Methods".

A drop of the sediment from each tube was first examined qualitatively for recording all species. Later, the tube was shaken and a drop of the turbid liquid was examined in ten fields under the microscope. To maintain uniformity, the drop was taken each time from the same pipette. Five such drops for each sample were examined and the average calculated.

Fig. 4. A view of the Ajwa with the Pavagadh hill at the back ground.

The frequences of the plankton organisms present in each haul are expressed in symbols of Fritsch and Rich (1913). The numerical values to the various symbols for the entire sample from each haul are expressed so that rrr = 1; rr = 1-50; r = 50-100; c = 100-200; cc = 200-500; ccc =>500. The system of classification followed for phytoplankton is according to Smith (1950). The organisms were identified with the help of standard keys and reference books. Later, they were also sent to specialists in Europe and America for confirmation and correct identification. Their help has been acknowledged.

The meteorological conditions on the days of sample collection in the Ajwa reservoir are shown in Table No. III (Appendix).

Section A: THE AJWA RESERVOIR

(a) Physical Conditions:

i) Location: The town of Baroda draws its water supply from a storage tank or reservoir which is located near a village called " Ajwa " about fifteen miles away from the town. The reservoir is, therefore, called the Ajwa reservoir; and also as " Sayaji reservoir" named after the last ruler of the erstwhile Baroda State. The reservoir is situated about a few miles from the foot of the famous Pavagadh hill, the most familiar hill of Gujarat situated in the western Panchamahals. The reservoir was first formed by

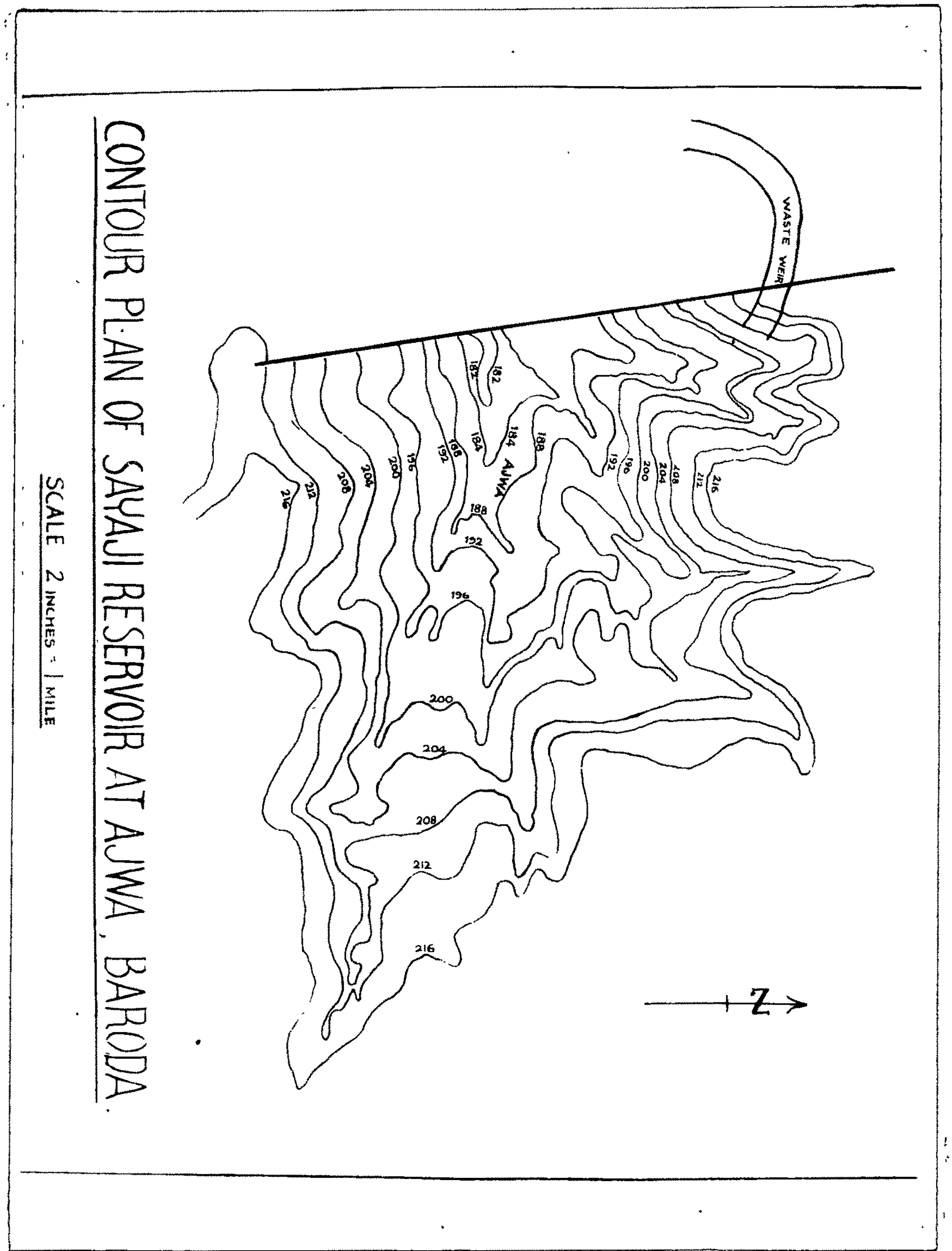

Fig. 5. Contour map of the Ajwa reservoir.

damming the river Surya, with a drainage basin of about 35.2 sq. miles and its storage capacity was 1287 million cubic feet with the full storage level (F.S.L.) at R.L. 208 prior to 1900. Next, the Visvamitri project was completed in 1900 and it added 14.8 sq. miles of catchment area. With the introduction of this feeder the F.S.L. of the Ajwa reservoir was raised to the present R.L. 211. Even after the construction of this feeder project, it was not possible to raise the water level to R.L. 211 in bad monsoon years. Therefore, another feeder tank, known as the Pratab Singh reservoir with a catchment area of 27.64 sq. miles was constructed later. Thus, today, the catchment area of the Ajwa reservoir is 78.64 sq. miles and the F.S.L. is at R.L. 211, when it has a storage capacity of 1717 million cubic feet. The reservoir is also provided with a waste weir 800 ft. long at its right and a valve tower with inlets at R.L. 188 and R.L. 198 at the deepest part of the reservoir for drawing off water for the water purification works at Nimeta about five miles away from Ajwa on the main trunk road to the town.

ii) Morphometry : The reservoir is dammed on one side only and the length of the dam or embankment is 3.4 miles (5.47 Km) and on the other three sides, mostly flats. Its maximum length at full tank level (R.L.211) is 4.05 miles (6.52 Km). Its breadth is found to be 3.26 miles (5.24 Km). Its shoreline circumference is 13.5 miles (21.72 Km). The mean breadth is 1.305 miles (2.1 Km) and the mean depth is 11.32

Fig. 6. The Intake Tower at the Ajwa reservoir.

TABLE NO. 4

THE AREA AND VOLUME OF WATER AT 5 FEET INTERVALS

Depth in Ft. R.L.	Area: Area in Sq.Ft. x 1000	Area: % of Surface	Stratum in 5 Ft. R.L.	Volume of each stratum in million Cft.	Percentage of Total Volume	Underlying volume in % of the Total	Remarks
211	157,026	100.00	-	-	-	-	
206	118,220	75.28	211-206	678,00	39.48	60.52	
201	86,936	49.00	206-201	472.00	27.49	33.03	
196	46,356	29.54	201-196	304.00	17.70	15.33	
191	23,429	14.91	196-191	173.00	10.07	5.26	
186	7,000	4.45	191-186	76.00	4.42	0.84	
181	332	0.21	186-181	13.83	0.81	0.03	
				1716.85	100.00		

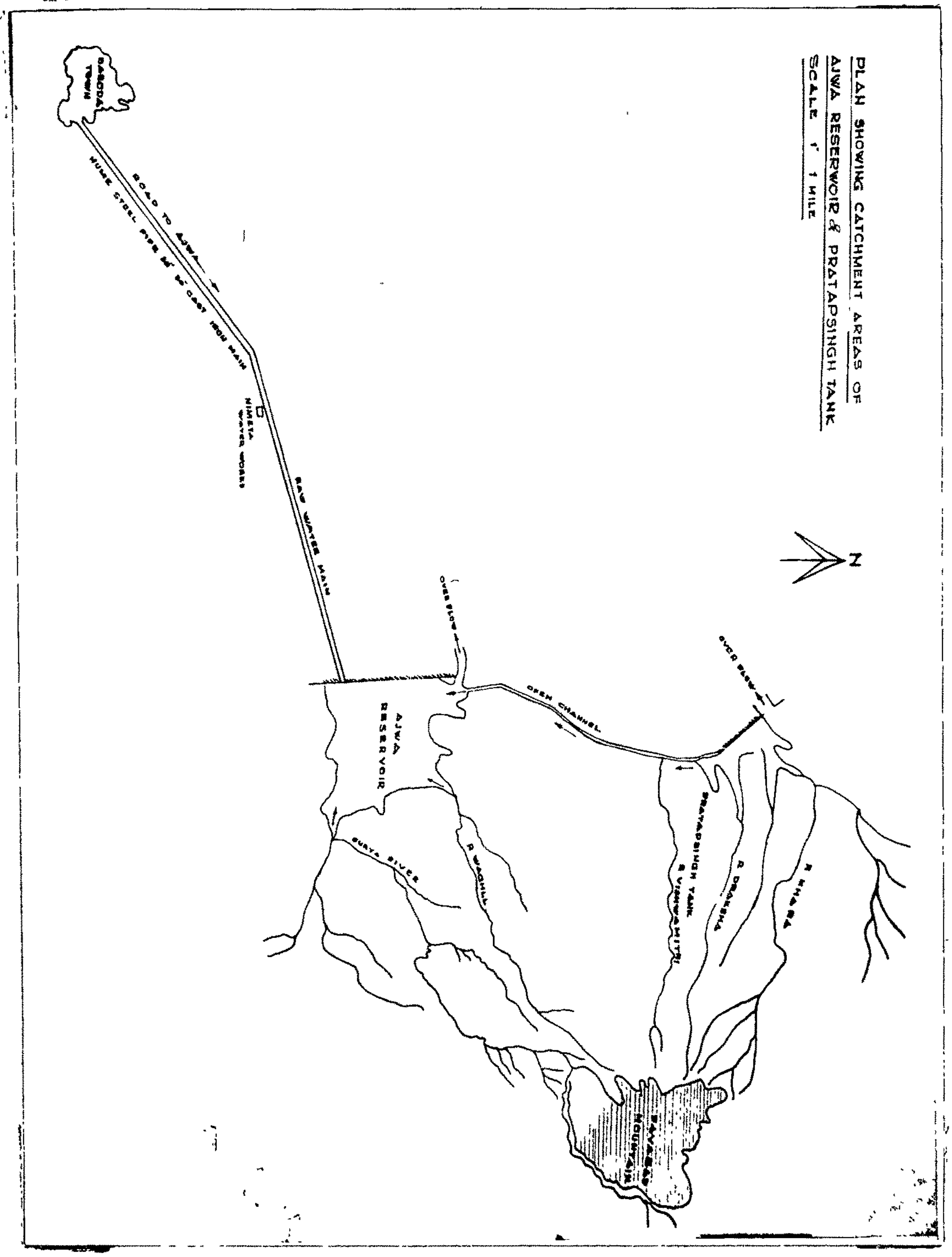

Fig. 7. Catchment area of the Ajwa reservoir.

feet, the maximum theoritical depth being 30 feet. The area and volume of water at 5 feet intervals are shown in TABLE No.4:

The length of contours and the area between contours in the Ajwa reservoir are shown in TABLE NO. 5:

iii) Edaphic and Geological factors: The main catchment area of the reservoir is composed of reserve forests consisting of wild shrubbery and trees. Cultivated lands and plantations are negligible. There is no organic pollution of any kind. The feeder streams carry a lot of silt during the monsoon season making the reservoir water turbid for nearly six months in the year i.e. from July to October.

The regional geology of the area around the Sayaji Sarovar (Ajwa reservoir) can be summarised as follows:-

Alluvial deposits	-	Recent & sub-recent.
Basalts of Deccan Trap	-	Cutaceo - Eocene
Sandstones of Bagh beds	-	Cretaceous

Bagh Beds: Stray exposures of these marine Cretaceous rocks, generally coarse sandstones, are recorded in the area of a few miles to the east of the Sarovar, in the river Dhadhar and its tributary nalas along the tract between Pavagadh and Gambhirpura. (These exposures are just out side the Catchment area)

TABLE NO. 5

THE LENGTH OF CONTOURS AND THE AREA BETWEEN CONTOURS IN THE AJWA RESERVOIR

Depth in Feet (R. L.)	Length of contours miles	Stratum in (Feet 5) (R.L.)	Area between countours in Sq.ft. x 1000	% Total area between contours	Slope between contours in %
211	13.00	-	-	-	-
206	11.00	211-206	38,806	24.76	0.81
201	8.75	206-201	41,284	26.34	0.63
196	8.00	201-196	30,580	19.50	0.72
191	4.37	196-191	22,927	14.69	0.71
186	3.00	191-186	16,429	10.06	0.59
181	0.44	186-181	6,668	4.25	0.68
-	-	-	156,694	100.00	-

Deccan Trap: The basalts of the Deccan Trap are exposed in the Pavagadh hills. This hill, which lies about 8 miles to the N.E. of the Tank, constitutes the main watershed of the catchment area. Numerous varieties of Volanic rocks, viz. fine-grained and amygdaloidal basalts, andesites and bedded tuffs constitute a layered sequence capped by a flow of rhyolite. This exposure of Deccan trap stands out as an isolated hill surrounded on all sides by the soils and alluviem. On going SW, the traps underlie the alluviem, and possibly at the Sarovar, it is occurring under a thin cover of river deposits.

Alluviem: The Sarovar is situated in the Recent and Sub-Recent Alluviem, which is most widespread in the area. It is obvious that the alluvial plain in which lies the Sarovar is made up mostly of the sediments derived from the Pavagadh hill, brought down by the streams originating on the SW slopes of the hill.

Water Level: Ordinarily the level of water depends upon the climatic donditions especially the rainfall and temperature of the locality in which it is situated and to draw-off for the town supply. The rain-fall season for this region is the south-west monsoon season (July-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 TABLE NO. 4: (Appendix).

The maximum and minimum levels and the seasonal changes during 1963 and 1964 are shown in TABLE NO. 6 below:

TABLE NO. 6

ANNUAL RANGE

Year	Maximum	Month	Minimum	Month	Sill level
1963	210.92	Sept.	202.93	July	181.00
1964	208.18	Sept.	204.55	June	181.00

The water level decreased gradually from January to June or July when the lowest level was reached. Thereafter, the level rose up rather abruptly to the maximum in September or October and later again continued to decrease in November and December. With the decrease in level the shore all around consisting of meadow land and the resulting shallow depth of water encouraged the development of aquatic vegetation in very large areas every year.

v) Colour of Water : varied from dark green to greyish depending upon the seasons. Green colour of water was dominant in the months of October, November, December, January, February and March and greyish during the rest of the year.

vi) Temperature Characteristics (TABLE NO.5 Appendix) Temperature of water is an important attribute which has to

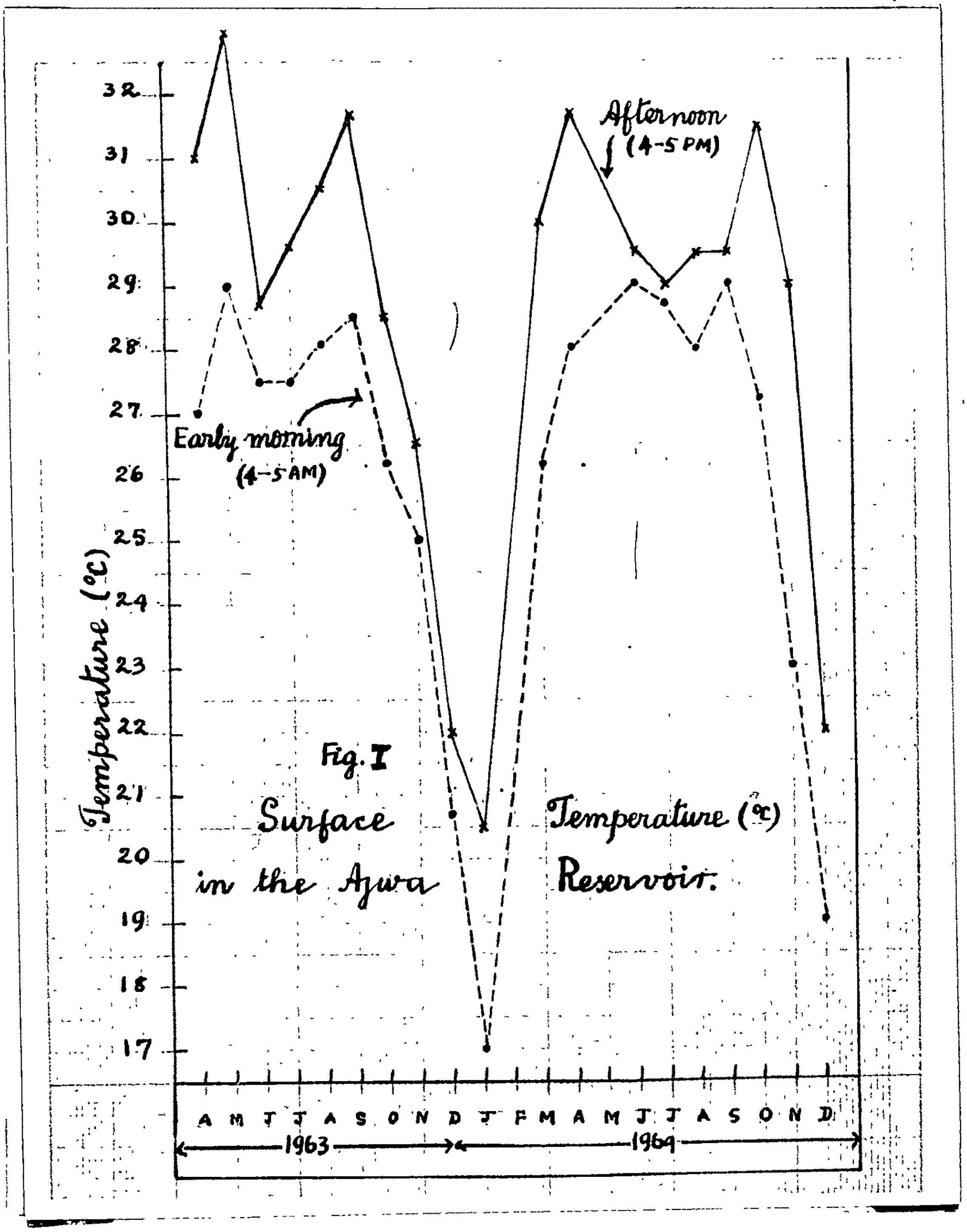

Fig. 8. Graph showing the temperature of surface water in the reservoir.

be considered in the management of a reservoir directly connected to a Water Works system about which Water Works Engineers generally pay no heed in India. Its importance has already been explained in the introductory portion of this paper. The temperature data collected during 1963 and 1964 from near the intake tower are taken as representative of atleast the mean temperature conditions in the whole reservoir and they are discussed below.

Temperature of the Surface water and its seasonal variations:

(The maximum and minimum values and the seasonal variations are summarised in the Table No.7).

Maximum and Minimum values: The early morning and afternoon values showed two maxima and two minima. The maxima for the early morning series varied between 28.5 and 29.0. The first maximum was reached in May or June and the second maximum in September. The maxima for the afternoon series varied between 31.5 and 33.0. The first maximum was reached in April or May and the second maximum in September or October.

The values for the minima varied between 17.0 and 27.0 for the early morning series; and those for the afternoon series between 20.5 and 28.7. The first lower minimum was reached in January for both the morning and afternoon series and the second higher minimum was reached in December for both the early morning and afternoon series.

TABLE NO. 7

Time of collection	First maximum				Second maximum			
	1963		1964		1963		1964	
	Value	Month	Value	Month	Value	Month	Value	Month
Early-morn (4-5 A.M.)	29.0	May	29.0	June	28.5	Sept.	29.0	Sept.
Afternoon (4-5 P.M.)	33.0	May	31.7	April	31.7	Sept.	31.5	Sept.

Time of collection	First minimum				Second minimum			
	1963		1964		1963		1964	
	Value	Month	Value	Month	Value	Month	Value	Month
Early-mron (4-5 A.M.)	27.0	April	17.0	January	20.7	Dec.	19.0	Dec.
Afternoon (4-5 P.M.)	28.7	June	20.5	January	22.2	Dec.	22.0	Dec.

Seasonal variations: The data are shown in Table No. 8 given below:

TABLE NO. 8

Year & Time	Cold Weather Dec. Jan. & Feb.	Hot Weather March to June	Monsoon Season July to September	Post-monsoon October & November
1963: Early morn.	20.7	27.0-28.0	27.5-28.5	26.2-25.0
Afternoon.	22.0	28.7-33.0	29.6-31.7	28.5-26.5
1964:				
Early morn.	17.0-19.0	26.2-29.0	27.0-29.0	27.2-23.0
Afternoon.	20.5-22.0	29.5-31.7	28.5-29.5	31.5-25.0

Early morning series 1963: During the hot weather the highest temperature recorded was 29.0 and it was reached in May; thereafter there was a fall in the monsoon season when the lowest temperature of 27.0 was reached in July; and later there was a slight rise until September. Then, during the post-monsoon season there was a gradual fall until the lowest temperature was reached in December.

1964 : During the cold weather the lowest temperature of 17.0 was recorded in January. Then there was a rise in the hot weather until the highest temperature of 19.00 was reached

TABLE NO. 9

TEMPERATURE OF THE BOTTOM LAYER AND ITS SEASONAL VARIATIONS (Fig.II)

Time of collection	First maximum				Second maximum			
	1963		1964		1963		1964	
	Value	Month	Value	Month	Value	Month	Value	Month
Early-morn (4-5 A.M.)	29.0	May	29.0	June	28.2	Sept.	29.0	Sept.
After-noon (4-5 P.M.	30.5	May	30.2	April	30.0	August	29.5	Sept.

Time of collection	First minimum				Second minimum			
	1963		1964		1963		1964	
	Value	Month	Value	Month	Value	Month	Value	Month
Early-morn (4-5 A.M.)	27.0	April	17.0	January	20.7	Dec.	19.0	Dec.
After-noon (4-5 P.M.)	27.5	April	18.0	January	20.5	Dec.	21.0	Dec.

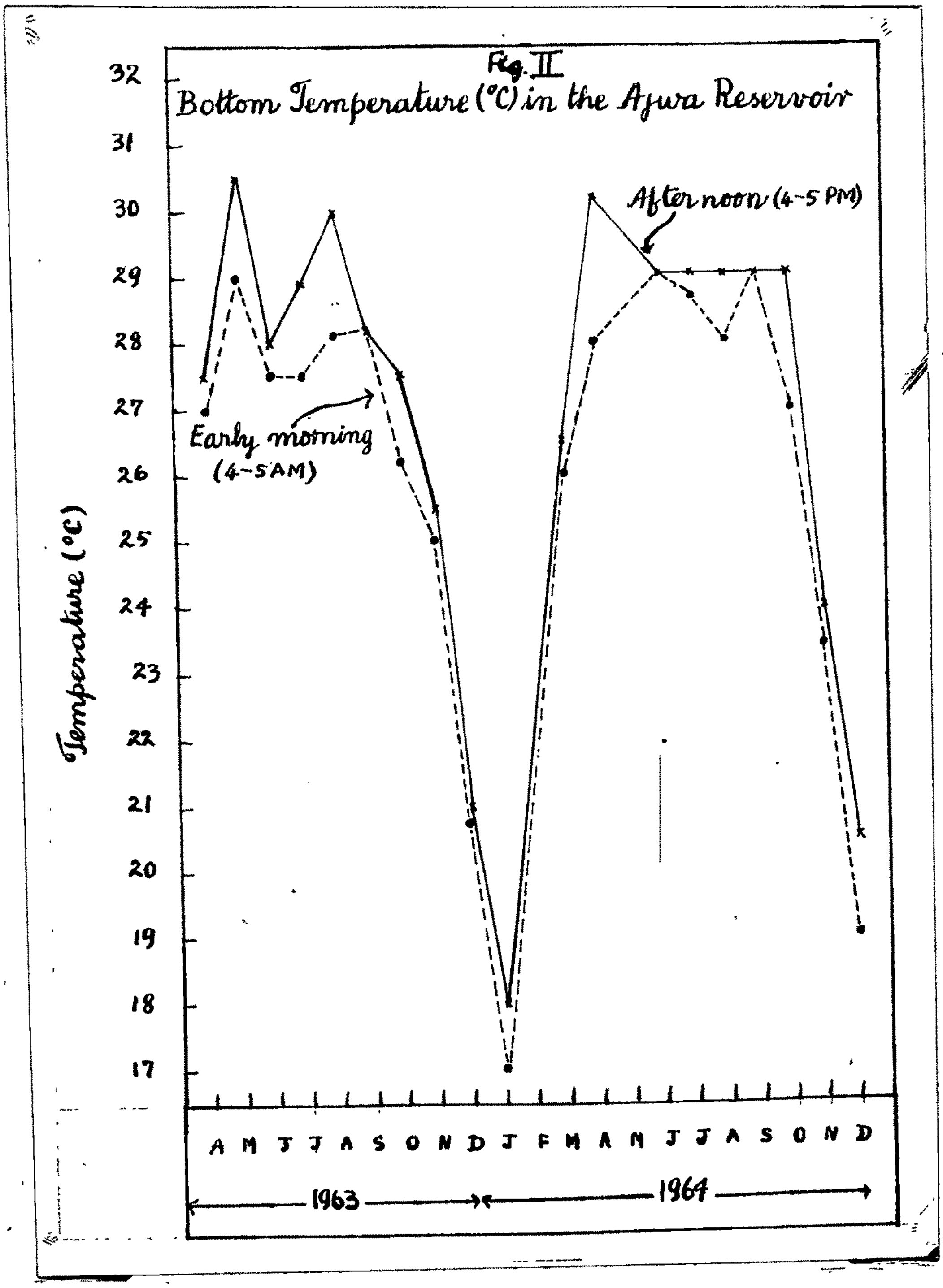

Fig. 9. Graph showing the temperature of the bottom layers of water in the reservoir.

in June; thereafter during the monsoon season, the second lowest temperature was reached in August and then a rise in September only to be followed by a decline in temperature in the post-monsoon season.

Afternoon series 1963 : During the highest temperature of 33.0 was reached in May followed by a rapid fall in June to 28.7. But in the monsoon season there was a rise in temperature until the second lower maximum of 37.7 was reached in September. Thereafter there was a gradual fall in the post-monsoon season.

1964 : The lowest temperature of 20.5 was reached in the cold weather period of January. Then, during the hot weather there was a rapid rise until the first maximum of 31.7 was reached in April. But in June there was a fall of nearly 2.0° C. During the monsoon season the temperature was more or less the same (28.5 to 29.5); but during the post-monsoon season there was a rise in October to 31.5 and then a fall to 25.0 in November

Temperature of the bottom layer and its seasonal variations:

The maximum and minimum values are shown in Table No. 9.

There were two maxima and two minima for the early morning and afternoon series. The maxima for the early morning series varied between 28.2 and 29.0 and for the afternoon series between 29.5 and 30.5. The first maximum was reached in April, May or June and the second lower maximum in August or September.

The values for the minima varied between 17.0 and 27.0 for the early morning series and between 18.0-27.5 for the afternoon series. The first lower minimum was reached in January or April for both the morning and evening series and the second higher minimum in December for both the series.

Seasonal Variations : The data are shown in a tabular form below:

TABLE NO. 10

Year & Time	Cold weather Dec. Jan. & Feb.	Hot weather March to June	Monsoon Season July to September	Post-monsoon October & November
1963:				
early morn.	20.7	27.0-29.0	27.5-28.2	26.2-25.0
After-noon	21.0	27.5-30.5	28.2-30.0	27.5-25.5
1964:				
early morn.	17.0-19.0	26.0-29.0	28.0-29.2	27.0-22.9
After-noon	18.0-20.5	26.5-30.2	28.5-29.5	29.0-23.5

Early morning series 1963: During the hot weather the highest temperature of 29.0 was reached in May and thereafter there was a gradual fall until the lowest temperature of 27.5 was reached in July. Then, there was a gradual rise until the second maximum was reached in September. In the post-monsoon season there was a further fall which continued into the cold weather period.

1964 : The lowest temperature of 17.0 was reached in January. From January onwards there was a steady rise until the first maximum was reached in June. During the monsoon season there was a gradual fall until August and in September there was a slight rise only to be followed by a gradual fall in the post-monsson season.

Afternoon series 1963: During the hot weather the highest temperature of 30.5 was reached in May and thereafter there was a fall and then a rise during the monsson season until the second maximum was reached in August. Thereafter there was a fall during the post-monsoon season and the cold weather period.

1964 : The lowest temperature was recorded in the cold weather, and there was a gradual rise in the hot weather until the first maximum was reached in April. Thereafter, there was a gradual fall during the monsoon season until the minimum was reached in August. Then, there was a rise in September when the second lower minimum was reached. During the post-monsoon season and cold weather there was a gradual decline in temperature. In short both the surface

TABLE NO. 11

Month	1963 (4-5 A.M.) Surface	Bottom	Difference	Actual depth in feet.	1964 (4-5 A.M.) Surface	Bottom	Difference	Actual depth in feet
January	-	-	-	-	17.0	1[illegible].0	0.0	21.0
February	-	-	-	-	-	-	-	-
March	-	-	-	-	26.2	26.0	0.2	20.0
April	27.0	27.0	0.0	20.0	28.0	28.0	0.0	20.0
May	29.0	29.0	0.0	18.0	-	-	-	-
June	27.5	27.5	0.0	16.0	29.0	29.0	0.0	18.0
July	27.5	27.5	0.0	16.0	28.7	28.7	0.0	18.0
August	28.1	28.1	0.0	20.0	28.0	28.0	0.0	21.0
September	28.5	28.2	0.3	22.0	29.0	29.0	0.0	21.0
October	26.2	26.2	0.0	22.0	27.2	27.0	0.2	22.0
November	25.0	25.0	0.0	22.0	23.0	22.9	0.1	22.0
December	20.7	20.7	0.0	22.0	19.0	19.0	0.0	20.0
Average	26.6	26.5	0.1	19.8	25.4	25.3	0.1	20.3

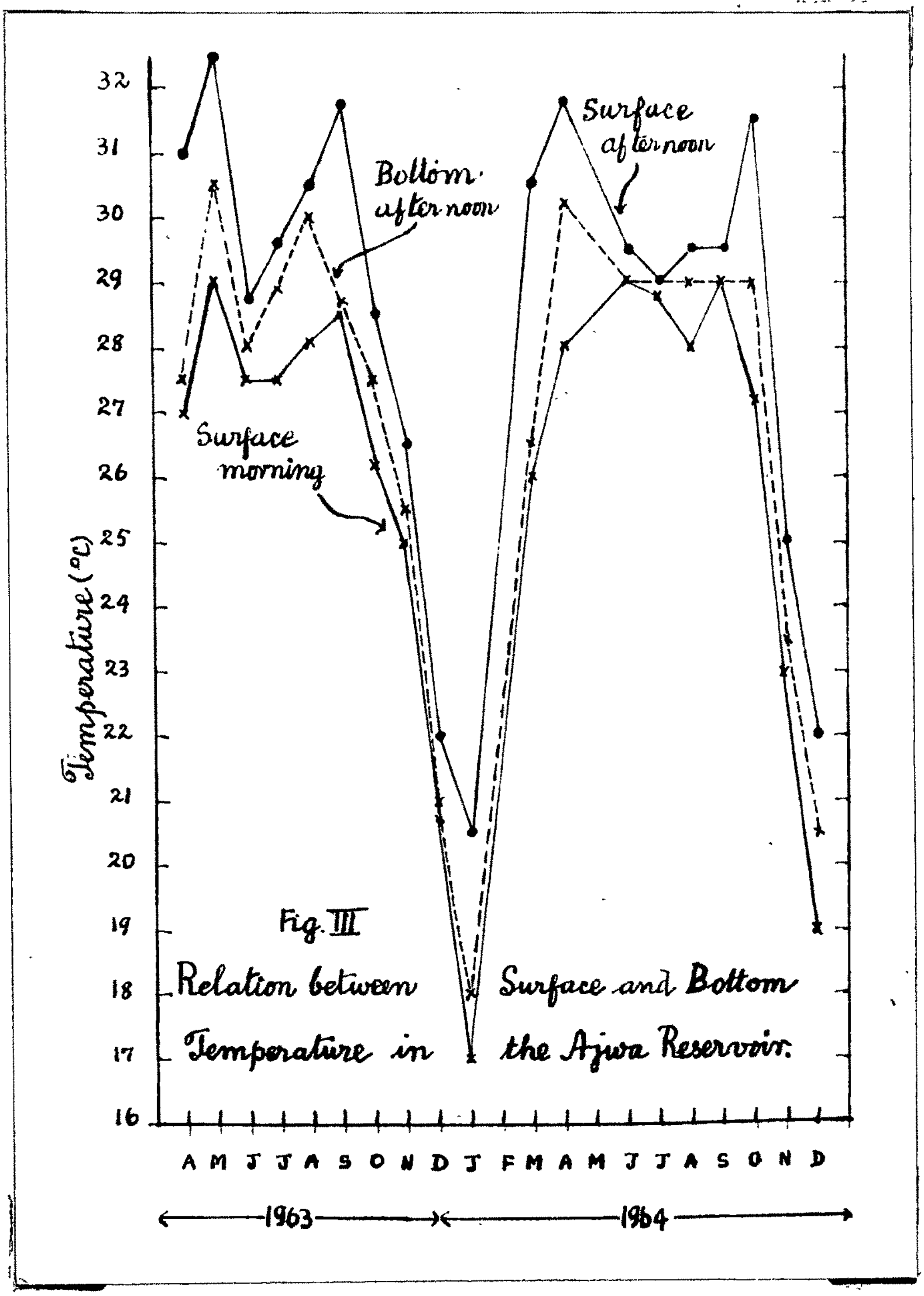

Fig. 10. Graph showing the relation between the surface & bottom temperatures in the reservoir.

and bottom layers followed the fluctuations of the atmospheric temperature (See Table No. VI Appendix).

Thermal Stratification :

a) Two series of temperature measurements were taken: one in the early morning hours and another in the afternoon of the same day, every month in the vertical direction at the deepest place near the intake tower for nearly two years. In the subjoined table No. 11 (on page 33) the surface and bottom temperatures and their differences are shown for the early morning series.

From a study of the table No. 11 it will be seen that (a) in September,'63, March,'64, October,'64 and November,'64, the differences between the surface and bottom temperatures varied between 0.1 and 0.2; ~~in January '64 it was 0.9~~ and in the remaining months there was no differences at all. In other words, the conditions in the reservoir was practically isothermal in the early morning hours, in the summer and cold weather seasons of 1963 and 1964; and during the other seasons a very slight difference in the temperature was noted. So it would appear that there was complete circulation taking place every day throughout the year in the early morning hours in the reservoir.

Afternoon series : The surface and bottom temperatures and their differences are shown in subjoined table No. 12.

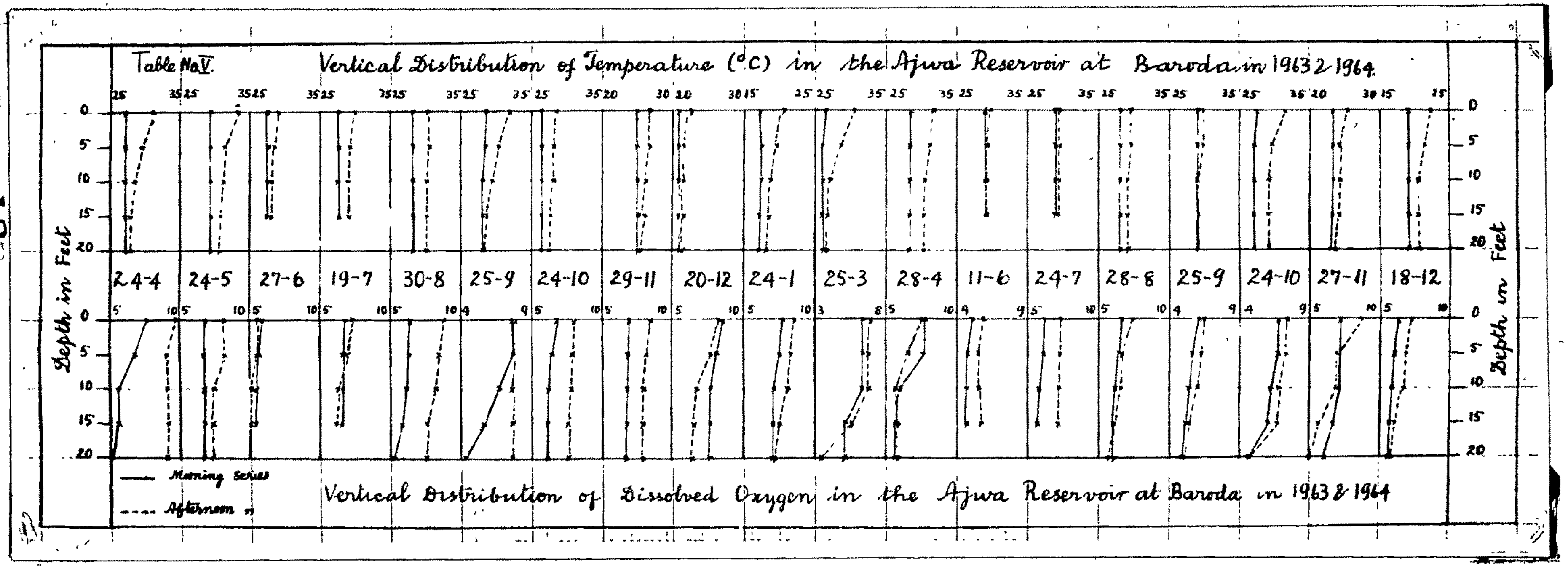

Fig. 11. Vertical distribution of temperature and dissolved oxygen in the reservoir.

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TABLE NO. 12

Month	1963 (4-5 A.M.)				1964 (4-5 A.M.)			
	Surface	Bottom	Difference	Actual Depth in feet	Surface	Bottom	Difference	Actual Depth in feet
January	-	-	-	-	20.5	18.0	2.5	21.0
February	-	-	-	-	-	-	-	-
March	-	-	-	-	30.5	26.5	4.0	20.0
April	31.0	27.5	3.5	20.0	31.7	30.2	1.5	20.0
May	33.0	30.5	2.5	18.0	-	-	-	-
June	28.7	28.0	0.7	16.0	29.5	29.0	0.5	18.0
July	29.6	28.9	0.7	16.0	29.0	29.0	0.0	18.0
August	30.5	30.0	0.5	20.0	29.5	29.0	0.5	21.0
September	31.7	28.2	3.5	22.0	29.5	29.0	0.5	21.0
October	28.5	27.5	1.0	22.0	31.5	29.0	2.5	22.0
November	26.5	25.5	1.0	22.0	25.0	23.5	1.5	22.0
December	22.0	21.0	1.0	22.0	22.0	20.5	1.5	20.0
Average	29.1	27.5	1.6	19.8	27.8	26.4	1.4	20.3

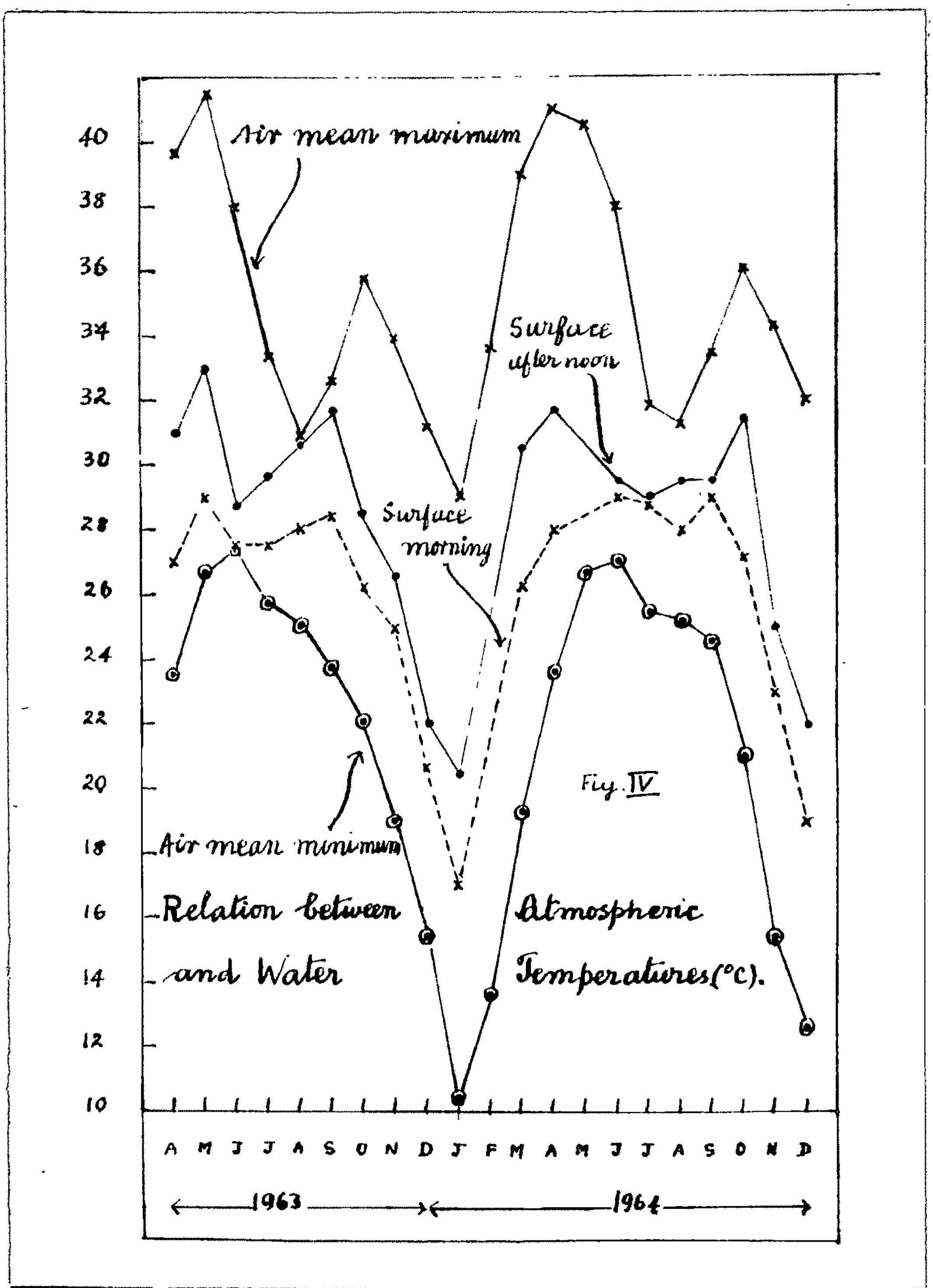

Fig. 12. Relation between the atmospheric and water temperatures in the reservoir.

It will be seen from the table No. 12 that in almost all the months of the two year period there were greater differences in temperature between the surface and bottom layers, indicating the formation of a well defined thermal stratification in the higher ranges of temperature. Maximum differences were noted in April '63 (3.5°C), and March '64 (4.0 C). The highest differences were recorded in the summer season. So, it would appear that there was thermal stratification every day in the afternoon and circulation or complete turnover in the early morning hours throughout the year in the Ajwa reservoir. Also the entire reservoir got heated up during the course of the day especially in the afternoons as a result of which the bottom temperature also rose up and also showed seasonal variations just like the atmospheric temperature.

ANNUAL HEAT BUDGET

Birge (1915, p167) defined the annual heat budget of a lake as, " the amount of heat necessary to raise its water from the minimum temperature of winter to the maximum summer temperature" and it is expressed in terms of the total number of calories necessary to warm a column of water of unit base (1 cm^2) and a height equal to the mean depth of the lake" (Birge 1915, p.171).

The mean depth of the Ajwa reservoir is 11.32 feet. The lowest temperature recorded in cold weather was 20.7 and the maximum attained was 33.0 in the hot weather in 1963; and again, the lowest temperature recorded in the cold weather was 17.0 and the maximum reached in summer was 31.7 in 1964. So, the calculated annual heat budgets for the two years are:

1963 = 1.0 x(11.32 x 30.48)x 12.30 C = 4243.9 g. cal/sq.cm

1964 = 1.0 x(11.32 x 30.48)x 14.70 = 5072.0 g. cal/sq.cm

(where 1ft = 30.48 cm).

Hutchinson (1957, p. 496-500) has furnished the heat budgets of the adequately known lakes of the world. The annual heat budget of Ranu Klindungan in Indonesia (a lake situated in the equatorial regions) is given as 3,410 g. cal per sq.cm. which is considerably lower than that in the Ajwa Reservoir.

Heat storage in the Ajwa Reservoir

The heat budget for each 5 feet layer(Munster-strom 1931, p. 496-507 cited by Jenkins 1942) is the number of calories necessary to warm a column of unit base and height equal to the summer temperature of the layer. This "reduced depth" is obtained by dividing the volume of the layer by the area of the surface of the whole lake (through which, incidentally all heat exchange with the atmosphere must take place.) Since the sum of all reduced depths is equal to the mean depth of the lake, the sum of these heat budgets for the layer

TABLE NO. 13

Stratum in R.L.	Layer in feet	Vol. in mcft.	Reduced depth in meters	Cold Weather Temp. on 24th Jan.	Calculated heat budgets in g. cal. per sq.cm in 1964								
					24th Mar.	23th April	11th June	24th July	28th Aug.	25th Sept.	24th Oct.	27th Nov.	18th December
211-206	0-5	678.00	1.315	17.0	17,740	19,370	16,410	15,780	16,440	16,410	19,050	10,530	6,570
206-201	5-10	472.00	0.915	17.2	9,490	12,810	10,740	10,770	11,210	11,210	11,210	6,180	3,490
201-196	10-15	304.00	0.590	17.2	5,750	7,820	6,930	6,940	7,230	7,230	6,940	3,990	1,920
196-191	15-20	173.00	0.335	17.0	3,180	4,440	4,020	4,030	4,190	4,190	4,020	2,350	1,170
191-186	20-25	76.00	0.141	17.0	1,340	1,870	1,690	1,690	1,690	1,690	1,690	920	490
186-181	25-30	13.85	0.027	-	-	-	-	-	-	-	-	-	-

gives the total heat budget for the whole column of water as specified by Birge.

In the table No. 13 (shown on page 38)the heat stored in the reservoir from March to December, 1964 is shown. From the study of the table it will be seen that the heat stored in the Ajwa Reservoir is maximum in April and minimum in December.

vii) Hydrogen ion concentration (pH): (TABLE NO.VII Appendix).

The pH values of the surface layer and its seasonal variations.

The results of the early morning and afternoon series of observations are shown below:

Maximum and Minimum values:

The values for the morning and afternoon series varied as under:

	Early morning	Afternoon
Maximum	8.3 - 8.4	8.8
Minimum	8.1	8.1 - 8.2

Seasonal variations:

The results are shown in Table No. 14.

TABLE NO. 14

1963				1964			
Date	Early-morn	After-noon	Diff-erence	Date	Early morn	After-noon	Differ-ence
24-4	8.3	8.8	0.5	24-1	8.3	8.4	0.1
24-5	8.5	8.8	0.3	25-3	8.3	8.6	0.3
21-6	8.4	8.7	0.3	28-4	8.3	8.6	0.3
19-7	8.5	8.7	0.2	11-6	8.2	8.8	0.5
30-8	8.3	8.5	0.2	24-7	8.3	8.4	0.1
25-9	8.4	8.5	0.1	28-8	8.2	8.3	0.1
24-10	8.2	8.4	0.2	25-9	8.2	8.2	0.0
29-11	8.1	8.3	0.2	29-10	8.2	8.3	0.1
20-12	8.1	8.3	0.2	27-11	8.3	8.4	0.1
				18-12	8.3	8.5	0.2

The values were comparatively higher during the first six months of the year and later there was a slight decrease in the rest of the year. Lowest values were recorded in the Cold weather and highest during the hot weather and monsoon seasons. Two points emerge from a study of the above table. Compared to the early morning values, the afternoon values show more alkalinity and are due to photosynthesis by the water plants. But a pH of 9.0 was never reached, the maximum reaction obtainable in the case of calcium carbonate. Also " Since saturated calcium bicarbonate solution in equilibrium with air containing about 3.0 parts per 100,000 is close to pH = 8.1, any pH value over this shows that photosynthesis exceeds respiration and may be taken to denote approximate saturation with oxygen, higher values often accompany supersaturation " (Atkins and Harris 1924).

pH values of the bottom layer and its seasonal variations :

(The results are tabulated below)

TABLE NO. 15

Date	Early morn	After -noon	Differ- ence	Date	Early morn	After- noon	Differ- ence
24- 4	8.2	8.3	0.1	24- 1	8.0	8.1	0.1
24- 5	8.3	8.4	0.1	25- 3	8.3	8.4	0.1
21- 6	8.3	8.4	0.1	28- 4	8.3	8.4	0.1
19- 7	8.3	8.4	0.1	11- 6	8.3	8.4	0.1
30- 8	8.3	8.4	0.1	24- 7	8.3	8.4	0.1
25- 9	8.2	8.3	0.1	28- 8	8.3	8.4	0.1
24-10	8.2	8.3	0.1	25- 9	8.2	8.3	0.1
29-11	8.0	8.1	0.1	29-10	8.1	8.2	0.1
20-12	8.0	8.1	0.1	27-11	8.0	8.1	0.1
				18-12	8.0	8.1	0.1

The pH values of the morning samples were slightly less than those of the afternoon samples in both the years, the differences always amounting to 0.1 unit. Also, they were comparatively lower than those for the surface indicating that there were other forces at work to bring down the values. More of this under discussion.

The pH values of the South African lakes range from a minimum of 3.7 to a maximum of 9.8 (Hutchinson et al 1932). Jenkins (1932, p547) has recorded values ranging from pH 8.3 in lake Naivasha to pH 12 in the lake Nakuru of the Rift valley in Kenya.

The seasonal and vertical changes in the Madras Red Hills reservoir (Ganapati 1964) show that its water was definitely alkaline throughout the year, the values ranging between 8.4 and 8.9. Graham (1929) found in the lake Victoria significant differences between the surface (8.5) and the bottom (7.4). In the lakes of Sumatra, Java and Bali, Ruttner (1931) found that in almost all the lakes the pH values were never above pH 8.0 and those of the bottom layers varied between 7.2 - 7.4. Worthington (1930) found diurnal variations from 7.95 to 8.7 in the lake Victoria. Beadle (1932) found in the lake Baringo a change of 0.1 unit only from 6.30 a.m. (8.7) to 12.30 p.m. (8.8) and of 0.2 units only from 12 mid-night (9.4) to 12 midday (9.6) in Lake Rudolf.

SUMMARY

1. The Ajwa Reservoir of great surface area and moderate depth is located in a windy region of low humidity.

2. The colour of water is greenish from January to July and greyish from July or August to September or October, and becomes, again, greenish from October or November and December.

3. The water level is found to decrease gradually from January to June or July and then it increases in the monsoon season until the maximum is reached in September and thereafter the level again goes down gradually.

4. The reservoir does not develop any persistent thermal density stratification characteristic of a classical temperate lake. Heating occurs by day followed by loss of heat and complete nocturnal cooling. So, there is diurnal stratification in the afternoon and homothermal conditions in the early morning hours.

5. The entire reservoir water is definitely alkaline but there is a slight difference in the degree of pH, the bottom layers showing less than the surface.

6. The surface layers of water are clearer than the bottom layers which are comparatively more turbid.

(b) Chemical Environment and Nutrient Supply.

General Characteristics of the Water:

(Table No. 8 Appendix)

" Normal fresh waters are dilute solutions of alkali and alkaline earth bicarbonate and carbonate, sulphate and and chloride with a variable quantity of largely undissociated silicic acid (Page 789) which is often present in excess of sulphate and chloride. There are also a number of minor constituents in true solution, some of them being of great biological interest, and a variety of colloidal materials both inorganic and organic ....." (Hutchinson 1957, p. 552). In this section an attempt is made to indicate the relative abundance of the major ionic constituents and their seasonal variations in so far as they determine the over-all chemical characteristics of the water.

viii) Total solids: The total organic and inorganic materials dissolved in the water as estimated by evaporating a known volume of the water to dryness has been found to vary between 224 and 320 ppm; and these figures are within the permissible International Standards for Drinking Water (1958). The solids were found in maximum in June or July and minimum in August or September. The graph for solids runs almost counter to that for the reservoir level. An inverse correlation is seen to exist between the two.

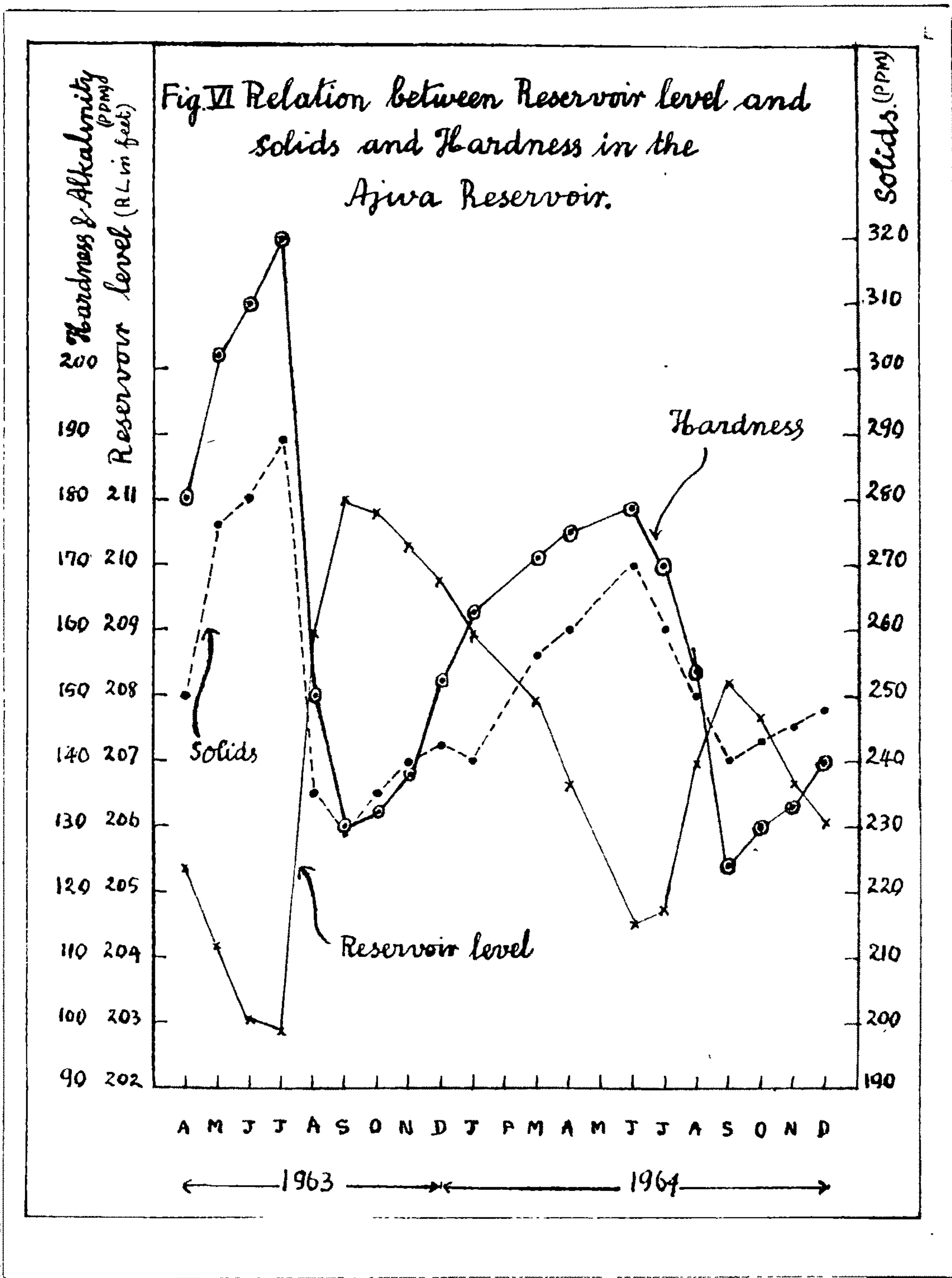

Fig. 13. Relation between rese rvoir level, and solids and hardness in the reservoir.

(ix) Alkalinity: Free CO_2 occurs in natural waters either chemically combined with alkali and alkaline earth metals which are found in excess of the quantities already combined with strong acids or as free CO_2. The chemically fixed CO_2 is found as bound CO_2 or monocarbonates and half-bound or bicarbonates.

All the three forms are of considerable importance in the household economy of lake waters. The free CO_2 is first used up by plants in water during photosynthesis. When all the available free CO_2 is used up, the half-bound CO_2 is used up; and when the first two sources are exhausted, the fully bound CO_2 or monocarbonates may be utilised (Juday et.al 1935).

In the reservoir under study, free CO_2 was not detected at any time. Its absence may be traced to its utilisation by the higher plants, to agitation and evaporation. The last factor is greatest in shallow lakes of large area, where evaporation is most effective (Welch 1935, p. 96) as in the Ajwa reservoir.

Carbonate Alkalinity in the Surface Layers and its Seasonal Variations:(Table No.IX Appendix)

The results of the early morning and afternoon series are shown in a tabular form on page 46 from which the following inferences are drawn.

Maximum and Minimum values: The values for the maxima varied between 26 and 36 and between 36 and 44 ppm for the early morning and afternoon series respectively.

The values for the minima varied between 14 and 16 and 16 and 24 for the early morning and afternoon series respectively.

Seasonal variations: The values gradually decreased from hot weather through the monsoon season to the post-monsoon and cold weather seasons in both the years and in both cases.

TABLE NO. 16

1963				1964			
Date	Early morn	After -noon	Differ -ence	Date	Early morn	After -noon	Differ-ence
24- 4	28	40	12	24- 1	20	30	10
24- 5	36	44	8	25- 3	24	32	8
21- 6	32	44	12	28- 4	26	36	10
19- 7	20	32	12	11- 6	24	32	8
30- 8	20	24	4	24- 7	24	32	8
25- 9	16	24	8	28- 8	16	24	8
24-10	16	24	8	25- 9	16	32	8
29-11	16	24	8	29-10	14	16	8
20-12	16	24	8	27-11	14	20	6
				18-12	16	24	8

Diurnal variations: There was a sharp increase in the carbonate content in the afternoons as a result of photo-synthesis, so that the differences were found to be greater in the first six months of the year.

Carbonate Alkalinity in the Bottom Layers and it's Seasonal variations:

The figures are shown in Table No. 17

TABLE NO. 17

Date	1963 Early morn	After -noon	Differ -ence	Date	1964 Early morn	After -noon	Differ-ence
24- 4	28	30	2	24- 1	20	22	2
24- 5	36	38	2	25- 3	24	26	2
21- 6	32	34	2	28- 4	26	26	0
19- 7	20	20	0	11- 6	24	26	2
30- 8	20	22	2	24- 7	24	26	2
25- 9	16	18	2	28- 8	16	18	2
24-10	16	18	2	25- 9	16	18	2
29-11	16	16	0	29-10	8	10	2
20-12	16	16	0	27-11	10	10	0
				18-12	16	16	0

It will be seen from a study of the above table that there is a gradual increase in the values during the first six months in both series. But the differences between the morning and after-noon values are comparatively lower.

From a study of both the tables for carbonate values, it is seen that: (i) the values for carbonates in the early morning hours are almost the same from the surface to the bottom; (ii) by the afternoon a weakly expressed stratification is seen; (iii) the diurnal variations in the surface layers are greater than in bottom layers.

Juday et al (1935) found that the surface waters were alkaline to phenolphthalein in all the " drainage " lakes investigated by them. They state: " This alkaline reaction to phenolphthalein was due to photosynthetic activity of the various aquatic plants, chiefly to phytoplankton forms; these organisms remove some of the half-bound carbon dioxide, thus leaving a certain amount of normal carbonates in water which gave it an alkaline reaction." Our reservoir is also of the " drainage " type; and the water is always alkaline to phenolphthalein from the surface to the bottom.

<u>Bicarbonate Alkalinity in the Surface Layers and its Seasonal Variations</u> :

(The results of the early morning and afternoon series are shown in Table No. 18)

TABLE NO. 18

Date	1963 Early morn	1963 After-noon	1963 Differ-ence	Date	1964 Early morn	1964 After-noon	1964 Differ-ence
24- 4	110	70	40	24- 1	125	98	27
24- 5	110	64	54	25- 3	118	98	20
21- 6	136	68	68	28- 4	119	104	15
19- 7	138	88	50	11- 6	146	116	30
30- 8	112	86	26	24- 7	136	106	30
25- 9	108	102	6	28- 8	138	124	14
24-10	120	104	16	25- 9	144	100	44
29-11	134	116	18	29-10	138	124	14
20-12	128	106	22	27-11	144	119	25
				18-12	136	106	20

A study of the above table shows that a difference between the values for the two series was noted during the two years. In 1963, the afternoon alkalinity was found to be lower by 4 to 33% than the early morning alkalinity; and in 1964, the range of difference was found to be smaller (1.3 to 14%). The greatest difference was seen in the summer and monsoon seasons. The difference is due to photo-synthesis.

Bicarbonate Alkalinity in the Bottom Layers and its Seasonal Variations :

(The results of the early morning and afternoon series are showin in Table No.19).

TABLE NO. 19

Date	1963 Early morn	After -noon	Differ -ence	Date	1964 Early morn	After -noon	Differ -ence
24- 4	112	112	0	24- 1	125	126	1
24- 5	109	110	1	25- 3	116	118	2
21- 6	136	136	0	28- 4	120	124	4
19- 7	140	138	2	11- 6	148	150	2
30- 8	114	118	4	24- 7	138	138	0
25- 9	124	128	4	28- 8	138	136	-2
24-10	122	122	0	25- 9	144	142	-2
29-11	134	134	0	29-10	136	146	10
20-12	128	134	6	27-11	146	154	8
				18-12	140	144	4

From a study of the above table, it is seen that a difference is noted in both the years between the early morning and afternoon series; but the difference is comparatively less than for the surface layers. The values for the afternoon series were greater than those for the early-morning series in several cases by 0 to 5% in 1963 and 0 to 3% in 1964. The increase noted in the bottom layers may be attributed to the precipitation of $CaCO_3$ from the surface layers due to photosynthesis and their subsequent conversion into bicarbonates on account of the respiratory activities of the large number of zoo-plankton organisms at the bottom.

(X) HARDNESS

(Table No.VIII, Appendix)

The figures for hardness varied between a maximum of 189 ppm and a minimum of 129 ppm in 1963; and between 170ppm and 140ppm in 1964. The maximum figure was found in July 1963, and in June 1964, and in both the years the minimum was in September. There was a gradual increase in hardness from the beginning of the year until the maximum was reached in July; and thereafter there was a sudden fall in August until the minimum was reached in September and then again there was a gradual increase in values.

Taylor (1958) has classified waters as soft and hard as detailed below:

Less than 50 ppm	Soft
50 to 100 ppm	moderately soft
100 to 150 ppm	slightly hard
Greater than 150 & less than 250 ppm ...	moderately hard
Greater than 250 & less than 350 ppm ...	hard
Greater than 350 ppm	very hard.

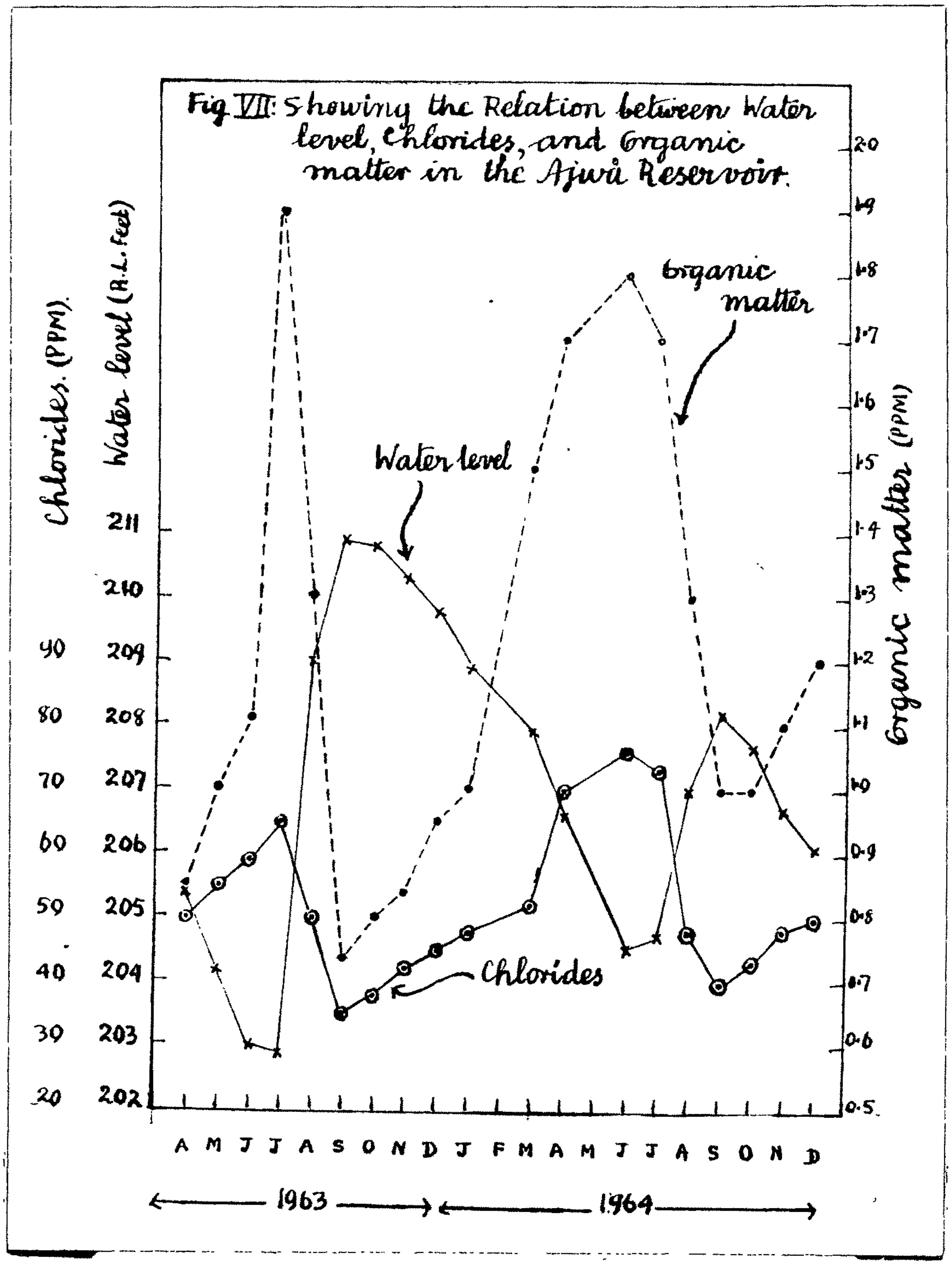

Fig. 14. Relation between water level, chlorides and organic matter in the reservoir.

According to the above classification the Ajwa reservoir varies between a slightly hard and a moderately hard water.

The seasonal variation in the values for hardness is also found to run diametrically opposite to the reservoir level so that there is an inverse correlation between the two.

XI CHLORIDE

(Table No. VIII, Appendix).

The values for chloride were found to vary from a minimum of 35 ppm in September to a maximum of 65 ppm in July in 1963; and again from a minimum of 40 ppm in September to a maximum of 76 ppm in June in 1964. The figures were found to increase from January until the maximum was reached in June or July and thereafter there was a sudden fall in August or September and then a gradual rise until the end of the year.

The graph for chloride just like those for total solids and hardness showed an inverse correlation with the reservoir level.

DISSOLVED GASES

(Table No. XI, & XII)

xii) Free CO_2 : was not found both at the surface and bottom at any time during the two year period.

xiii) Dissolved Oxygen: Lakes and reservoirs receive their supplies of oxygen mainly from two sources.

From the atmosphere the surface layers of water get oxygen by mechanical admixture of air through wind and wave action, so that when the lake water is in complete circulation, the entire lake is saturated with Oxygen. The second source is through the process of photosynthesis, when the chlorophyll-bearing organisms diminish or deplete the supply of CO_2 and increase the oxygen content beyond saturation. So, the quantity of oxygen present at any time of the day is the resultant of the several factors such as diffusion, photosynthesis, respiration, the chemical processes of decay and of reducing substances. If the consumption of oxygen by various organisms present in water and by decomposition of organic matter exceeds the supply of oxygen derived from photosynthetic activity then the amount is below the saturation point. But if the latter exceeds that of the former, then the water is saturated or supersaturated (Birge and Juday 1914).

The results of oxygen determinations are expressed in milligrams per litre and also in terms of percentage saturation which was calculated from the table prepared by Whipple and Whipple as given in the " Standard Methods."

The Oxygen Content in the surface layer and its seasonal variations :

The Maximum and Minimum values:

(Results are shown in Table No. 20)

TABLE NO. 20

Time of Collection	MAXIMUM				MINIMUM			
	1 9 6 3		1 9 6 4		1 9 6 3		1 9 6 4	
	Value	Month	Value	Month	Value	Month	Value	Month
Early morn 4-5A.M.	8.41	Dec.	7.64	Jan.	5.81	June	5.04	June
After-noon 4-5P.M.	9.81	April	8.44	Jan.	5.61	June	5.75	June

It will be seen from the above that the maximum value for Oxygen is reached in December or April and the minimum value in June in both the years.

Seasonal variations:

(The data are shown in tabular form below)

TABLE NO.21

Year & Time	Cold weather Dec. Jan. & Feb.	Hot weather March to June	Monsoon Season July to September	Post-monsoon October & November
1963				
Early-morn	8.41	7.62-5.81	6.22-7.63	6.63-6.83
After-noon	8.23	9.81-5.61	7.21-8.71	7.83-8.24
1964				
Early-morn	6.23-7.64	7.51-5.04	6.01-6.61	6.81-7.04
After-noon	7.23-8.44	7.53-5.75	6.21-7.23	7.23-8.61

From a study of the above it is seen that both the highest and lowest values are recorded in the hot weather in both years. Comparatively, the cold weather, and the post-monsoon season show higher values than the other two weather periods.

Oxygen content of the bottom layer and its seasonal variations:

(The maximum and minimum values are tabulated below)

TABLE NO.22

Time of collection	MAXIMUM 1963 Value	MAXIMUM 1963 Month	MAXIMUM 1964 Value	MAXIMUM 1964 Month	MINIMUM 1963 Value	MINIMUM 1963 Month	MINIMUM 1964 Value	MINIMUM 1964 Month
Early-morn 4-5 A.M.	7.62	Dec.	7.04	Jan.	4.23	Sept.	4.61	Oct.
After-noon 4-5 P.M.	9.00	April	7.00	Jan.	5.05	June	3.41	Mar.

It will be evident from the above that oxygen content in the bottom layer was found to be maximum in December and April 1963 and in January 1964 in both the series and minimum in March, June, September or October in both the years.

Seasonal Variations: The data are shown below

TABLE NO. 23

Year & Time	Cold weather Dec.,Jan. & Feb.	Hot weather March to June	Monsoon season July to Sept.	Post-monsoon October & November
1963				
Earlymorn	7.62	5.00-6.42	6.53-4.23	6.04-6.62
Afternoon	6.42	9.00-5.05	7.52-6.41	7.04-7.83
1964				
Earlymorn	5.61-7.04	5.60-4.74	5.03-6.04	4.61-6.02
Afternoon	5.61-7.00	5.83-3.41	4.82-6.12	4.43-5.02

From the above it is seen that the bottom layer was not totally deficient in Oxygen at any time during the two year period.

Vertical distributions of Oxygen :

(a) Early morning series: The oxygen values for the surface and bottom layers with their differences are shown in Table No. 24. It has to be remembered that the bottom samples were taken always about a foot above the bottom mud.

In six out of 16 cases only there is definitely an appreciable decrease in concentration in the deep water. In all other cases, there is no appreciable decrease in concentration. Such a distribution has been called " Orthograde " by Aberg and Rodhe (1942, cited by Hutchinson 1957, p. 603). It is not " clinograde ".

(b) Afternoon series: The results of the surface and deep water samples are shown in Table No. 25.

In this series there were appreciable differences between the surface and bottom samples. Largest differences of 3.42 mg./l. in March and 2.80 mg./l. in October and 3.59 in November 1964 were recorded. Hutchinson (1957, p.607) says: " Following in part of 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 organism has sedimented below the compensation point

TABLE NO. 24

	1963 (4-5 A.M.)				1964 (4-5 A.M.)			
	Surface	Bottom	Difference	Actual Depth in feet	Surface	Bottom	Difference	Actual Depth in feet
January	-	-	-	-	7.64	7.04	0.60	21.0
February	-	-	-	-	-	-	-	-
March	-	-	-	-	6.42	5.00	1.42	20;0
April	7.62	5.24	2.38	20.0	7.51	5.60	1.91	20.0
May	6.82	6.42	0.42	18.0	-	-	-	-
June	5.81	5.24	0.57	16.0	5.04	4.74	0.30	18.0
July	6.62	6.53	0.09	16.0	6.03	5.71	0.32	18.0
August	8.22	7.32	0.90	20.0	6.61	6.04	0.57	21.0
September	7.63	4.23	3.40	22.0	6.01	5.03	0.98	21.0
October	6.63	6.04	0.59	22.0	6.81	4.61	2.20	22.0
November	6.83	6.62	0.21	22.0	7.04	6.02	1.02	22.0
December	8.41	7.62	0.79	22.0	6.23	5.61	0.62	20.0
Average	7.18	6.14	1.04	19.8	6.61	5.54	1.07	20.3

TABLE NO. 25

	1963 (4-5 P.M.)				1964 (4-5 P.M.)			
	Surface	Bottom	Differ-ence	Actual Depth in feet	Surface	Bottom	Differ-ence	Actual Depth in feet
January	-	-	-	-	8.44	7.00	1.44	21.00
Feburary	-	-	-	-	-	-	-	-
March	-	-	-	-	6.83	3.41	3.42	20.00
April	9.81	9.00	0.81	20.00	7.53	5.83	1.70	20.00
May	8.04	7.25	0.79	18.00	-	-	-	-
June	5.61	5.05	0.56	16.00	5.75	4.64	1.11	18.00
July	7.21	6.41	0.80	16.00	6.21	6.12	0.09	18.00
August	8.71	7.53	1.18	20.00	7.23	5.63	1.60	21.00
September	7.62	7.24	0.38	22.00	6.42	4.82	1.60	21.00
October	7.83	7.04	0.79	22.00	7.23	4.43	2.80	22.00
November	8.24	7.83	0.41	22.00	8.61	5.02	3.59	22.00
December	8.23	6.42	1.81	22.00	7.23	5.61	1.62	20.00
Average	7.13	6.38	0.75	19.08	6.87	5.25	1.62	20.03

and is using reserves or is heterotrophic; (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 the Ajwa reservoir animal respiration appears 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 the 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. More of this under discussion.

Secondly, the increased amounts of oxygen in the surface layers will have to be attributed to surface aeration and/or photosynthesis.

XIV Percentage saturation of Oxygen.

(Tables No. XII(a) & XII(b) Appendix)

" It is often useful to know, not only the oxygen content of a water sample, but also the content it would have when saturated with atmospheric oxygen. The ratio of the two contents usually expressed as " percentage saturation " can in some circumstances throw light on the previous physical and biological history of the sample; and the ratio also controls the rate at which oxygen is taken up from the air (32)" (Mortimer 1956). So, the values for percentage saturation were calculated and are discussed below:

The percentage saturation in the surface layers and its seasonal variations:

The maximum and minimum values are tabulated below :

TABLE NO. 26

Time of Collection	Maximum				Minimum			
	1963		1964		1963		1964	
	Value	Month	Value	Month	Value	Month	Value	Month
Early morn (4-5 A.M.)	97.3	Sept.	94.8	April	72.7	June	65.0	June
After-noon (4-5 P.M.)	130.7	April	102.7	Nov.	72.2	June	74.7	June

The maximum value is recorded in April, September or November and the minimum in June.

The Seasonal Variations are tabulated below:

TABLE NO. 27.

Year & Time	Cold Weather Dec. Jan. & February	Hot Weather March to June	Monsoon Season July to September	Post-monsoon October and November
1963				
Early morn	93.0	94.4-72.7	78.5-97.3	81.0-81.5
After noon	93.2	130.7-72.2	93.9-115.3	100.0-101.2
1964				
Early morn	66.6-78.5	94.8-65.0	77.3-83.4	84.7-81.1
After noon	81.9-92.9	101.4-74.7	80.0-94.0	95.7-102.7

From the above it is seen that the highest and lowest values are recorded in the hot weather in both the years.

The percentage saturation of Oxygen in the bottom layer and its seasonal variations.

The maximum and minimum values are tabulated below:

TABLE NO. 28

Time of collection.	MAXIMUM				MINIMUM			
	1963		1964		1963		1964	
	Value	Month	Value	Month	Value	Month	Value	Month
Early morn (4-5 A.M.)	86.6	Dec.	76.3	Aug	53.7	Sept.	57.1	Oct.
After-noon (4-5 P.M.)	112.6	April	76.3	Aug.	63.8	June	41.9	March

It will be seen from the above that the maxima were recorded in April, August, or December and the minima in March, June, September or October. On one occasion only in April '63 the bottom layer was supersaturated with oxygen.

Seasonal variations: The data are tabulated below:

TABLE NO. 29

Year & Time	Cold weather Dec.Jan. & Feb.	Hot weather March to June	Monsoon season July to Sept.	Post-monsoon season October & November
1963				
Early morn	86.6	62.0-82.5	81.7-69.0	73.8-79.0
After-noon	71.4	112.6-63.8	82.5-99.0	88.1-94.3
1964				
Early morn	60.0-72.2	60.8-70.7	76.3-64.7	57.1-69.4
After-noon	61.7-73.3	41.9-77.0	78.7-62.0	57.0-58.4

There was no complete deficit of oxygen during any season.

Vertical distribution of percentage saturation:

The percentage saturation values for the surface and bottom layers with their differences are shown in Table No. 30 for the early morning series.

From the above Table differencer($>$ 10%) were noted in April, August and September 1963 and in March, April, September, October and November 1964.

The results of the afternoon series are shown in Table No. 31.

TABLE NO. 30

	1963 (4-5 A.M.)				1964 (4-5 A.M.)			
	Surface	Bottom	Difference	Actual Depth in feet	Surface	Bottom	Difference	Actual Depth in feet
January	-	-	-	-	78.5	72.2	6.3	21.0
February	-	-	-	-	-	-	-	-
March	-	-	-	-	78.7	60.8	17.9	20.0
April	94.4	62.0	32.4	20.0	94.8	70.7	24.1	20.0
May	87.7	82.5	5.2	18.0	-	-	-	-
June	72.7	65.6	7.1	16.0	65.0	61.0	4.0	18.0
July	82.8	81.7	1.1	16.0	77.3	73.2	4.1	18.0
August	78,5	67.2	11.3	20.0	83.4	76.3	7.1	21.0
September	97.3	53.7	43.6	22.0	77.4	64.7	12.7	21.0
October	81.0	73.8	7.2	22.0	84.7	57.1	27.6	22.0
November	81.5	79.0	2.5	22.0	81.1	69.4	11.7	22.0
December	93.0	86.6	6.4	22.0	66.6	60.0	6.6	20.0
Average	85.4	72.5	12.9	19.8	78.7	66.5	12.2	20.3

TABLE NO. 31

Month	1963 (4-5 P.M.) Surface	Bottom	Difference	Actual Depth in feet	1964 (4-5 P.M.) Surface	Bottom	Difference	Actual Depth in feet
January	-	-	-	-	92.9	73.3	19.6	21.0
February	-	-	-	-	-	-	-	-
March	-	-	-	-	90.5	41.9	48.6	20.0
April	130.7	112.6	18.1	20.0	101.4	77.0	24.4	20.0
May	110.1	96.0	14.1	18.0	-	-	-	-
June	72.2	63.8	8.4	16.0	74.7	59.7	15.0	18.0
July	93.9	82.5	11.4	16.0	80.0	78.7	1.3	18.0
August	115.3	99.0	16.3	20.0	94.0	72.5	21.5	21.0
September	103.0	91.4	11.6	22.0	83.4	62.0	21.4	21.0
October	100.0	88.1	11.9	22.0	95.7	57.0	38.7	22.0
November	101.2	94.3	6.9	22.0	102.7	58.4	44.3	22.0
December	93.2	71.4	21.8	22.0	81.9	61.7	20.2	20.0
Average	102.2	88.8	13.4	19.8	89.7	64.2	25.5	20.3

From the above table differences ($>10\%$) were noted almost in all the months in the afternoon series.

Ruttner (1926, cited by Welch, 1935, p. 170), has stated that the respiration of aquatic organisms depends not alone on the dissolved oxygen 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 the deeper waters in summer or winter, the temperature must be considered in determining the respiratory value of the dissolved oxygen present; and that the practice of expressing the results of dissolved oxygen in percentages of saturation is misleading, since from the point of view of the oxygen demand by organisms, the respiratory value is not taken into account." Unfortunately, the respiratory value of the organisms was not determined.

IONS INVOLVED IN PLANT NUTRITION

(Tables XIII,XIV & XV Appendix)

xv) Inorganic forms of nitrogen :

Nitrogenous compounds occur in varying amounts in lake water, depending upon the nature of the watershed, the season, the amount of pollution and the abundance of plankton life in them. They occur in two forms: organic and inorganic. Organic nitrogen is found partly 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 water. These can be easily removed from water by centrifuging or filtration. The soluble organic nitrogen (in true and colloidal solution) results from (a) the decomposition of dead organic matter by bacterial action and (b) excretions of aquatic animals.

The inorganic forms of nitrogen consists of ammonium salts, nitrites and nitrates. Free ammonia or ammonium salts result from decomposition of organic matter by saprophytic bacteria; and 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 water. Estimations of free ammonia, nitrites and nitrates were made regularly on the surface and bottom samples of the early morning and afternoon series every month. All the three forms were found to be absent.

Ruttner (1931) who examined the lakes of Sumatra, Jawa and Bali found that the ammoniacal nitrogen in largest amounts in the bottom layers and completely absent in the surface layers. Hutchinson et al (1932) found nitrites in traces in all the pans and lakes of South Africa. Beadle (1932) found traces of or none at all of nitrites and nitrates in the Rift Valley lake of East Africa.

In the lakes of the English Lake District Pearsall (1930) could not detect ammonia in the surface layer at any season.

xvi) Phosphate (PO_4)

This was also not detected in the surface or bottom samples of the early morning and afternoon series every month, during the two-year period.

Srinivasan (1964) did not find the soluble phosphates in the Rivers Bhavani and Moyar and the reservoir, Bhavanisagar. Also Rao and George (1959) and Ganapati (1940) did not detect phosphate in the reservoirs studied by them. Einsele (1938) has shown that under oxidising conditions phosphate is precipitated in the presence of iron as insoluble ferric phosphate on the mud-surface and that appears to be so in the Ajwa reservoir.

xvii) Silica (SiO_2) (Table No.XIII, Appendix)

"Silicon is almost universally present in some more or less reactive form in all natural waters" (Hutchinson 1957 p. 788). According to Hutchinson (1957, p. 791) 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-water interface, though very little is known definitely about this " (Hutchinson 1957, p. 792).

Silica was estimated regularly both at the surface and bottom layers in the early morning and afternoon collections. The results are shown in Table XIII, Appendix. The surface layers were found to contain less than the bottom layers. ~~In the surface layers~~ The range was found to vary between 0.05 and 0.20 mg./l in the surface and between 0.20 and 0.25 mg./l in the bottom layers in 1963. In the following year they were found to range between 0.10 and 0.15 mg./l at the surface and between 0.25 to 0.50 mg./l at the bottom. They were found to be greater in 1964 than in 1963.

xviii) Iron:

Iron was estimated qualitatively only. It was not found at the surface at any time during the two year period; but the bottom samples showed traces or slightly more than traces of ferric iron in the bottom samples especially when the samples were more turbid.

xix) Calcium :(Table No. XIV, Appendix)

Calcium was estimated during 1964 only; and it was found to vary between a maximum of 13.75 mg./l in June to a minimum of 6.40 mg./l in September in the surface samples. The annual average was 10.85 mg./l.

xx) Magnesium :

Magnesium was not actually determined; but it is believed to be present in sufficient amounts in the water from the values of " hardness ". So, it is not likely to constitute a limiting factor.

xxi) Sodium : (Table No.XIV, Appendix)

Sodium was also estimated during 1964 only and it was found to vary between a maximum of 61.41 mg./l in December and a minimum of 45.55 mg./l in September.

xxii) Potassium : (Table No. XIV, Appendix)

Potassium was also estimated during 1964 only and it was found to fluctuate between a maximum of 3.90 mg./l in August, September and October and a minimum of 1.50 mg./l in January. It was not a limiting factor at any time.

xxiii) Dissolved organic matter:(Table No.XV,Appendix)

Dissolved organic matter is present in all lake or reservoir waters; and may be considered either as allochthonous when the organic material is derived from external sources or autochthonous when it is developed from within. The nature of latter varies from lake to lake according as it is the result of phyto-plankton or aquatic weeds and also according to the species of either involved (Hutchinson 1957, p.882).

The values of permanganate oxygen consumed (Tidy's 4 hours) were determined in samples drawn both at the surface and bottom in the two series of monthly collections. The results are shown in Table XV (Appendix). The values for the surface samples are lower than those for bottom which were almost always comparatively more turbid. The values for the surface samples vary between 0.78 and 1.92 ppm in 1963 and between 1.00 and 1.83 ppm in 1964. They increase from January to June and then decrease gradually till the minimum is reached in September or October and then, again, begin to increase.

The values for the bottom samples varied between 1.22 and 5.80 ppm in 1963 and between 1.40 and 2.84 ppm in 1964. The values did not show any seasonal variation as those for the surface water which varied with the reservoir level. The comparatively higher values at the bottom may be attributed to disturbances of the bottom sediments by the hundred of carps and crocodiles inhabiting the reservoir.

SUMMARY OF CHEMICAL CONDITIONS

1. The total solids are found in maximum in June or July and in minimum in August or September. The graph runs almost inversely to that for water level.

2. Carbonate alkalinity is found to be higher in the afternoon series than in the early morning series, but the values are almost same from the surface to the bottom in the early morning series.

3. Bicarbonate alkalinity in the surface layers is found to be lower in the afternoon series due to photosynthesis; and it is found to be comparatively higher in the bottom layers due to respiratory activities of the microorganisms.

4. The reservoir water varies between slightly hard and moderately hard; and the values seem to fluctuate inversely with the water level.

5. There is a seasonal variation in Chlorides and this graph also shows inverse correlation with the reservoir level.

6. Free CO_2 is absent. The vertical distribution of dissolved oxygen is not " Clinograde " but is orthograde according to the type distribution of oxygen ~~by Moyer and Rodhe,~~ so that there is always enough of dissolved oxygen in the bottom layers. Thé surface water in the reservoir is found to be supersaturated on a few occasions.

7. The ions involved in plant nutrition such as ammonia, nitrate, nitrite, and phosphate are always absent. Silicates, though found in comparatively smaller amounts are present. Sodium, potassium, calcium and magnesium are present and are not likely to be limiting factors.

8. The dissolved organic matter as determined by the permanganate oxygen consumed (Tidy's 4 hours test) was comparatively greater in the bottom layers. It is of autochthonous origin.

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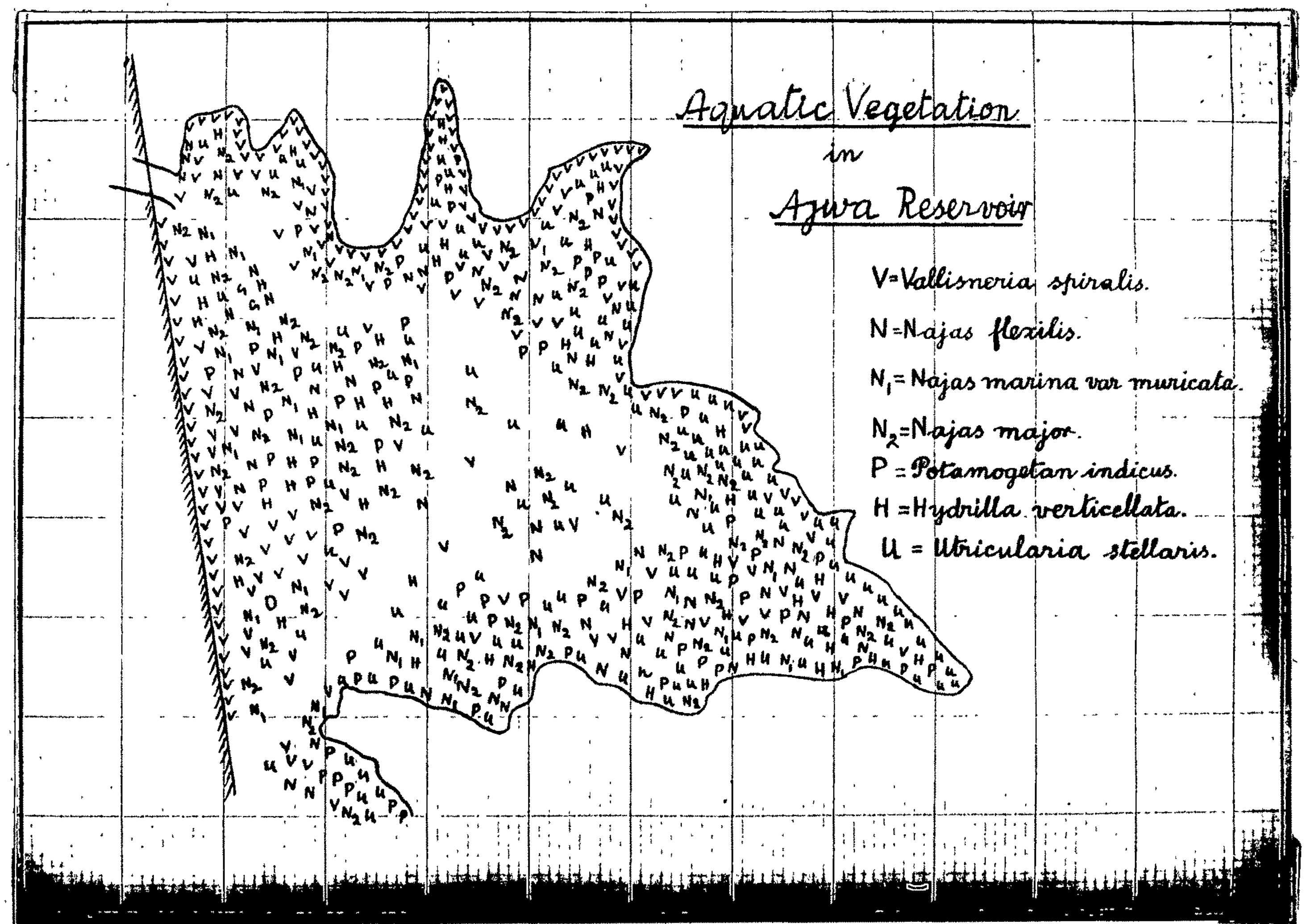


Fig. 15. Aquatic vegetation in the Ajwa reservoir.

(C) BIOLOGICAL CONDITIONS

(Tables No. XVI & XVII Appendix)

(i) The larger aquatic vegetation:

A rich growth of rooted and submerged hydrophytes was typical of this reservoir. The hydrophytes in order of their abundance are listed below:

Hydrocharitaceae: Vallisneria spiralis; and Hydrilla verticellata.

Naiadaceae: Naias flexilis; Naias marina var muricata; Naias major.

Potamogetanaece: Potamogeton indicus.

Lentibulariaceae: Utricularia stellaris.

Gramineae: Gramineae sp.

The distribution of the plants in the reservoir when the water level was lowest is shown in Fig. 15. Vallisneria was seen flowering in November and December months; and its pollen grains were seen floating in abundance on the water surface.

(ii) Chemical composition of the dominant plants:

"Since in their growth processes the higher plants remove temporarily atleast, certain essential substances from the water and from the bottom deposits, the chemical composition of the plants themselves may give some information as to kinds and amounts of these substances used. On the death and decay of plants, a certain return of the contained material is made to the lake. Very little is known concerning this exchange"(" Welch 1935, p. 281).

As already stated the four dominant plants in order of abundance are Vallisneria spiralis, Potamogeton indicus, Naias flexilis and Hydrilla verticellata. The results of chemical analysis of ash of the above plants furnished by Schuette and Hoffman (1922), Schuette and Alder (1928,1929), Mayer and Gorham (1951) and Gorham and Gorham (1954) are given below in two tabular statements:

TABLE NO. 32

(From Scheutte and Hoffman; and Scheutte and Alder)

Constituents	PERCENT		
	Vallisneria	Potamogetan	Naias flexi-lis
Silica (SiO_2)	5.45	0.78	1.89
Ferric oxide (Fe_2O_3)	0.81	0.11	0.40
Aluminium oxide(Al_2O_3)	0.57	0.23	0.25
Mangano-manganic oxide (Mn_3O_4)	0.52	0.08	0.05
Calcium oxide (CaO)	8.16	3.38	8.56
Magnesium oxide (MgO)	1.87	1.38	1.61
Sodium Oxide (Na_2O)	0.81	0.26	1.05
Potassium oxide (K_2O)	5.48	2.08	2.19
Chloride (Cl)	1.32	0.56	0.51
Sulphur (S)	0.85	0.82	0.48
Phosphorus (P)	0.23	0.13	0.30

TABLE NO. 33

(From Mayer and Gorham)

Plant species	Ash % dry weight	Mn.mg. per 100gm dry weight	Fe.mg. per 100gm. dry weight	Soil	
				pH	Loss on ignition. % dry Wt.
Potamogeton perfoliatus	17.0	48	55	6.80	21
Potamogeton crispus	15.5	185	22	6.80	21
Potamogeton natans	9.4	70	33	6.54	25
Potamogeton alpinus	15.3	288	303	6.52	28

It is evident from the above that the annual requirements for an annual crop of the above higher plants in the Ajwa reservoir will be considerably high, though they have not been actually estimated. For purposes of comparision, in Lake Mendota in Wisconsin, U.S.A., where the dominant plant is Vallisneria as in our reservoir, the annual crop of this plant alone requires a provision of 185, 300 kg of mineral matter, and that the annual Potamogeton crop requires some 127,000 kg. (Welch 1935, p. 281). So, the aquatic vegetation in our reservoir would have taken away almost all the inorganic nutrient substances of biological significance leaving practically little or next to nothing for the requirements of phytoplankton. Under these circumstances one cannot expect the growth and development of phytoplankton in the Ajwa reservoir. This finding is in confirmity with the observations made by others. Whipple (1927) has stated that lakes and reservoirs which are free from the larger aquatic vegetation are more productive of plankton than are those rich in such growth. Moyle (1949) found an inverse correlation between plankton productivity and the presence of larger aquatic plants in reservoirs. Matheson (1952, p. 789) found little plankton in Minnesota lakes where aquatic weeds grew to a depth of 25 ft. While in lakes where heavy water blooms are seen to take place, few weeds are found to grow beyond 4 ft; and ~~xxx~~ so the development of plankton is believed to be limited by the robust growth of the rooted plants." It is also quite possible that higher plants may produce substances that inhibit plankton (Langhans in Schreiter 1928)- a view which receives some support from the studies of Hasler and Jones (1949) " (Hutchinson 1957, p. 901).

iii) THE PHYTO-PLANKTON

A List of the algae recorded in this reservoir:

CHLOROPHYTA

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

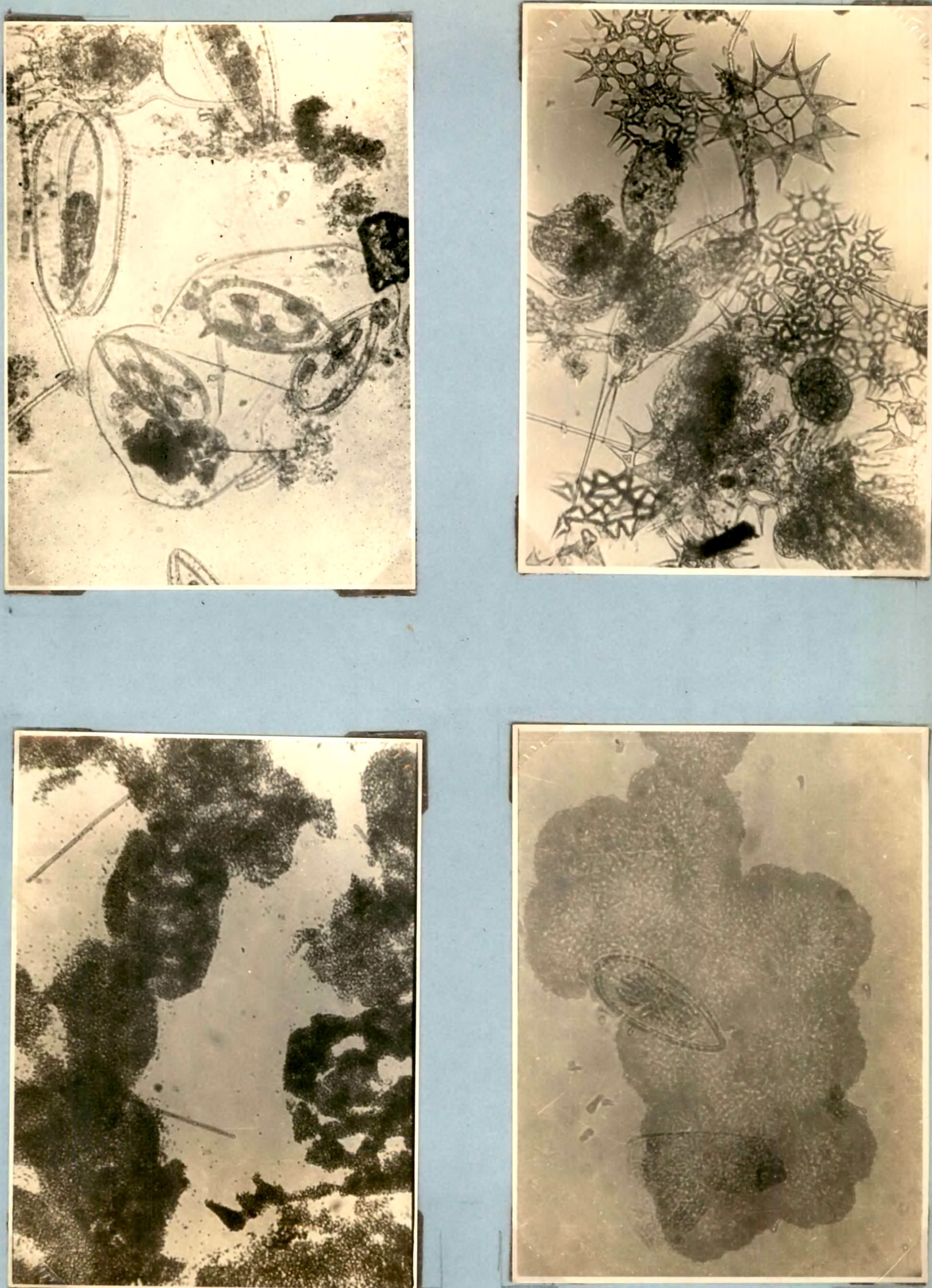


Fig. 16. Pediastrum, Botryococcus, Microcystis and Surirella in the reservoir.

EUGLENOPHYTA

5. Trachelomonas Sp.

CHRYSOPHYTA

6. Botryococcus braunii

BACILLARIOPHYCEAE

7. Achnanthes exilis (Kuts.)

8. Achnanthes minutissima (Kutz.)

9. Amphora beneta (Kuts.) Huzt.

10. Cocconeis placentula (Ehr) var. lineata

11. Cymbella affinis (Kutz.)

12. Cymbella microcephala (Grun.)

13. Cymbella tumida (Breb.) V.H.

14. Diploneis (Cf. D. Smithii) Breb.

15. Epithemia sorex (Kutz.)

16. Epithemia argus (Kutz.)

17. Fragillaria crotenensis Kitt.

18. Gomphonema gracile var auritum (A.Br.) V.H.

19. Gomphonema gracile var dichotomum (W.Sm.) V.H.

20. Gomphonema sub-clavatum Grun.

21. Mastigloia smithii v. amphicephala Grun.

22. Melosira granulata var angustissima O. Mull.

23. Navicula cryptocephala Kutz.

24. Nitzschia (Cf. N. acicularis W. Sm.)

25. Nitzschia Kutzingiana Hilse.

26. Pleurosigma delicatulum W.Sm.

27. Rhopalodia gibba (Ehr) O. Mull

28. Surirella tenera var. nervosa A.S.

29. Synedra ulna (Nitz) Ehr.

30. Synedra acus (Kutz.)

31. Synedra acus var. radians (Hust.)

32. Anabaena Sp.

33. Anacystis cyanea (Kutz.) Dr. & Daily.

34. Cylindrospermum Sp.

35. Microcoleus chthonoplasters (Mert) Zanard.

36. Oscillatoria tenuis Ag.

PERCENTAGE COMPOSITION OF THE DIFFERENT ALGAL GROUPS

TABLE NO. 34

S.No.	Name of the Algal group	No. of species in each group	% of the Total
1.	Chlorophyta	4	11.1
2.	Euglenophyta	1	2.8
3.	Chrysophyta	26	72.2
4.	Cyanophyta	5	14.0
	Total	36	100.1

From the above statement it is seen that Diatoms constituted the largest single group claiming 72.2% of the organisms. Next in order come blue-greens claiming 14.0 %

of the total number of organisms. Next come the Chlorophyta group with 11.1 % of the total and lastly Euglinophyta with 2.8% only.

Quantitative grouping of the organisms.

Although there were 36 species of phytoplankton, almost all of them were found as rare , very rare or stray. The only organism which was not only constant but also attained maximum (ccc) abundance at one time or other during the period of investigation was Pediastrum simplex, Meyen. But Botryococcus Braunii was also a constant organism.

Those organisms which were very common (cc) or Common (c) at one time or other during the period of investigation were:

Cosmarium depressum Nag.
Botryococcus Braunii ; and
Surirella tenera var. nervosa A.S.

The rest of the organisms numbering 33 were found as rare, very rare or stray.

Periodicity of the most dominant species.

(Table No. XVI Appendix)

The only organism which was most dominant was Pediastrum simplex Meyen; and it was found in abundance(ccc)

EXPLANATION TO TEXT FIGURES

Fig. I. *Anuraeopsis coelata De Beauchanp.*

a) Dorsal, most common form. b) Same form ventral.
c) Same form lateral. d) Form with one-piece dorsal kells.

Fig. 2. *Anuraeopsis fissa* (Gosse)

a) Ventral b) Lateral c) Cross-section.

Fig. 3. *Ascomorpha saltans n. var. indica.*

(a) and (b) Contracted animals, lateral n and dorsal with three balls of excreta.
(c) Cross-section (d) "Kauer" dorsal
(e) Lateral, "Sr = Supra rami" (spotted).

Fig. 4. *Brachionus bidentata Anderson*

Form A: (a) Lateral (b) Ventral
(c) Form B: nov. f. adorna. (d) Trophi

Fig. 5. *Brachionus candatus Barrois & Daday*

Figures A to E show several forms drawn to one scale. The arrangements in B correspond exactly to that of *B. angularis* u="Uncus", m= "Manubriu". Form F= B.caudatus var. aculeatus (Hauer).

Fig. 6. *Brachionus forficula Wierzejski*

a) Big form, ventral b) Another specimen dorsal
c) and (d): Small form, dorsal and ventral
e) Another specimen, forsal.
All figures are drawn to the same scale.

Fig. 7. *Collotheca mira* Husson

a) Animal completely withdrawn into its shell.
b) Animal with extending cilia.

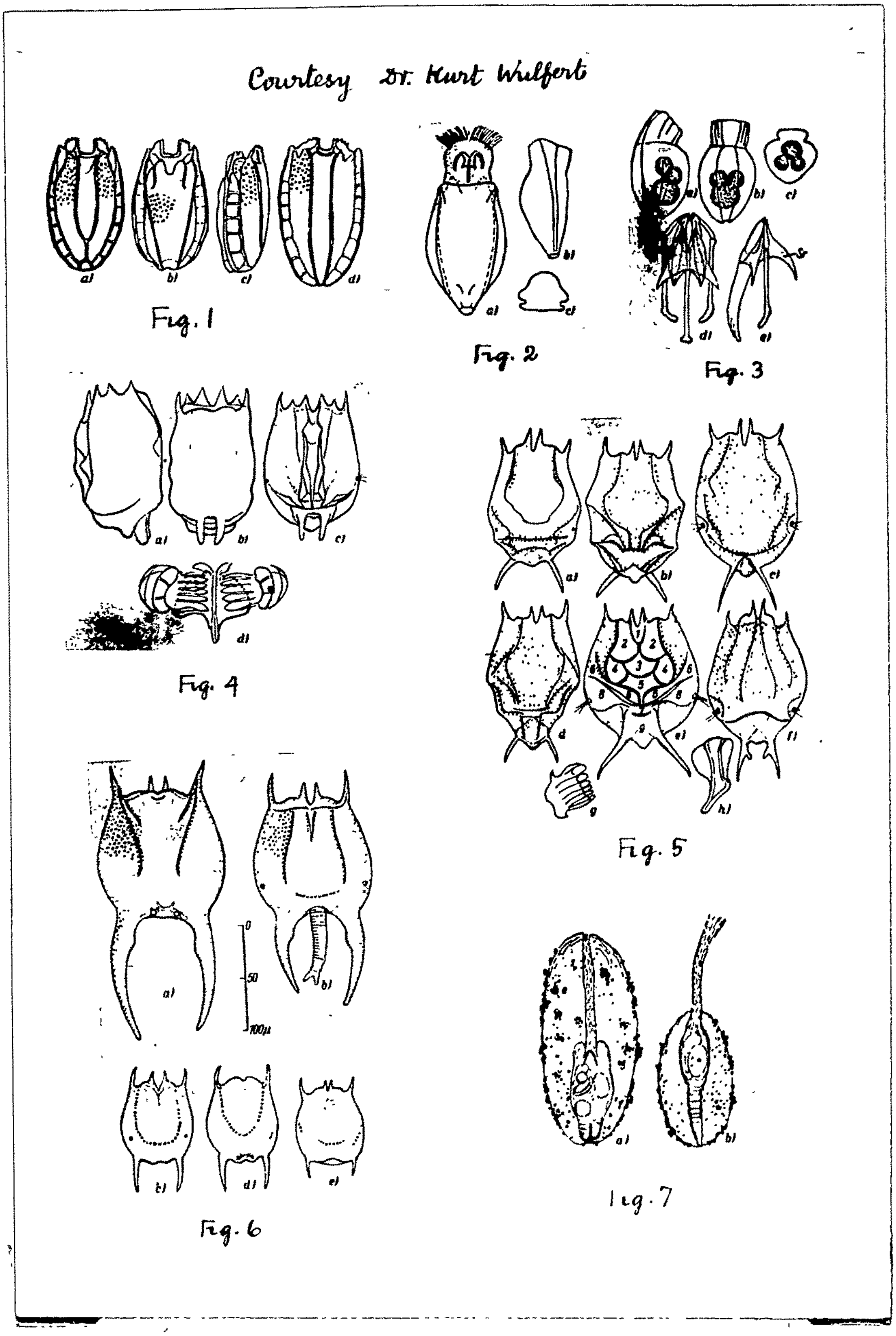


Fig. 17.a. Rotifer fauna in the reservoir

only on one occasion, i.e. on 24th July 1964. On 25th September 1964, it was very common (cc) and on June, July 1963 and April 1964, it was common and on the other dates was either rare (r), very rare (rr), or stray (rrrr).

(iv) THE ZOO-PLANKTON

A List of Zoo-plankton organisms recorded in the reservoir is given below:

PROTOZOA

1. Arcella
2. Difflugia hydrostatica
3. Centropyxis
4. Lecquereusia
5. Vorticella

ROTIFERA

6. Anuracopsis coclata
7. Anuracopsis fissa
8. Ascomorpha saltans indica
9. Brachionus angularis
10. Brachionus caudatus
11. Brachionus diversicornis
12. Brachionus falcatus
13. Brachionus forficula
14. Cephalodella gibba
15. Cephalodella megalocephala

Fig. 8. Colurella: Species 1. C. ovalis n. sp.

(a) dorsal (b) lateral

Species 2. C. oxycauda carlin.
Species 3. C. sulcata stenross.
Species 4. C. uncinata (O.F.Muller).

(a) lateral (b) ventral.

Fig. 9. Dicranophorus epicharis Harr. & Myers.

(a) contracted animal (b) toes (c) "kauer" ventral
(d) fulcrum lateral (e) "Manubrium" (f) Uncus.
(g) unci seen from the front
(h) Rami lateral with uncus(V) and Epipharnyx (E).
(i) (K) separate parts of ramus.

Fig. 10. Encentrum longipes Wulfert nov. nom.

(a) contracted animal with permanent ovum
(b) Kauer, (c) the same lateral, (d) Uncus
(e) Ramus-end.

Fig. 11. Filinia or Tetramastix sp. Different views.

(f) Kauev.

Fig. 12. Keratella valga f. tropica Apstein. Different

(a) to (c) Regular, (d) Broad (e) Form with irregular ornaments. All drawn to same scale.

Fig. 12 (a) - forma tropica from Germany (Westphalia) Court. of " W. Koste".

Fig. 13. Lecane arcuata Bryce.

(a) Dorsal (b) Ventral

Fig. 14. Lecane arcula Harring

Fig. 15. Lecane bulla (Gosse).

(a) Var. styrax. H & M.
(b) Big size with long toe
(c) kind of fold pattern

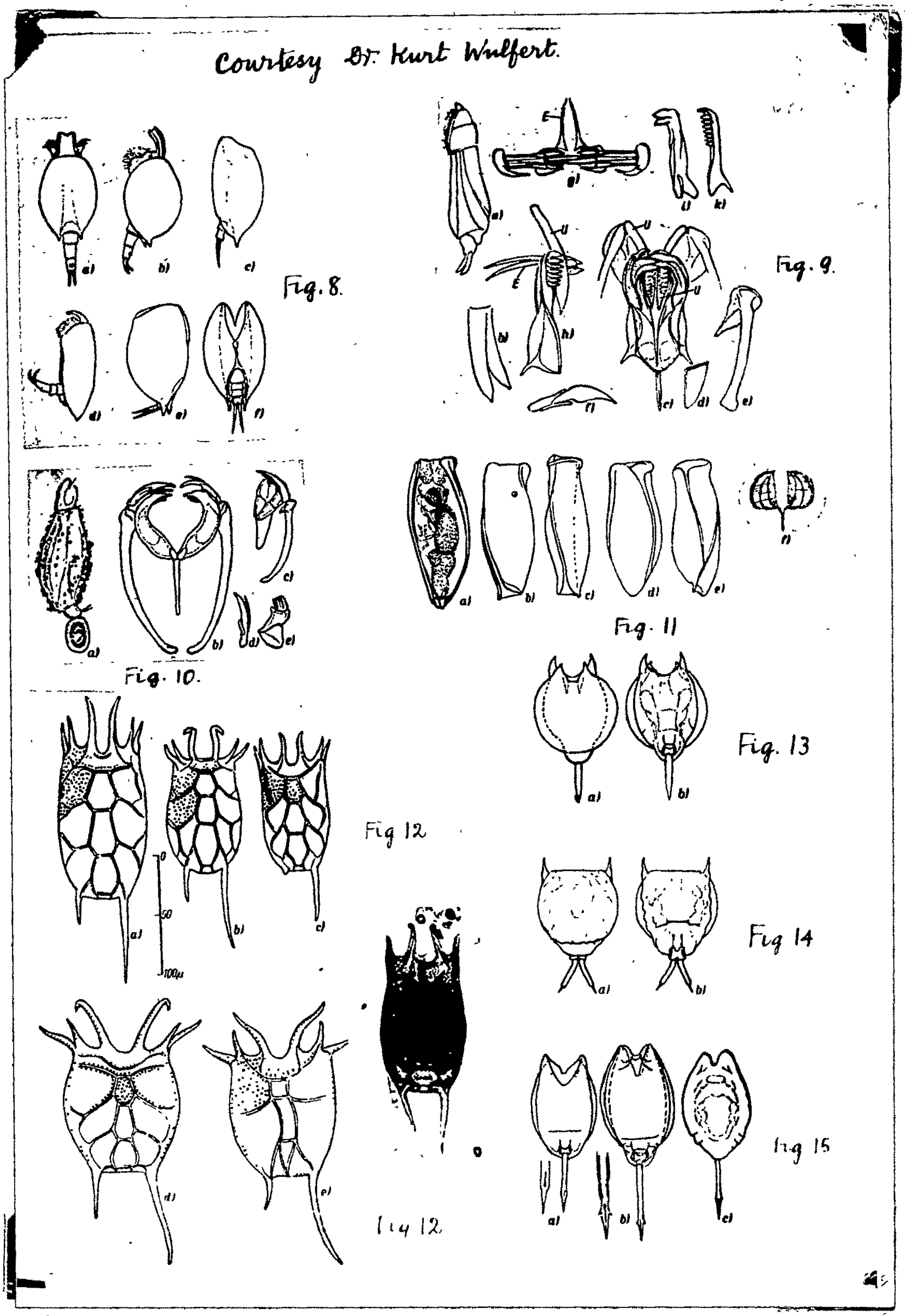


Fig. 17.b. Retifera fauna in the reservoir.

ROTIFERA (Contd.)

16. Colurella oxycauda
17. Collotheca
18. Dicranophorus epicharis
19. Euchlanis dilatata
20. Filinia terminalis
21. Keratella valga tropica
22. Lecane arcuata
23. Lecane arcula
24. Lecane bulla
25. Lecane closterocerca
26. Lecane galeata
27. Lecane hamata
28. Lecane harringi
29. Lecane hornimanni
30. Lecane luna
31. Lecane lunaris
32. Lecane papuana
33. Lecane quadridentata
34. Lecane thienemanni
35. Lecane unguitata
36, Lecane ungulata
37. Mytilina ventralis
38. Notommata
39. Pidalia

Fig. 16: Lecane crepida Harring
(a) & (b) Narrow form, (c) to (e) wide form

Fig. 17: Lecane curvicormis nitida Haver.
(a) dorsal (b) ventral

Fig. 18: Lecane elachis (H & H)
I from B.68 sample
II from C.10 sample (a) dorsal (b) ventral.

Fig. 19: Lecane galeata (BRYCE)
(a) Ventral view (b) Lateral view (c) from back view

Fig. 20: Lecane hamata (Stokes) (a) A specimen with swollen toes from sample No. B.69.
(b) & (c) Animals from sample No.A 20., all ventral views

Fig. 21: Lecane harringi Arlstrom
(a) Ventral view (b) toe according to A Haver 1963; (c) lateral view (d) view from back.

Fig. 22: Lecane hastata (Murray).
(a) dorsal (b) ventral (c) toe

Fig. 23: Lecane hornemanni (Ehrbg).
(a) dorsal (b) ventral (c) specimen from Bangweulu Lake, Africa, with rare pattern of carapace.

Fig. 24: Lecane lunaris (Ehrbg.)

Fig. 25: Lecane nana (Murray)
(a) ventral side (b) foot and toes.

Fig. 26: Lecane neali nov. spec.
(a) & (b) Narrow form (c) foot and toes, (d) & (e) broad form (f) lateral view.

Fig. 27. Lecane nodosa Haver.
(a) dorsal (b) ventral (c) vlateral (d) toe from side.

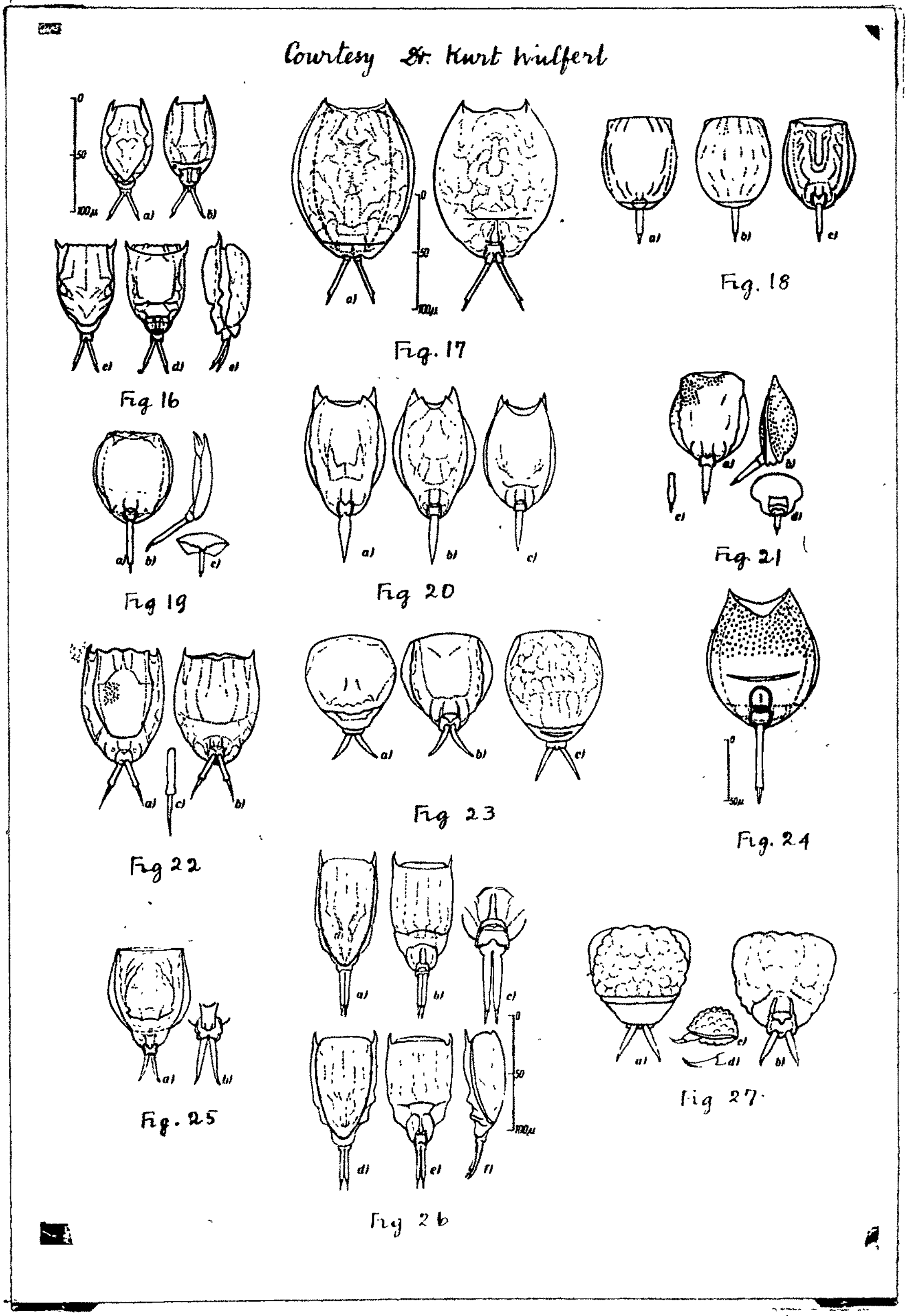


Fig. 17.c. Rotifer fuana in the reservoir

ROTIFERA (Contd.)

40. Polyarthra

41. Pompholyx complanata

42. Ptygura furcata

43. Ptygura sp.

44. Testuninella patina

45. Tetramastix opoliensis.

46. Trichocera mycersi

47. Trichocera ruttneri

48. Trichocera similis

49. Bdelloidea

COPEPODA

50. Allodiaptomus Raoi Kiefer

51. Allodiaptomus cinctus (Gurney)

52. Mesocyclops leuckart deccanensis Lindberg.

53. Nauplius larvae

54. Diaptomus

55. Heliodiaptomus cinctus Gur.

56. Harpatctictade

CLADOCERA

57. Alona affinis

58. Alona Cf. Archeri

59. Alona Baird

Fig. 28. Lecane papuana (Murray). (a) to (c) different forms, all ventral view. (d) foot of the fourth specimen.

Fig. 29. Lecane pawlowskii nov. spec.(a) dorsal view, (b) ventral view, (c) lateral view.

Fig. 30. Lecane perplexa (Ahlstrom). (a) dorsal, (b) ventral with turned-in toe. (c) side view

Fig. 31. Lecane ploenensis (Voigt). (a) dorsal, (b)ventral.

Fig. 32. Lecane schraederi nov. spec. (a) dorsal, (b) ventral.

Fig. 33. Lecane sinuata Haver.
Ventral.

Fig. 34. Lecane sola Haver. (a) dorsal side, (b) other form of toe.

Fig. 35. Lecane stenroosi (Meiszner).
(a) elliptical form from the collection B.25. with normal toe; (b) the same enlarged; (c) specimen from the lake Bangwenla with toe of the same size. n.f. lineata.

Fig. 36. Lecane sympoda Haver.
(a) and (b) specimen from B.62 with toes grown together at basis only; (c) fully grown with toes; (d) and (e) specimen from the lake Bangwenla; (f) lateral.

Fig. 37. Lecane thienemanni Haver.
(a) dorsal; (b) another specimen, ventral; (c) front rim of a third specimen with dorsal. Eckdornen. (d) back end with foot and toe.

Fig. 38. Lecane unquitata Fadew.
(a) to (b) Indian specimens; (d) and (e) found in Nigeria; All views except (b) dorsal.

Fig. 39. Lecane unqulatum (Gosse).
(a) ventral view; (b) and (c) toes without Nebendornen; (d) second joint with Kittdrusen according to Cohen-Kadar.

Fig. 40. Lepadella kostei nov. spec.
(a) dorsal; (b) ventral.

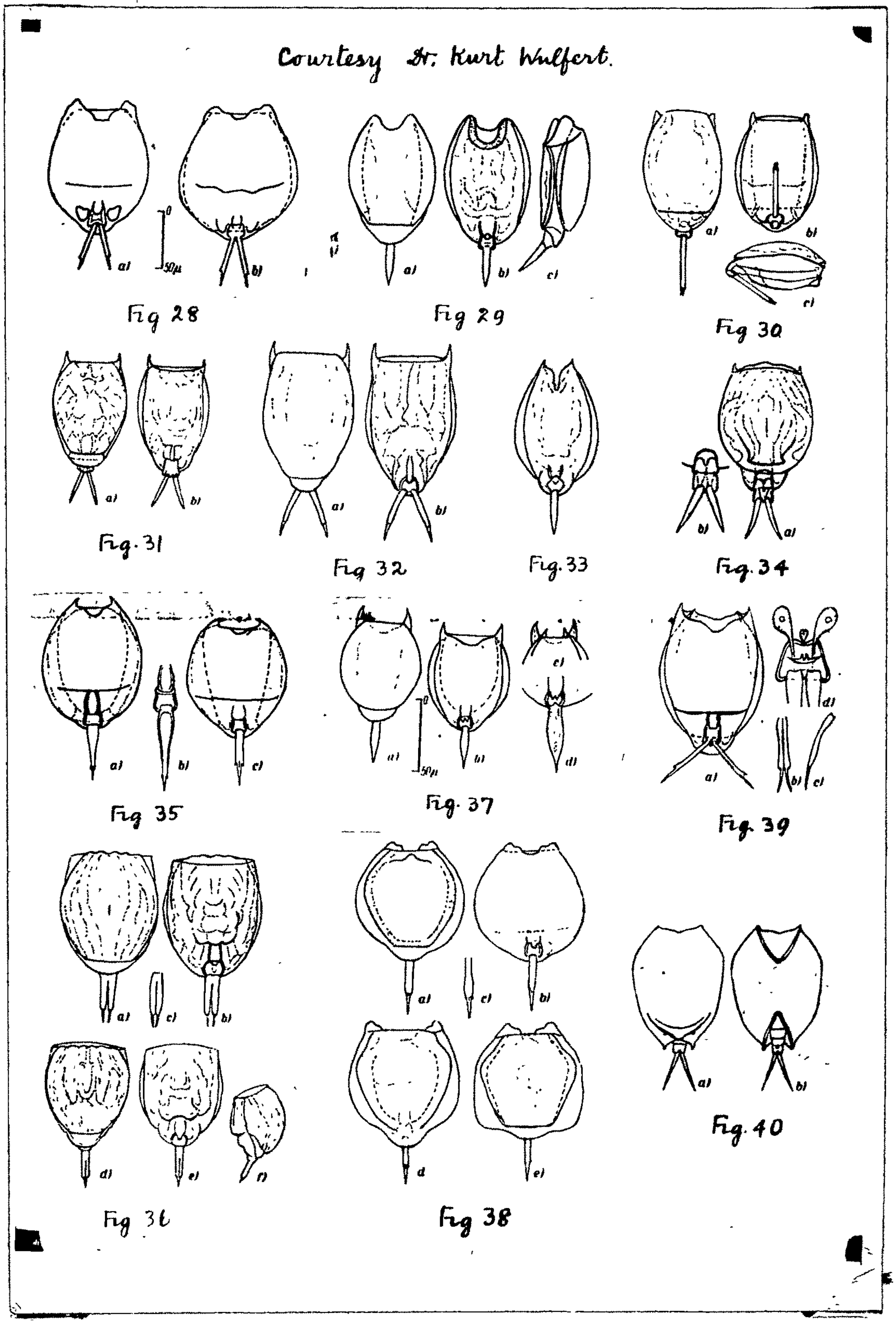


Fig. 17.d. Rotifer fauna in the reservoir.

CLADOCERA (Contd.)

60. Alona Cambouei

61. Alona Chydorus

62. Alona Intermedia

63. Alona macrothrix

64. Alona verrucosa

65. Alonella Karua

66. Bosminopsis Cf Pernodi

67. Cerodaphnia riguadi Rich.

68. Chydorus Barroisi

69. Daphnia lumholtzi.

70. Diaphanosoma paucispinosum Brem.

71. Dunhe vedia

72. Macrothrix Baird

73. Moina dubia Rich.

74. Sida Sp.

Percentage composition of the different Groups.

TABLE NO. 35

S.No.	Names of the Genera	No. of organisms	% of the Total
1.	Protozoa	5	6.6
2.	Rotifera	44	58.7
3.	Copepoda	7	9.3
4.	Cladocera	18	24.0
5.	Oligochaetes	-	-
6.	Nematoda	-	-
7.	Porifera	1	1.3
	Total	75	99.9

Fig. 41. Notommata glyphura wulfert.
(a) contracted specimen; (b) Kauer dorsal; (c) same lateral; (d) and (e) Manubria; (f) and (g) unci. DR = dorsal part of ramus (Supraramus); VR = ventral part of ramus.

Fig. 42. Notommata pseudo-cerberus, De Beauchamp.
(a) ventral; (b) lateral; (c) Uncus; (d) only Fulcrum form.

Fig. 43. Pompholyx complanata Gosse.
(a) Living specimen; (b) contracted with side rims turned over; (c) lateral; (d) differently contracted; (e) and (f) several cross sections; (g) seen from front.

Fig. 44. Proales indira nov. spec.
(a) fixed specimen; (b) Kaner; (c) Uncus; (d) Manubrium.

Fig. 45. Ptygura furcillata (Kellicott).
(a) and (b) fixed lateral and dorsal; (c) radernd observed by Mr. Rumford U.S.A.;(d) specimen from Singapure; (e) specimen after drawing by H.G.S. Wright; (f) to (h) hooks and prongs; (a) and (b) originals; (c) to (g) according to Wright; (h) according to Jennings.

Fig. 46. Trichocerca myersi (Haver). (a,b):
(a) and (b) from right and left; (c) Kaner

Trichocerca nitida Harrin (d, e):

Trichocerca ruttneri Donner (f,g,h):
(a) from right; (b) dorsal; (c) Kaner.

Trichocerca similis (Wierzejski).
(a) half right; (b) left lateral; (c) and (d) views of Kauner.

Fig. 47. Trichotria tetractis (Ehrbg).
(a) Form from sample B.26; (b) and (c) form B from sample C 10; (d) and (e) from c from sample C.15; all views excepting (c) and (e) dorsal.

Fig. 48. Bdelloides. Rotifer with long neck part, indefinite.

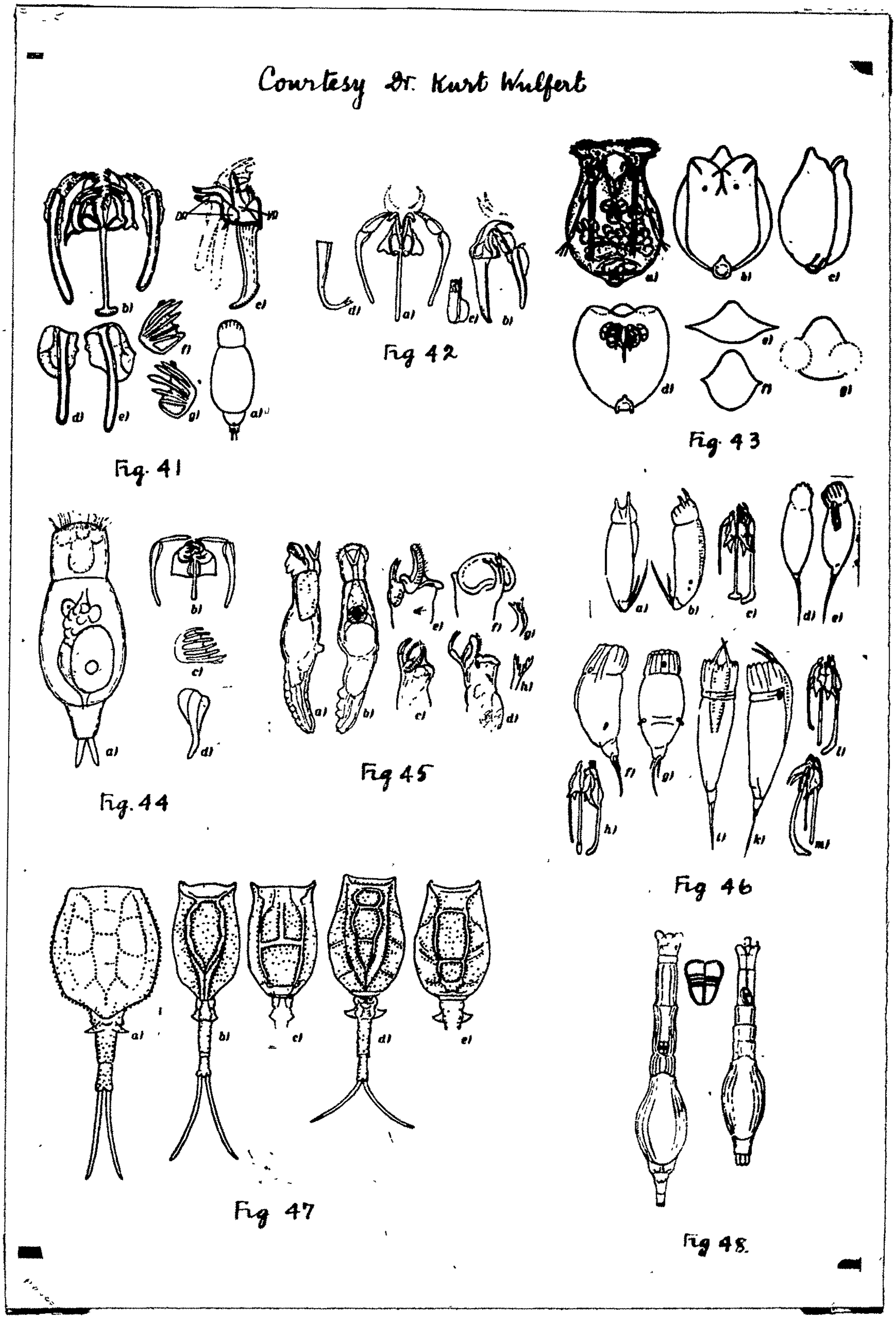


Fig. 17a. Rotifer fauna in the reservoir.

It will be seen from the above that the genera "Rotifera" forms the largest single group constituting about 60% of the organisms recorded for this reservoir. Next in order is Cladocera claiming 24.% of the total number of organisms; and next is Copepoda with 9.3% and the last is Protozoa with 6.6; and Porifera 1.3%.

General grouping of the organisms according to their quantity:

The Zoo-plankton organisms recorded for the reservoir have been divided into three groups, Group I representing those forms which have shown the maximum (ccc) recorded abundance at one time; Group II. representing those organisms which were very common (cc) or Common (c) at one time or other and group III. representing those organisms which were found rare (r), very rare (rr) or stray (rrr) at one time or other during the period of investigation.

GROUP- I. ROTIFERA:

1. Anuracopsis coclata
2. Keratella valga tropica
3. Tetra mastix opoliensis
4. Brachionus falcatus

COPEPODA

5. Nauplius larvae
6. Allodiaptomus Raoi Kiefer
7. Mesocyclops leuckart deccanensis (Lindberg)

CLADOCERA

8. Daphnia Lumholtzi

GROUP II ROTIFERA

1. Anuracopsis fissa
2. Ascomorpha saltans indica
3. Brachionus angularis
4. Brachionus diversicornis
5. Brachionus falcatus
6. Brachionus forficula
7. Dicranophorus epicharis
8. Lecane bulla
9. Pidalia
10. Pompholhyx complanata
11. Ptygura furacata
12. Trichocera ruttneri
13. Trichocera similis

COPEPODA

1. Allodiaptomus Raoi Kiefer.
2. Mesocyclops leukart deccanensis (Lindberg)
3. Nauplius larvae
4. Diaptomus

CLADOCERA

1. Daphnia Lumholtzi
2. Moina dubia Rich.
3. Sida sp.

GROUP III: are those organisms which are not included in the above two groups. Their number is 52.

Constant forms: The organisms which were conspicuous by their presence in most of the collections were Keratella valga tropica; Brachionus falcatus; Mesocyclops leuckart deccanensis (Lindberg); Daphnia Lumholtzi.

PERIODICITY OF THE MOST DOMINANT SPECIES:

(Table No. XVI Appendix)

The most dominant species of zoo-plankton organisms were four Rotifers; three Copepods and one Cladoceran. The periodicity of each of these organisms is described below:

1. Anuracopsis Coclata: This rotifer was most dominant (ccc) only in April '64; very common (cc) in October, November and December 1963, Common (c) in April, May 1963 and in July '64; and on other occasions it was either rare (r), very rare (rr) or stray (rrr).

2. Brachionus falcatus: was found to be most dominant on two occasions i.e. in October 1963 and 1964; very common in September and November 1963 and April 1964; common in August '63, March, June, September and November 1964; and in other months it was either rare, very rare or stray.

3. Keratella valga tropica: was found to be most dominant in August, September, October and November 1963;

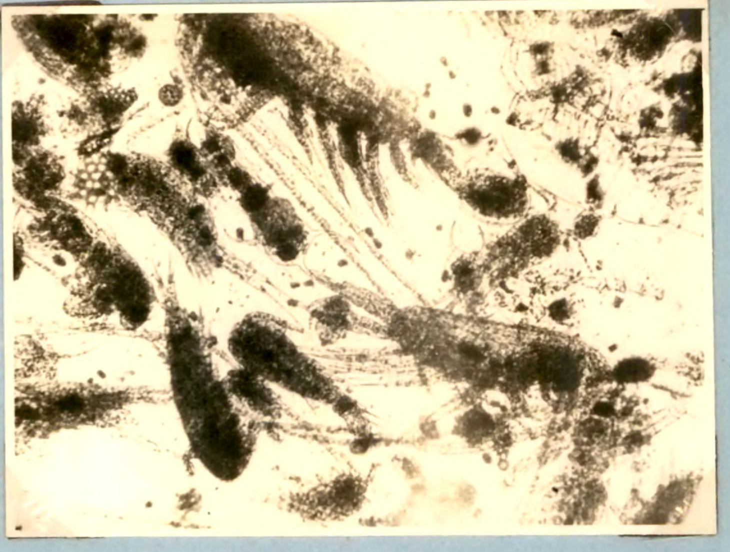
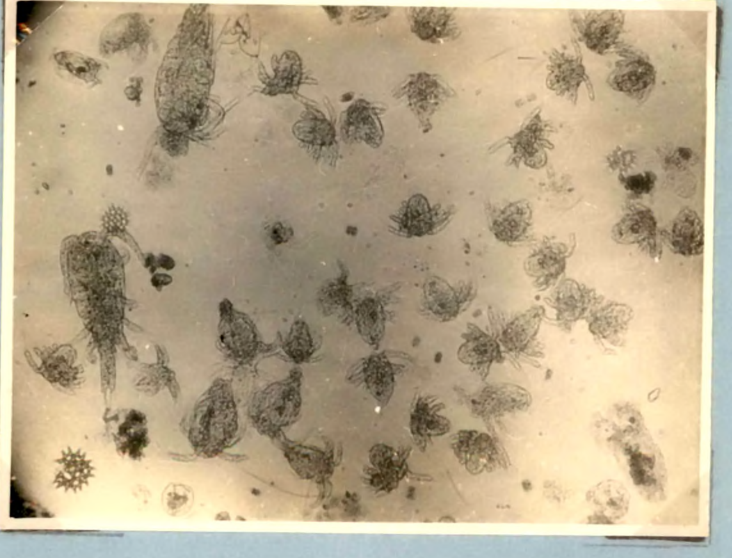


Fig. 18. Crustaceans and Nauplius larvae in the reservoir.



April, June, July and August 1964; very common in June, July and December 1963; March and September 1964; and in the other months it was either rare, very rare or stray.

4. Tetra-mastix opoliensis: was most dominant only once in July '63; very common in August '63 and July '64; and on other occasions it was either rare, very rare, stray or absent.

5. Nauplius larvae: were found in abundance (ccc) in September '63, July '64 and September '64; common in June and August and rare, very rare or stray in other months.

6. Allodiaptomus Raoi Kiefer: was most dominant in July '63, June '64 and July'64; very common in June '63 and August '63 and common in April, August and September'64. On other occasions it was found to be rare, very rare or stray.

7. Mesocyclops leuckart deccanensis (Lindberg): This organism was found to be most dominant in July '63, July and August '64; very common in June, August, September and December 1963 and September 1964 and common in April 1964 and in other months it was found to be either rare, very rare or stray.

8. Daphnia Lumholtzi: This cladoceran was found to be most dominant in July and August 1963, only very common in June, September, October, November 1963 and August, September, October 1964; and common in December 1963; and April, June,

and July 1964. In other months it was either rare, very rare, stray or absent.

QUANTITATIVE ESTIMATION OF PLANKTON IN THE SURFACE AND BOTTOM LAYERS OF THE AJWA RESERVOIR:

(Table No. XVII, Appendix)

This was done on four occasions i.e. on 24th January, 28th April, 24th October and 18th December 1964 and the results of the quantitative estimations are shown in Table No. XVII. Fifty litres of water were strained through the plankton net on each occasion.

A study of the table shows that the zoo-planktonts were found in far larger numbers at the bottom than at the surface; and that the quantity was nearly two to three times that recorded for the surface. So, it would appear that the raw water reaching the Nimeta Water Works contains far more zoo-plankton organisms as it is from the bottom that raw water is being drawn for purification at Nimeta from the Ajwa reservoir.

SUMMARY OF BIOLOGICAL CONDITIONS

1. The Ajwa reservoir is almost completely filled up with aquatic weeds, the dominant species being *Vallisneria spiralis*, *Naias flexilis*, *Naias muricata*, *Hydrilla verticellata*, and *Potamageton indicus*.

2. The chemical composition of the dominant submerged aquatics would seem to indicate that they have consumed all the inorganic nutrients of biological significance leaving practically little for the basic needs of the phyto-plankton, whose content is, therefore, comparatively poor.

3. The total number of planktonic organisms recorded in the reservoir is 110 of which nearly 33% alone are phytoplankton and 67% zoo-plankton. Of the phytoplankton organisms 62.5% constitute diatoms. Taking the zoo-plankton organisms alone into consi= deration, nearly 60% are rotifers, 24.4% Cladocerans and 9.4% Copepods.

4. The bottom layers are found to contain comparatively more zoo-plankton organisms than the surface layers, especially in the afternoon collections.

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(d) BACTERIOLOGICAL CONDITIONS:

(Table No.XVIII Appendix)

The surface water was collected both in the morning and afternoon for this purpose and the results are shown in Table No. XVIII.

It will be seen from a study of the results that the surface water was on the whole of poor quality. Highest number of coliforms per 100 ml was recorded in July '63 and in September '64. On all other occasions the number of coliforms was few.

E. Coli (Type I) was found on a few occasions i.e. in July, August, September, October and November in 1963, and in August, September and November 1964 after rains.

Faecal strepotococci were also found in August'63 and in August and September 1964 after rains.

S U M M A R Y

The bacteriological condition of the Ajwa reservoir is far from satisfactory.

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DISCUSSION OF RESULTS

From the foregoing studies of the biochemical and biological conditions in the Ajwa reservoir the following important characteristics of the reservoir emerge and they require detailed consideration. They are: (i) the high transparency of the surface water as against the comparatively more turbid bottom water; (ii) absence of thermal-density-viscosity stratification for a prolonged period; (iii) diurnal thermal stratification and nocturnal cooling; (iv) the existence of a β -orthograde type of vertical distribution of oxygen; (v) poor fertility of the aquatic soil; and the resultant poor development of phytoplankton; (vi) abundance of macrophytic vegetation and zoo-plankton organisms especially more being found in the bottom layers; and (vii) the water always being drawn from the bottom layers for purification at the Nimeta Water Works.

Temperature and biological production:

The importance of thermal conditions in a reservoir lies in their direct effect upon the biological productivity of the water by influencing the intensity of the three vital processes: assimilation due to photosynthesis, regeneration due to processes of decomposition and transport of nutrient substances from the bottom to the top during circulation. The higher range of temperature (17°- 32°C) from the surface to the bottom throughout the year existing in the Ajwa reservoir is bound to accelerate the growth rate of the organisms in it. This is evident from the abundant growth of the higher aquatics and of the zoo-plankton organisms and not the phytoplankton, which require an explanation.

More important perhaps is the indirect effect of the thermal regime upon the turnover of water; and therefore, upon the supply of nutrient substances of biological significance from the hypolimnion to the phytoplankton in the well illuminated layers of the epilimnion. In the Ajwa reservoir there is neither seasonal stratification nor even the formation of the three well defined strata of thermal stratification as in a classical temperate lake, and there,-fore there is no stagnation or isolation of the hypolimnion absolutely for any great length of time. But there is only diurnal temporary stratification of very short duration of a few hours every day.

Interest will therefore centre round the diurnal thermal stratification and whether it obstructs circulation in the Ajwa reservoir. This may be viewed from the two standpoints: the qualitative aspect of how completely the stratification may seal off the hypolimnion from the epilimnion and the quantitative aspect of the duration of this isolation. Several factors such as the stability of the thermal stratification (due to the effect of temperature upon the density), the form and extent of the reservoir surface and the amounts of rain fall and evaporation will also influence the degree of isolation following upon given initial temperature gradient. But in the Ajwa reservoir the temperature differences between the upper and bottom layers of water are comparatively little throughout the year excepting on a few occasions in the afternoon when the differences are greater due to the prevalance of bright sunshine and absence of wind. It is only on these latter occasions that the bottom layers are isolated for a few hours only, for very soon nocturnal cooling brings about homo-thermal conditions before dawn every day even though the stability of thermal stratification on these few occasions may be comparatively greater. So, the duration of isolation of the bottom layers is only for a few hours on a few occasions depending upon the climatic conditions. The climatic conditions and the morphometric features of the reservoir are helpful in preventing the development of thermal-density-viscosity stratification for a season or for any greater length of time.

Reasons for the Poor Development of the Phyto-plankton in the Ajwa reservoir.

The absence of a stable thermal stratification coupled with the presence of a β -orthograde type of vertical oxygen distribution seems to be mainly responsible for the absence of nutrient substances of biological importance in the

Ajwa reservoir. How this is brought about is explained below.

Increased bottom temperature in a reservoir may be expected to increase the ions involved in the plant nutrition in the bottom mud or sediments due to processes of increased bacterial activity or decomposition. But the nutrient substances formed in the bottom mud can be transported to the water column above by eddy diffusion only under certain circumstances as explained by Mortimer (1942). He has shown that redox conditions in the mud controls the distribution of dissolved nutrient substances in natural lake systems. He has also demonstrated the controlling influence of the concentration of redox potential and iron and of other dissolved substances in lakes. Besides, Muller (1938), Einsele and Vetter (1938), Pearsall and Mortimer (1939) have shown that the exhaustion of dissolved oxygen in the hypolimnion during thermal stratification is attended by reduction processes and by considerable increases in the concentrations of dissolved substances such as silica and phosphate which could not be regarded as primary products of reduction.

Mortimer (1942 p, 197-198) states: " Reduction of the mud surface and the associated increase in supply of solutes to the water may be expected to augment plankton production. The occurrence or non-occurrence of this event is determined by the balance between (1) the reducing power of the mud and (2) amount of oxygen supplied to the mud surface. (2) depends on (a) the volume of the hypolimnion and (b) the degree of turbulence there. As (a) and (b) are roughly proportional (Fig.36) it is suggested that in all but extremely oligotrophic lakes morphometric (including climatic) as well as edaphic factors determine the level of productivity".

It is now possible to explain why there is very poor development of phytoplankton in the Ajwa reservoir. It is evident from the above that seasonal changes in the bottom sediments or mud of the Ajwa reservoir are correlated with and largely control the seasonal changes in the water column above. The absorbent complex in the bottom mud surface, according to Mortimer (1941, p. 325) is possibly a ferri-silico-complex, ferric hydroxide, and ferric phosphate. If this surface oxidised layer of the bottom mud is not reduced to a ferrous state at any time during the year, then there is absence of large variations in the concentrations of dissolved substances in the water. The relatively high concentration of dissolved oxygen which was maintained at the mud surface throughout the year in the Ajwa was perhaps responsible for the failure of the lower layers of bottom sediments to reduce the ferric complexes in the mud surface, and to help to transfer the soluble substances from the bottom sediments by eddy diffusion to the water column above. The surface oxidised layer of bottom sedimants acted as a seal and thus prevented the flow of soluble inorganic nutrient substances of biological significance to the upper layers of water. Consequently phytoplankton organisms which depend upon these nutrient substances could not proliferate and become dominant at any time in the Ajwa reservoir.

Lⱷmnological role of the higher submerged aquatics in the reservoir:

It is the general belief that the submerged aquatic plants in a lake or reservoir derive their nourishment from the surrounding water and that the substratum provides only a medium for mechanical support of the plants (CF. Welch 1935). But the distribution of rooted aquatic vegetation in nature has been found to be related to the nature of the substratum according to Pearsall (1920, 1929). He found from his studies of the major English lakes that the distribution of aquatic plants is correlated with the variations in the distribution of the quality and quantity of silt which are of two kinds : coarser and finer. Coarser silts are generally confined to shore regions and the finer to comparatively deeper portions. According to him, finer silts are effective absorbents of nutrients and

TABLE NO. 36

1964 Date	Results expressed in mg per litre - surface water									
	Na	K	Na+ K	Ca	$\frac{Na + K}{Ca}$	SiO_2	CO_3	NO_3	Org. matter	Turbidity
24- 1	52.32	1.50	53.82	9.50	5.7	0.15	30	Nil	1.00	7.0
24- 3	55.80	2.39	58.19	11.50	5.1	0.10	32	"	1.54	9.0
28- 4	56.81	2.39	59.20	13.50	4.4	0.15	36	"	1.80	9.0
11- 6	59.34	2.92	62.26	13.75	4.5	0.10	32	"	-	22.0
24- 7	53.82	2.90	56.72	12.00	4.7	0.15	32	"	1.70	21.0
28- 8	50.59	3.90	54.49	7.20	7.6	0.15	24	"	1.32	45.0
24- 9	45.55	3.90	49.45	6.40	7.7	0.10	32	"	1.04	24.0
24.10	51.97	3.90	55.87	10.00	5.6	0.10	16	"	1.00	16.0
28-11	59.33	1.95	61.28	12.40	5.0	0.15	10	"	1.14	14.0
18-12	61.41	3.12	64.53	12.80	5.0	0.15	24	"	1.28	18.0

therefore, contain more phosphates and nitrates taken away from the water.

He found Isoetes and Nitella primitive group of plants to grow on coarser silts while species of Potamogeton and Naias flexilis which are comparatively highly evolved on finer and richer soils. The above relationship between types of silts and types of vegetation has been established for the major English lakes.

In the Ajwa reservoir the dominant submerged aquatic vegetation consists of Vallisneria spiralis, Potamogetan indicus, Naias flexilis, and Hydrilla verticellata. They are rooted at the bottom and often form large dense areas particularly in summer when the growths attain their maximum. The growth of the hydrophytes especially Vallisneria spiralis and Naias flexilis is found to be enormous covering almost the entire bottom of the reservoir; and they are comparatively highly evolved plants. It would seem, therefore, that the bottom silt or sediments in the Ajwa reservoir must be finer in consistency and richer in nutrients like potash and phosphates taken away from the water.

Again, according to Pearsall (1929) more silt produces more vegetation; and therefore, more organic matter and more of the products of decay. He has also stated that

TABLE NO. 37

Name of the Lake	RESULTS EXPRESSED IN PARTS PER MILLION								
	Type	Potash & Soda	Lime	$\frac{K + Na}{Ca}$	Silica	Carbonate	Nitrate	Organic matter	Relative transparency of water
Wastwater	Rocky	13.1	2.4	5.4	1.4	3.9	-	4.3	9.0
Ennerdale	"	7.3	2.4	3.0	1.4	2.4	-	5.6	8.3
Buttermere	"	15.4	2.8	5.5	1.4	3.2	-	6.5	8.0
Crummock	"	15.2	4.0	3.8	1.4	2.4	-	8.0	8.0
Hawes Water	"	12.3	4.0	3.1	2.8	7.1	Trace	4.3	5.8
Derwent Water	"	7.7	7.5	1.0	2.1	3.1	Trace	2.4	5.5
Bassenthwaite	Silted	8.3	7.9	1.50	2.8	5.7	0.4	6.1	2.2
Coniston	"	11.2	4.8	2.30	2.8	8.5	0.05	7.1	5.4
Ullswater	"	10.6	5.6	1.9	4.3	7.8	1.1	11.4	5.4
Windermere	"	5.4	10.1	0.53	3.3	6.4	1.4	10.8	5.5
Esthwaite	"	10.4	9.5	1.1	3.0	7.6	2.0	13.8	3.1

the English silted lakes have a lower Na + K/Ca ratio, more carbonates, nitrates and silicates in solution (Table No.37). The results of analysis of the Ajwa reservoir water for the above chemical variations are shown in Table No.36, for 1964.

From a study of the Table No.36 it will be seen that the ratio of Na + K/Ca and carbonates are higher, nitrates are absent, silicates and organic matter are very low compared to the English " Silted " lakes, where the ratio of Na + K/Ca is lower, carbonates, nitrates, silicates and organic matter are higher as will be evident from the tabular Statement No. 37, for the English lakes (Pearsall 1929, p. 670).

Dominance of Zoo-plankton organisms in the Ajwa reservoir:

It has already been pointed out that there is a dominance of zoo-plankton organisms and that they constitute nearly double the number of species of phyto-plankton organisms, which is rather unusual. An explanation for this inverse correlation is needed. Harvey et al (1935) have suggested that the grazing effect of the herbivorous zoo-plankton is sufficient to limit the phytoplankton population in time and quantity.

But this explanation seems to be untenable in the case of the Ajwa reservoir for the phytoplankton organisms are not found in greater abundance than the zoo-plankton organisms at any time during the two-year period of investigation. It has already been shown that the absence of nutrient substances of biological significance is mainly responsible for the poor development of phytoplankton organisms. Also zoo-plankton organisms do not require dense phytoplankton growths for successful domination of an environment. Many of them feed on organic debris which will be found in the bottom of the Ajwa reservoir, where there is, apparently, plenty of plant material and the macrophytes also are probably supporting sessile growth of the algae, like the diatoms.

The Character of the Raw Water reaching the Water Works at Nimeta for purification:

The raw water reaching Nimeta Water Works is comparatively more turbid, and alkaline with a fair amount of dissolved oxygen in it. The nutrient substances of biological significance such as ammonia, nitrate, nitrite, and phosphate are alsway absent. Silicates are found in smaller amounts. The dissolved organic matter as determined by the acid permanganate test is comparatively greater.

Zoo-plankton organisms are found in far larger numbers than the phyto-plankton organisms, the dominant group being Rotifers.

CONCLUSION

The author is not aware of the existence of any published data applying the basic principles of hydrobiology to the use of a storage reservoir which serves as a source of water supply and the water works attached to it in India.*

For economic purification of the water from the Ajwa reservoir, it is advisable to tap the uppermost layers of the reservoir water which are comparatively clearer, and also seem to contain much less micro-organisms than the bottom layers from which raw water is now being drawn for purification at the Nimeta Water Works.

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* In this connection it will be interesting to read the announcement made on page 11, No.3, 1965 of "AQUA" that the Seventh International Water Supply Congress to be held at Barcelona in Spain on 3-7,October 1966, has invited Dr. J.W.G.Lund, F.R.S. to present to the Congress the Lecture on "Limnology and its Application to Potable Water Supplies".

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A P P E N D I X

" T A B U L A R   S T A T E M E N T S "

TABLE NO. I

CLIMATOLOGICAL DATA FOR BARODA FOR 1963

Month	Temperature (°C)		Hours of Bright Sunshine (Monthly average)	Rain Fall		Average Humidity at 8.30 a.m.	Wind Velocity	
	Mean Maximum	Mean Minimum		No. of days	Total Fall (mm)	%	Maximum	Minimum
January	31.1	13.6	09.3	1	8.8	69	14	2
February	35.7	15.4	09.5	0	0.0	67	20	1
March	37.3	19.5	09.5	0	0.0	53	30	1
April	39.7	23.5	09.6	0	0.0	58	21	2
May	41.6	26.7	11.2	0	0.0	62	49	6
June	38.0	27.5	09.0	3	84.9	74	52	10
July	33.4	25.8	04.2	10	309.8	86	36	4
August	30.9	25.1	03.0	18	410.7	92	27	3
September	32.6	23.7	06.6	6	148.6	86	14	5
October	35.8	22.1	09.5	3	45.1	73	18	3
November	33.9	19.0	08.6	1	37.2	77	28	2
December	31.2	15.4	08.6	0	0.0	72	-	-
Average	35.1	21.5	08.2	-	-	72.4	-	-

TABLE NO. II

CLIMATOLOGICAL DATA FOR BARODA FOR 1964

Month	Temperature (°C) Mean Maximum	Temperature (°C) Mean Minimum	Hours of Bright Sun shine (monthly average)	Rain Fall No. of days	Rain Fall Total Fall (mm)	Average Humidity at 8.30 a.m. %	Wind Velocity Maximum	Wind Velocity Minimum
January	29.1	10.4	09.8	0	0.0	68	-	-
February	33.7	13.6	09.2	0	0.0	55	7	0
March	39.0	19.3	08.9	0	0.0	57	-	-
April	41.0	23.6	10.1	0	0.0	58	18	3
May	40.6	26.7	10.9	1	1.4	72	34	6
June	38.0	27.1	08.0	5	95.5	77	34	7
July	31.9	25.4	04.6	18	428.1	91	18	3
August	31.3	25.2	03.5	15	163.5	92	18	0
September	33.5	24.6	06.7	7	116.0	88	21	0
October	36.2	21.0	10.2	0	0.0	74	-	-
November	34.4	15.4	09.6	-	0.0	74	-	-
December	32.0	12.6	09.7	-	0.0	74	-	-
Average	35.1	20.4	08.4	-	-	73.3	-	-

III

TABLE NO. III

METEOROLOGICAL CONDITIONS IN THE AJWA RESERVOIR ON THE DAYS OF SAMPLE COLLECTION

1963 Date	Time	1963 Meteorological Conditions	1964 Date	Time	1964 Meteorological Conditions
24- 4	5.30 A.M. 3.30 P.M.	Twilight-Sl.W-[illegible]. S.S.A. B.S.S.-N.W.-S.E.	24- 1	5.00 A.M. 4.00 P.M.	Dark-cold-N.W.-S.E. B.S.S.= N.W.-S.E.
24- 5	4.00 A.M. 4.00 P.M.	Dark-Sl. W-S.S.A. B.S.S.-N.W.-S.E.	25- 3	5.00 A.M. 4.10 P.M.	Dark.-N.W. - S.E. B.S.S.-N.W.-S.E.
21- 6	5.00 A.M. 5.00 P.M.	Break of day-Sl.W.-S.A. B.S.S.-Sl.W.-S.S.A.	28- 4	5.10 A.M. 6.25 P.M.	Moonlight-Cold-S.E. B.S.S.-N.W.-S.E.
19- 7	5.00 A.M. 5.00 P.M.	Twilight.-N.W.-S.E. B.S.S.-N.W.-S.A.	11- 6	5.10 A.M. 4.10 P.M.	Dark clouds-N.W.-S.E. C.S.-St.-W.-S.A.
30- 8	5.15 A.M. 2.30 P.M.	Twilight-raining slight-S.A. I.B.S.S.-St.W.-S.A.	24- 7	5.00 A.M. 4.00 P.M.	Dark-Sl.W-S.S.A. C.S.-Drizzling-S.S.A.
25- 9	5.15 A.M. 3.30 P.M.	Dark-N.W.-Cold.-S.E. B.S.S.-St. W-S.A.	28- 8	5.00 A.M. 4.00 P.M.	Moonlight-Sl.W.-S.S.A. C.S.-Sl.W - S.S.A.
24-10	5.25 A.M. 4.00 P.M.	Twilight-Sl. W-S.A. C.S.-N.W.-S.E.	25- 9	5.00 A.M. 3.35 P.M.	Moonlight-N.W.-S.E. C.S.-Sl. W. S.S.A.
29-11	5.00 A.M. 3.00 P.M.	Dark-cold breeze-S.S.A. C.S. -N.W.-S.E.	24-10	5.00 A.M. 4.45 P.M.	Moonlight-N.W.-S.E. B.S.S.-N.W.-S.E.
20-12	5.00 A.M. 3.00 P.M.	Dark-St. cold wind-S.A. B.S.S.-N.W.-S.E.	27-11	5.10 A.M. 4.00 P.M.	Moonlight-Sl. W.-S.S.A. B.S.S.-N.W.-S.E.
			18-12	5.00 A.M. 4.00 P.M.	Dark-Sl.W.-S.S.A. B.S.S.-N.W.-S.E.

Note: Sl.W= Slight Wind; M.W.=Moderate wind; N.W.=No wind; St.W.=Strong wind; B.S.S.=Bright sun shine; I.B.S.S.=Intermittent bright sun shine; C.S.= Cloudy sky; S.A.= Surface agitated; S.E.= Surface even; S.S.A.= Surface slightly agitated.

TABLE NO. IV

SHOWING THE WATER LEVELS IN THE AJWA RESERVIOR ON THE DAYS OF SAMPLE COLLECTION DURING 1963 AND 1964

1963	Reservoir level R.L. in Feet	1964	Reservoir level R.L. in Feet
24- 4	205.45	24- 1	208.95
24- 5	204.16	25- 3	207.91
21- 6	203.03	28- 4	206.62
19- 7	202.93	11- 6	204.55
30- 8	208.96	24- 7	204.70
25- 9	210.92	28- 8	206.98
24-10	210.83	25- 9	208.18
29-11	210.27	24-10	207.70
20-12	209.80	27-11	206.66
		18-12	206.06

Sill Level = 183.0

TABLE NO. V(a)

VERTICAL DISTRIBUTION OF TEMPERATURE (^{0}C) IN THE AJWA RESERVOIR AT BARODA - FOR 1963

1963	24-4		24-5		21-6		19-7		30-8		25-9		24-10		29-11		20-12	
Time	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Depth in Feet	5-30	3-30	4-00	4-00	5-00	5-00	5-00	5-00	5-15	2-30	5-15	3-30	5-25	4-00	5-00	3-00	5-00	3-00
0.0	27.0	31.0	29.0	33.0	27.5	28.7	27.5	29.6	28.1	30.5	28.5	31.7	26.2	28.5	25.0	26.5	20.7	22.0
5.0	27.0	29.5	29.0	31.0	27.5	28.2	27.5	29.0	28.1	30.5	28.5	30.0	26.2	28.0	25.0	26.5	20.7	21.5
10.0	27.0	28.5	29.0	31.0	27.5	28.0	27.5	28.9	28.1	30.0	28.2	29.5	26.2	28.0	25.0	26.0	20.7	21.2
15.0	27.0	27.5	29.0	30.7	27.5 16ft	28.0 16ft	27.5 16ft	28.9 16ft	28.1	30.0	28.2	28.2	26.2	27.5	25.0	25.5	20.7	21.2
20.0	27.0	27.5	29.0 18ft	30.5 18ft					28.1	30.0	28.2 22ft	28.2 22ft	26.2 22ft	27.5 22ft	25.0 22ft	25.5 22ft	20.7 22ft	21.0 22ft
Difference	0.0	3.5	0.0	2.5	0.0	0.7	0.0	0.7	0.0	0.5	0.2	3.5	0.0	1.0	0.0	1.0	0.0	1.0

TABLE NO. V (b)

VERTICAL DISTRIBUTION OF TEMPERATURE (°C) IN THE AJWA RESERVOIR AT BARODA FOR 1964.

1964	24-1		25-3		28-4		11-6		24-7		28-8		25-9		24-10		27-11		18-12	
Time	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Depth in Feet	5.00	4.00	5.00	4.10	5.10	6.25	5.10	4.10	5.00	4.00	5.00	4.00	5.00	3.35	5.00	4.45	5.10	4.00	5.00	4.00
0.0	17.0	20.5	26.2	30.5	28.0	31.7	29.0	29.5	28.7	29.0	28.0	29.5	29.0	29.5	27.2	31.5	23.0	25.0	19.0	22.0
5.0	17.0	19.5	26.0	27.5	28.0	31.2	29.0	29.0	28.7	29.0	28.0	29.5	29.0	29.5	27.0	29.5	23.0	24.0	19.0	21.0
10.0	17.0	18.7	26.0	27.0	28.0	30.5	29.0	29.0	28.7	29.0	28.0	29.5	29.0	29.0	27.0	29.0	23.0	24.0	19.0	20.5
15.0	17.0	18.5	26.0	26.5	28.0	30.2	29.0 18ft.	29.0 18ft.	28.7 18ft.	29.0 18ft.	28.0	29.5	29.0	29.0	27.0	29.0	23.0	24.0	19.0	20.5
20.0	17.0 21ft.	18.0 21ft.	26.0	26.5	28.0						28.0 21ft.	29.0 21ft.	29.0 21ft.	29.0 21ft.	27.0 22ft.	29.0 22ft.	22.9 22ft.	23.5 22ft.	19.0	20.5
Difference	0.0	2.5	0.2	4.0	0.0	1.5	0.0	0.5	0.0	0.0	0.0	0.5	0.0	0.5	0.2	2.5	0.1	1.5	0.0	1.5

TABLE NO. VI

SHOWING THE MONTHLY MAXIMUM AND MINIMUM TEMPERATURES OF THE ATMOSPHERE AND IN SURFACE AND BOTTOM LAYERS OF THE AJWA RESERVOIR AT BARODA

Atmospheric Temperature (^{o}C)

Mean maximum								Mean minimum							
Maximum				Minimum				Maximum				Minimum			
1963		1964		1963		1964		1963		1964		1963		1964	
Value	Month	Value	Month	Value	Month	Value	Month	Value	Month	Value	Month	Value	Month	Value	Month.
41.6	May	41.0	April	30.9	Aug.	29.1	Jan.	27.5	June	27.1	June	13.6	Jan.	10.4	Jan.

Water Temperature (^{o}C)

	Surface Layer								Bottom Layer							
1.	29.0	May	29.0	June	20.7	Dec.	17.0	Jan.	29.0	May	29.0	June	20.7	Dec.	17.0	Jan.
2.	33.0	May	31.7	April	22.0	Dec.	20.5	Jan.	30.5	May	30.2	April	20.5	Dec.	18.0	Jan.

(1) Morning Series (2) After-noon Series

TABLE NO. VII

SHOWING HYDROGEN ION (pH) VALUES IN THE SURFACE AND BOTTOM LAYERS OF THE AJWA RESERVOIR, BARODA.

	1963					1964			
Date	Early morning		After-noon		Date	Early morning		After-noon	
	Surface	Bottom	Surface	Bottom		Surface	Bottom	Surface	Bottom
24- 4	8.3	8.2	8.8	8.3	24- 1	8.3	8.0	8.4	8.1
24- 5	8.5	8.3	8.8	8.4	25- 3	8.3	8.3	8.6	8.4
21- 6	8.4	8.3	8.7	8.4	28- 4	8.3	8.3	8.6	8.4
19- 7	8.5	8.3	8.7	8.4	11- 6	8.2	8.3	8.8	8.4
30- 8	8.3	8.3	8.5	8.4	24- 7	8.3	8.3	8.4	8.4
25- 9	8.4	8.2	8.5	8.3	28- 8	8.2	8.3	8.3	8.4
24-10	8.2	8.2	8.4	8.3	25- 9	8.2	8.2	8.2	8.3
29-11	8.1	8.0	8.3	8.1	29-10	8.2	8.1	8.3	8.2
20-12	8.1	8.0	8.3	8.1	27-11	8.3	8.0	8.4	8.1
-	-	-	-	-	18-12	8.3	8.0	8.5	8.1

TABLE NO. VIII

GENERAL CHARACTERISTICS OF THE AJWA RESERVOIR WATER, BARODA.

Date	Reservoir level	Actual Depth in Ft.	Colour of water	mg. per litre		
				Total solids	Hardness	Chloride
1963						
24- 4	205.45	20	Green	280	150	50
24- 5	204.16	18	Green	302	176	55
21- 6	203.03	16	Green	310	180	59
19- 7	202.93	16	Grey	320	189	65
30- 8	208.96	20	Grey	250	135	50
25- 9	210.92	22	Grey	230	129	35
24-10	210.83	22	Green	232	135	38
29-11	210.27	22	Green	238	140	42
20-12	209.80	22	Green	252	142	45
1964						
24- 1	208.95	21	Green	263	146	47
25- 3	207.91	20	Green	271	150	52
28- 4	206.62	20	Green	275	160	70
11- 6	204.55	18	Green	279	170	76
24- 7	204.70	18	Pale-green	270	160	73
28- 8	206.98	21	Grey	254	150	48
25- 9	208.16	21	Grey	224	140	40
29-10	207.70	22	Grey	230	143	43
27-11	206.66	22	Green	233	145	48
18-12	206.06	20	Green	240	148	50

TABLE NO. IX.

SHOWING CARBONATE ALKALINITY IN THE SURFACE AND BOTTOM LAYERS OF THE AJWA RESERVOIR, BARODA.

(Results expressed in mg/l)

	1963					1964			
Date	Early morning		After-noon		Date	Early morning		After-noon	
	Surface	Bottom	Surface	Bottom		Surface	Bottom	Surface	Bottom
24- 4	28	28	40	30	24- 1	20	20	30	22
24- 5	36	36	44	38	25- 3	24	24	32	26
21- 6	32	32	44	34	28- 4	26	26	36	26
19- 7	20	20	32	20	11- 6	24	24	32	26
30- 8	20	20	24	22	24- 7	24	24	32	26
25- 9	16	16	24	18	28- 8	16	16	24	18
24-10	16	16	24	18	25- 9	16	16	32	18
29-11	16	16	24	16	29-10	14	8	16	10
20-12	16	16	24	16	27-11	14	10	10	10
					18-12	16	16	24	16

TABLE NO. X

SHOWING BICARBONATE ALKALINITY IN THE SURFACE AND BOTTOM LAYERS OF THE AJWA RESERVOIR, BARODA.

(Results expressed in mg./l.)

Date	1963 Early morning		1963 Afternoon		Date	1964 Early morning		1964 After-noon	
	Surface	Bottom	Surface	Bottom		Surface	Bottom	Surface	Bottom
24- 4	110	112	70	112	24- 1	125	125	98	126
24- 5	110	109	64	110	25- 3	118	116	98	118
21- 6	136	136	68	136	28- 4	119	120	104	124
19- 7	138	140	88	138	11- 6	146	148	116	150
30- 8	112	114	86	118	24- 7	136	138	106	138
25- 9	108	124	102	128	28- 8	138	138	124	136
24-10	120	122	104	122	25- 9	144	144	100	142
29-11	134	134	116	134	29-10	138	136	124	146
20-12	128	128	106	134	27-11	144	146	119	154
-	-	-	-	-	18-12	136	140	106	144

TABLE NO. XI (a)

VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN (mg/litre) IN THE AJWA RESERVOIR AT BARODA FOR 1963.

1963	24-4		24-5		21-6		19-7		30-8		25-9		24-10		29-11		20-12	
Time	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Depth in Feet	5.30	3.30	4.00	4.00	5.00	5.00	5.00	5.00	5.15	2.30	5.15	3.30	5.25	4.00	5.00	3.00	5.00	3.00
0.0	7.62	9.81	6.82	8.04	5.81	5.61	6.62	7.21	6.22	8.71	7.63	7.62	6.63	7.83	6.83	8.24	8.41	8.23
5.0	6.81	9.05	6.82	8.04	5.63	5.05	6.53	6.83	6.22	8.43	7.63	7.24	6.41	7.83	6.62	8.55	7.91	7.60
10.0	5.24	9.06	6.82	7.25	5.24	5.05	6.53	6.41	6.04	8.32	6.62	7.24	6.22	7.62	6.62	7.83	7.62	6.60
15.0	5.25	9.06	6.82	7.25	5.24	5.05	6.63	6.41	5.61	7.52	5.44	7.24	6.04	7.04	6,62	7.83	7.62	6.42
20.0	5.00	9.00	6.42	7.25					5.32	7.52	4.23	7.24	6.04	7.04	6.62	7.83	7.62	6.42
Difference	2.62	0.81	0.40	0.79	0.57	0.56	0.09	0.80	0.80	0.90	3.40	0.38	0.59	0.79	0.21	0.41	0.79	1.81

TABLE NO. XI (b)

SHOWING VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN (mg/litre) IN THE AJWA RESERVOIR, BARODA.

1 9 6 4	24-1		25-3		28-4		11-6		24-7		28-8		25-9		24-10		27-11		18-12	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	R.M.	A.M.	P.M.	A.M.	P.M.
Time	5.00	4.00	5.00	4.10	5.10	6.25	5.10	4.10	5.00	4.00	5.00	4.00	5.00	3.35	5.00	4.45	5.10	4.00	5.00	4.00
Depth in Feet																				
0.0	7.64	8.44	6.42	6.83	7.51	7.53	5.04	7.75	6.03	6.21	6.61	7.73	6.01	6.42	6.81	7.23	7.04	8.61	6.23	7.23
5.0	7.43	8.23	6.42	6.63	7.52	6.52	4.82	5.46	6.03	6.21	6.41	6.61	5.62	6.22	6.81	7.23	7.04	6.02	6.02	6.82
10.0	7.04	8.00	6.24	6.63	5.82	5.83	4.74	5.43	5.82	6.12	6.22	6.61	6.41	6.03	6.22	6.82	7.04	6.02	5.81	6.82
15.0	7.04	7.44	5.04	5.24	5.83	5.83	4.74	4.64	5.71	6.12	6.04	6.02	5.22	5.63	5.02	6.82	6.62	5.61	5.61	6.04
20.0	7.04	7.00	5.00	3.41	5.60	5.83	-	-	-	-	6.04	5.63	5.03	4.81	4.61	4.43	6.02	5.02	5.61	5.61
Difference	0.60	1.44	1.42	3.42	1.91	1.70	0.30	1.11	0.32	0.09	0.57	1.60	0.98	2.60	2.20	2.80	1.02	3.50	0.62	1.62

TABLE NO. XII (a)

SHOWING VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN IN THE AJWA RESERVOIR AT BARODA

FOR 1963

(Expressed in percentage Saturation)

1 9 6 3	24-4		24-5		21-6		19-7		30-8		25-9		24-10		29-11		20-12	
Time	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Depth in Feet	5.30	3.00	4.00	4.00	5.00	5.00	5.00	5.00	5.15	2.30	5.15	3.30	5.25	4.00	5.00	3.00	5.00	3.00
0.0	94.4	130.7	87.7	110.1	72.7	72.2	82.8	93.9	78.5	115.3	97.3	103.0	81.0	100.0	81.5	101.2	93.0	93.2
5.0	84.4	117.6	87.7	107.2	70.5	64.0	81.7	87.9	78.5	111.6	97.3	95.3	78.3	98.8	79.0	98.8	89.0	85.3
10.0	64.9	114.7	87.7	96.6	65.0	63.8	81.7	82.5	76.2	109.5	84.0	94.0	76.0	96.2	79.0	95.3	86.6	73.7
15.0	64.9	113.4	87.7	96.6	65.6	63.8	81.7	82.5	70.8	99.0	69.0	91.8	73.8	88.1	79.0	94.3	86.6	71.7
20.0	62.0	112.6	82.5	96.0	-	-	-	-	67.2	99.0	53.7	91.4	73.8	88.1	79.0	94.3	86.6	71.4
Difference	32.4	18.1	5.2	14.1	7.1	8.4	1.1	11.4	11.3	16.3	43.6	11.6	7.2	11.9	2.5	6.9	6.4	21.8

TABLE NO. XII (b)

VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN (expressed in percentage saturation) IN

THE AJWA RESERVOIR AT BARODA DURING
1 9 6 4.

1964	24-1		25-3		28-4		11-6		24-7		28-8		25-9		24-10		27-11		18-12	
Time	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Depth in Feet	5.00	4.00	5.00	4.00	5.10	6.25	5.10	4.10	5.00	4.00	5.00	4.00	5.00	3.35	5.00	4.45	5.10	4.00	5.00	4.00
0.0	78.5	92.9	78.7	90.5	94.8	101.4	65.0	74.7	77.3	80.0	83.4	94.0	77.4	83.4	84.7	95.7	81.1	102.7	66.6	81.9
5.0	77.0	88.8	78.1	91.5	94.8	87.3	62.0	70.3	77.3	80.0	80.9	85.8	72.3	80.8	84.4	94.0	81.1	70.0	64.4	75.8
10.0	72.6	85.2	77.8	82.1	73.4	77.2	61.0	69.8	74.6	78.7	78.5	85.8	69.6	77.6	77.0	87.8	81.1	70.0	62.1	75.1
15.0	72.2	78.8	61.3	64.4	73.4	77.0	61.0	59.7	73.2	78.7	76.3	78.2	67.2	72.4	74.6	87.8	76.2	65.8	60.0	66.5
20.0	72.2	73.3	60.8	41.9	70.7	77.0	-	-	-	-	76.3	72.5	64.7	62.0	57.1	57.0	69.4	58.4	60.0	61.7
Difference	6.3	19.6	17.9	48.6	24.1	24.4	4.0	15.0	4.1	1.3	7.1	21.5	12.7	21.4	27.6	38.7	11.7	44.3	6.6	20.2

TABLE NO. XIII

SILICA CONTENT (SiO_2) IN THE SURFACE AND BOTTOM SAMPLES OF THE AJWA RESERVOIR, BARODA.

(Results expressed milligrams per litre)

	1963					1964			
Date	Early morning		After noon		Date	Early morning		After-noon	
	Surface	Bottom	Surface	Bottom		Surface	Bottom	Surface	Bottom
24- 4	0.10	0.25	0.10	0.30	24- 1	0.15	0.30	0.15	0.25
24- 5	0.10	0.20	0.10	0.30	25- 3	0.10	0.25	0.10	0.30
21- 6	0.10	0.25	0.14	0.34	28- 4	0.15	0.30	0.15	0.35
19- 7	0.15	0.20	0.10	0.25	11- 6	0.10	0.35	0.15	0.35
30- 8	0.20	0.20	0.15	0.30	24- 7	0.15	0.50	0.10	0.45
25- 9	0.20	0.20	0.10	0.25	28- 8	0.15	0.50	0.10	0.45
24-10	0.10	0.25	0.10	0.25	25- 9	0.10	0.30	0.10	0.50
29-11	0.10	0.25	0.10	0.25	27-10	0.10	0.25	0.10	0.30
20-12	0.05	0.20	0.05	0.25	27-11	0.15	0.30	0.15	0.30
-	-	-	-	-	18-12	0.15	0.30	0.15	0.30

TABLE NO. XIV

RESULTS OF ANALYSIS OF CALCIUM, SODIUM AND POTASSIUM BY EEL'S FLAME PHOTOMETER IN THE AJWA RESERVOIR WATER, BARODA

1 9 6 4	Milligrams per litre		
	Calcium	Sodium	Potassium
24- 1	9.50	52.32	1.50
24- 3	11.50	55.80	2.39
28- 4	13.50	56.81	2.39
11- 6	13.75	59.34	2.92
24- 7	12.00	53.82	2.90
28- 8	7.20	50.59	3.90
24- 9	6.40	45.55	3.90
24-10	10.00	51.97	3.90
28-11	12.40	59.33	1.95
18-12	12.80	61.41	3.12
Average	10.85	54.69	2.89

TABLE NO. XV

OXYGEN CONSUMED IN THE SURFACE AND BOTTOM SAMPLES OF THE AJWA RESERVOIR, BARODA

(Results expressed in mg/ l.)

Date	1963 Early morning		1963 Afternoon		Date	1964 Early morning		1964 Afternoon	
	Surface	Bottom	Surface	Bottom		Surface	Bottom	Surface	Bottom
24- 4	0.82	5.80	-	-	24- 1	1.00	1.40	1.00	2.46
24- 5	1.04	1.60	-	-	25- 3	1.50	2.60	1.54	2.68
21- 6	1.13	1.86	1.13	1.50	28- 4	1.78	1.80	1.80	2.84
19- 7	1.92	2.82	1.90	1.80	11- 6	1.83	2.48	-	-
30- 8	1.34	1.68	1.34	2.52	24- 7	1.72	2.42	1.70	2.60
25- 9	0.84	3.31	0.88	1.86	28- 8	1.34	2.00	1.32	1.58
24-10	0.78	1.22	0.80	1.29	25- 9	1.05	1.54	1.04	2.74
29-11	0.84	7.60	0.90	5.24	29-10	1.08	1.64	1.00	1.68
20-12	1.10	4.62	0.95	3.80	27-11	1.13	1.74	1.14	1.48
-	-	-	-	-	18-12	1.24	2.04	1.28	1.66

Table No. XVI Periodicity of the Phyto- and -Zooplankton Organisms in the Ajwa Reservoir at Baroda during 1963 & 1964

1963 — Time of collection / Description	24-4 AM 5.30	24-4 PM 3.00	24-5 AM 4.00	24-5 PM 4.00	21-6 AM 5.00	21-6 PM 5.00	14-7 AM 5.00	14-7 PM 5.00	30-8 AM 5.15	30-8 PM 2.30	25-9 AM 5.15	25-9 PM 3.30	24-10 AM 5.25	24-10 PM 4.00	29-11 AM 5.00	29-11 PM 3.00	20-12 AM 5.00	20-12 PM 3.00
A Phytoplankton (a) Chlorophyta																		
1 Cosmarium depressum Ray	–	–	–	–	–	–	rr	rr	–	r	rr	–	rr	rr	rr	–	–	rrr
2 ,, contractum Kirchn.	rrr	–	–	rrr	–	–	–	–	rrr	–	rrr	–	–	–	–	rr	rr	rr
3 Oedogonium sp	–	–	–	–	–	–	rrr	–	–	–	rrr	–	–	–	–	–	–	–
4 Pediastrum simplex Meyen	rr	rr	rr	rr	c	c	r	c	rr	–	r	r	r	r	r	rr	rr	r
(b) Euglenophyta																		
5 Trachelomonas volvocina (Ehrenb)	–	–	–	–	rrr	–	–	rrr	rr	rr	–	rr	–	–	–	–	rrr	–
(c) Chrysophyta																		
6 Botryococcus Braunii	r	r	r	r	r	c	c	c	r	r	rr	rr	rr	c	r	r	r	rr
Bacillariophyceae																		
7 Achnanthes exilis (Kütz)	–	rrr	.	–	–	rr	–	–	–	.	rrr	–	rr	rrr	–	–	–	–
8 ,, minutissima (Kutz)	–	–	rrr	rrr	–	–	rrr	–	–	–	–	–	–	–	–	rrr	–	–
9 Amphora beneta (Kutz) Hust	rr	–	–	–	rrr	–	–	rr	–	–	–	rr	–	–	–	–	–	–
10 Cocconeis placentula (Ehr) var lineata	–	rrr	–	–	–	–	–	–	rrr	.	–	–	rrr	–	–	–	–	–
11 Cymbella affinis (Kütz)	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–
12 ,, microcephala (Grun)	–	rrr	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	rrr	rrr
13 ,, tumida (Breb) VH	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–
14 Diploneis (cf D Smithii) Breb	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15 Epithemia sorex (Kutz)	–	–	–	rrr	–	–	–	rrr	–	–	–	–	.	–	–	–	–	–
16 ,, argus (Kutz)	rrr	–	–	–	–	rrr	..	–	–	rrr	–	rrr	..	..	–	–	–	–
17 Fragillaria crotenensis Kitt	–	rrr	–	rrr	–	rrr	–	–	rrr	–	–	–	..	.	–	–	rrr	rrr
18 Gomphonema gracile var aurutum (A.Br) VH	–	–	–	–	rrr	–	–	–	–	–	–	–	–	rrr	–	rrr	–	–
19 ,, ,, var dichotomum (W Sm) VH	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	rrr	rrr
20 ,, subclavatum Grun	rrr	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–
21 Mastogloia Smithii v amphicephala Grun	–	–	–	–	–	–	–	rrr	–	–	–	–	rrr	–	–	–	–	rrr
22 Melosira granulata var angustissima O Mull	rrr	–	–	rrr	–	–	–	–	rrr		–	rrr	–	–	–	rrr	–	–
23 Navicula cryptocephala Kutz	–	rrr	–	–	rrr	–	–	–		–	rrr	–	–	–	rrr	–	–	–

1964 — Time of collection / Description	24-1 AM 5.00	24-1 PM 4.00	25-3 AM 5.00	25-3 PM 4.00	28-4 AM 5.10	28-4 PM 6.25	11-6 AM 5.10	11-6 PM 4.10	24-7 AM 5.00	24-7 PM 4.00	28-8 AM 5.00	28-8 PM 4.00	25-9 AM 5.00	25-9 PM 3.35	24-10 AM 5.00	24-10 PM 4.45	27-11 AM 5.10	27-11 PM 4.00	18-12 AM 5.00	18-12 PM 4.00
A Phytoplankton (a) Chlorophyta																				
1 Cosmarium depressum Ray	rrr	–	rrr	–	–	–	–	–	rrr	rrr	r	r	c	c	rr	–	–	–	–	–
2 ,, contractum Kirchn.	–	–	–	rrr	–	rrr	rrr	rrr	–	–	rrr	rrr	rrr	rrr	r	r	–	–	–	–
3 Oedogonium sp	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	rrr	rrr	–	–	–	–
4 Pediastrum simplex Meyen	rr	rr	rr	rr	c	c	r	r	cc	ccc	rr	rr	cc	cc	rr	rr	rr	r	rr	r
(b) Euglenophyta																				
5 Trachelomonas volvocina (Ehrenb)	rrr	rrr	–	–	–	–	–	–	–	–	–	rr	rr	rr	–	rr	rr	rrr	rrr	rr
(c) Chrysophyta																				
6 Botryococcus Braunii	rr	rr	rr	rr	rr	r	rr	rr	rr	rr	rr	rr	rr	rr	rr	r	r	r	r	r
Bacillariophyceae																				
7 Achnanthes exilis (Kütz)	rrr	rrr	rrr	rrr	–	–	rrr	rrr	–	–	–	–	rrr	rrr	–	–	–	–	–	–
8 ,, minutissima (Kutz)	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9 Amphora beneta (Kutz) Hust	–	–	rrr	rrr	–	–	–	–	rrr	rrr	rrr	rrr	–	–	–	–	–	–	rrr	rrr
10 Cocconeis placentula (Ehr) var lineata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	rrr	–	–	–	–
11 Cymbella affinis (Kütz)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
12 ,, microcephala (Grun)	–	–	–	–	rrr	rrr	–	–	–	–	rrr	rrr	–	–	–	–	rrr	rrr	–	–
13 ,, tumida (Breb) VH	rrr	rrr	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–
14 Diploneis (cf D Smithii) Breb	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–
15 Epithemia sorex (Kutz)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr
16 ,, argus (Kutz)	rrr	r r	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–
17 Fragillaria crotenensis Kitt	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18 Gomphonema gracile var aurutum (A.Br) VH	–	–	–	–	rrr	rrr	–	–	–	–	rrr	rrr	–	–	rrr	rrr	–	–	–	–
19 ,, ,, var dichotomum (W Sm) VH	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	–	–
20 ,, subclavatum Grun	rrr	rrr	–	–	rrr	rrr	rrr	rrr	–	–	–	–	rrr	rrr	–	–	–	–	rrr	rrr
21 Mastogloia Smithii v amphicephala Grun	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	rrr	rrr	rrr
22 Melosira granulata var angustissima O Mull	–	–	–	–	rrr	rrr	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–
23 Navicula cryptocephala Kutz	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–

Table No XVI (contd): Periodicity of the Phyto- and Zoo-plankton Organisms in the Ajwa Reservoir at Baroda

1963

Time of Collection / Description	24-4 AM 530	24-4 PM 300	24-5 AM 400	24-5 PM 400	21-6 AM 500	21-6 PM 500	19-7 AM 800	19-7 PM 500	30-8 AM 515	30-8 PM 230	25-9 AM 515	25-9 PM 330	24-10 AM 525	24-10 PM 400	24-11 AM 500	24-11 PM 300	20-12 AM 500	20-12 PM 500
24 Nitzschia (cf N. acicularis W Sm)	rr	–	–	–	rr	rr	–	rrr	rrr	rrr	–	–	rrr	–	–	–	rrr	rrr
25 " Kutzingiana Hilse	rrr	rrr	rrr	rrr	–	–	–	–	–	–	rrr	rrr	–	rrr	rrr	rrr	–	–
26 Pleurosigma delicatulum W Sm	rrr	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	rrr	–
27 Rhopalodia gibba (Ehr) O Mull	–	–	–	–	rrr	rrr	–	–	rrr	rrr	–	–	–	–	–	–	–	–
28 Surirella tenera var nervosa AS	rrr	–	rrr	rr	rr	rr	r	r	rr	r	rrr	rr	–	–	rrr	rr	rr	rr
29 Synedra ulna (Nitz) Ehr	–	–	–	–	–	–	–	–	–	–	–	–	rrr	–	rrr	–	–	–
30 " acus (Kutz	–	–	–	–	rrr	–	–	–	–	rrr	–	–	–	–	–	rrr	–	–
31 " " var radians (Hust)	–	–	–	–	–	rrr	–	–	–	–	–	–	–	rrr	–	–	–	–
(d) Cyanophyta																		
32 Anabaena sp	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr
33 Anacystis cyana (Kutz) Dr & Daily	r	r	r	r	rr	rr	rr	rr	rr	rr	rr	rrr	–	–	–	–	–	–
34 Cylindrospermum sp	rr	–	rr	rr	–	rr	rrr	–	rr	–	rrr	–	rrr	–	rrr	rrr	–	–
35 Microcoleus chthonoplastes (Mert) Zanard	rr	rr	–	–	–	rrr	–	rrr	–	–	–	rrr	rrr	–	–	–	rrr	rrr
36 Oscillatoria tenuis Ag	rr	rr	rr	rr	–	–	rrr	–	–	–	rr	–	rrr	–	–	rr	–	–
B Zoo-plankton																		
(a) Protozoa																		
1 Arcella	–	rrr	–	–	–	–	rrr	rrr	–	–	–	rrr	rrr	rrr	–	–	rr	rrr
2 Difflugia hydrostatica	rr	rrr	–	–	–	–	–	–	–	–	r	r	r	rr	rr	rrr	rrr	–
3 Centropyxis	rrr	rrr	rrr	rrr	rr	rr	rr	rr	rr	r	rr	rr	rr	rrr	rrr	rrr	rrr	rrr
4 Lecquereusia	–	–	–	–	–	–	rrr	–	rrr	–	–	–	–	–	–	–	rrr	rrr
5 Vorticella	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	rrr	rrr
(b) Rotifera																		
6 Anuraeopsis coelata	c	c	c	c	r	r	rrr	rr	rr	r	r	rr	cc	cc	cc	cc	cc	cc
7 " fissa	–	rrr	–	–	rrr	rrr	–	rr	rrr	–	rr	–	rr	–	rr	–	rr	–
8 Ascomorpha saltans indica	rr	rr	–	–	rr	–	–	rr	rr	rr	–	–	rr	–	–	–	rr	–
9 Brachionus angularis	–	–	–	–	–	–	rrr	rr	rrr	rr	rr	rrr	r	c	cc	r	rr	rrr
10 " caudatus	–	–	–	–	–	rr	rr	–	–	rr	–	–	–	–	rr	rrr	rrr	rrr

1964

Time of Collection / Description	24-1 AM 500	24-1 PM 400	25-3 AM 500	25-3 PM 400	28-4 AM 510	28-4 PM 625	11-6 AM 510	11-6 PM 410	24-7 AM 500	24-7 PM 400	28-8 AM 500	28-8 PM 400	25-9 AM 500	25-9 PM 335	24-? AM 500	24-? PM 445	27-11 AM 510	27-11 PM 400	13-12 AM 500	13-12 PM 410
24 Nitzschia (cf N. acicularis W Sm)	–	–	rrr	rrr	–	–	–	–	rrr	rrr	rrr	rrr	–	–	–	–	–	–	–	–
25 " Kutzingiana Hilse	–	–	rrr	rrr	rrr	rrr	–	–	–	–	rrr	rrr	rrr	rrr	rrr	rrr	–	–	rrr	rrr
26 Pleurosigma delicatulum W Sm	–	–	rrr	rrr	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–
27 Rhopalodia gibba (Ehr) O Mull	rrr	rrr	–	–	–	–	–	–	rrr	rrr	rrr	rrr	–	–	–	–	–	–	–	–
28 Surirella tenera var nervosa AS	rr	rr	rr	rr	rr	rr	c	c	c	c	rr	rr	rr	rr	rr	rr	r	r	r	r
29 Synedra ulna (Nitz) Ehr	rrr	rrr	–	–	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	–	–	–	–	rrr	rrr	rrr	rrr
30 " acus (Kutz	–	–	rrr	rrr	rrr	rrr	–	–	rrr	rrr	–	–	–	–	rrr	rrr	–	–	–	–
31 " " var radians (Hust)	–	–	–	–	rrr	rrr	–	–	–	–	rrr	rrr	rrr	rrr	–	–	–	–	rrr	rrr
(d) Cyanophyta																				
32 Anabaena sp	–	–	rrr	rrr	rrr	rrr	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–
33 Anacystis cyana (Kutz) Dr & Daily	rr	rr	r	r	r	r	–	–	–	rrr	rrr	rr	rr	rrr	rr	rr	rr	rr	–	–
34 Cylindrospermum sp	–	–	r	r	r	r	r	r	r	rr	rr	rr	–	–	–	–	–	–	–	–
35 Microcoleus chthonoplastes (Mert) Zanard	–	–	rr	rr	rr	rr	–	–	rr	rr	rr	rr	rr	rr	–	–	rrr	rrr	–	–
36 Oscillatoria tenuis Ag	–	–	rrr	rrr	–	–	rrr	rrr	rrr	rrr	–	–	rrr	rrr	rr	rr	rr	rr	–	–
B Zoo-plankton																				
(a) Protozoa																				
1 Arcella	–	–	rrr	rrr	–	–	rrr	rrr	rrr	rrr	–	–	–	–	rrr	rrr	rrr	rrr	rrr	rrr
2 Difflugia hydrostatica	–	–	rr	rr	rr	rr	–	–	rr	rr	rr	rr	rr	rr	–	–	rrr	rrr	rrr	rrr
3 Centropyxis	rr	rr	rr	rr	rr	rr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr
4 Lecquereusia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5 Vorticella	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–
(b) Rotifera																				
6 Anuraeopsis coelata	r	r	rr	cc	acc	cc	r	r	c	c	r	r	rr	rr	rr	rr	rr	rrr	rrr	rrr
7 " fissa	–	rrr	r	cc	r	rr	–	–	rrr	rrr	–	–	–	–	rrr	rrr	–	rrr	rrr	rrr
8 Ascomorpha saltans indica	r	r	c	cc	cc	rr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	–	–	–	–	rrr	rrr
9 Brachionus angularis	–	–	rrr	rrr	rr	rr	rrr	rrr	rrr	rrr	rrr	rrr	–	rrr	–	–	–	–	–	–
10 " caudatus	–	–	rrr	rrr	rr	rr	rr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	..	–	rrr	–	–	rrr

Table No XVI (contd) Periodicity of the Phyto- and zoo-plankton Organisms in the Ajwa Reservoir at Baroda.

No.	1963 & 1964	24-4		24-5		21-6		19-7		30-8		25-9		24-10		29-11		20-12		24-1		25-3		28-4		11-6		24-7		28-8		25-9		24-10		27-0		18-[illegible]	
	Time of collection	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
	Description	5 30	3 00	4 00	4 00	5 00	5 00	5 00	5 00	5 15	2 30	5 15	3 30	5 25	4 00	5 00	3 00	5 00	3 00	5 00	4 00	5 00	4 00	5·10	6 25	5·10	4 10	5 00	4 00	5 00	4 20	5·00	3 35	5·00	4 45	5 10	4 40	5 00	4 00
11	Brachionus diversicornis	rr	rr	r	r	c	cc	c	r	c	rr	rr	rrr	rrr	–	rr	–	rrr	rrr	–	–	rrr	rrr	–	–	–	–	–	–	rr	rr	r	r	r	r	rrr	r	r	r
12	,, falcatus	rrr	rrr	–	–	–	rr	rr	rr	c	c	cc	cc	ccc	cc	cc	cc	rr	rr	r	r	c	c	cc	cc	c	c	rr	rr	r	r	c	c	ccc	cc	c	c	r	r
13	,, forficula	rrr	rrr	rr	rr	–		rr	rr	rrr	r	cc	c	cc	cc	rr	rr	rr	rrr	r	r	rr	rr	rr	rr	–	–	rr	rr	r	r	c	c	c	c	r	r	rr	rr
14	Cephalodella gibba	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15	,, megalocephala	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	–	–
16	Collotheca	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	rr	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17	Colurella oxycauda	–	–	rrr	rrr	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	rrr	rrr	rrr	rrr	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–
18	Dicranophorus epicharis	c	c	r	r	rr	rr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	c	cc	cc	r	r	–	–	–	–	–	–	–	–	–	–	–	–
19	Euchlanis dilatata	cc	cc	c	c	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
20	Filinia terminalis	–	–	–	–	–	rrr	–	rrr	–	–	rrr	rrr	rrr	rr	rrr	rr	rrr	rrr	–	–	rrr	rrr	rr	rrr	rrr	rrr	rr	rr	–	rrr	rrr	–	–	–	–	rrr	rrr	rrr
21	Keratella vulga tropica	rr	rr	r	r	cc	cc	cc	cc	ccc	ccc	ccc	ccc	ccc	ccc	ccc	ccc	cc	cc	r	r	cc	cc	ccc	ccc	ccc	ccc	ccc	ccc	ccc	ccc	cc	cc	rr	rr	rr	rr	r	r
22	Lecane arcuata	–	–	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	[illegible]	–	–	–	–	–	–	–	–	–	–	–	–
23	,, arcula	rrr	rrr	–	–	rrr	rrr	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	rrr	–	–	–	–	–	–	rrr	–	–
24	,, bulla	–	–	–	–	–	–	–	–	–	–	–	–	–	r	cc	cc	r	r	–	–	rrr	rr	rr	rr	–	–	–	–	–	–	–	–	–	–	rr	rr	rr	rr
25	,, closterocera	–	–	rrr	rrr	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26	,, galeata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27	,, hamata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28	,, harringi	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–
29	,, hornimanni	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
30	,, luna	rrr	rrr	–	–	–	–		–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31	,, lunaris	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr
32	,, papuana	–	–	–	–	–		–	–	–	–	–	–	–	–	rr	–	–	–	–	–	rrr	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	r	r	r	r
33	,, quadridentata	–	–	–	–	–	rrr	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	rrr	rrr	–	–	rrr	–
34	,, thienemanni	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	rr	rr	–	–	–	–
35	,, unguiculata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	rr	rr	rr	rr
36	,, ungulata	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
37	Mytilina ventralis	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–
38	Notommata	–	–	rrr	rrr	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	rrr	–	r	r	–	r	c	c	c	c	r	r	rr	rr	–	–
39	Pedalia	–	–	–	–	r	r	–	–	cc	cc	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	r	r	r	c	c	c	c	r	r	rr	rr	–	–
40	Polyarthra	rrr	rrr	–	–	–	–	–	–	–	–	rrr	–	–	–	–	–	–	–	–	–	–	rr	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–

Table No XVI (contd) Periodicity of the Phyto- and Zoo-plankton Organisms in the Ajwa Reservoir, at Baroda.

1963 & 1964	24-4		24-5		21-6		19-7		30-8		25-9		24-10		24-11		20-12	
Time of collection	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Description	5.30	3.00	4.00	4.00	5.00	5.00	5.00	5.00	5.15	2.30	5.15	3.30	5.25	4.00	5.00	5.00	5.00	3.00
41. Pompholyx complanata	—	—	—	—	r	r	c	c	r	r	rrr	rrr	rrr	rr	rr	rrr	rrr	rrr
42. Plygura furcata	c	c	r	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—
43 Ptygura sp	rrr	rrr	rrr	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
44. Testudinella patina.	—	—	—	—	—	—	—	—	—	—	rrr	—	—	—	—	—	—	—
45 Tetramastix opoliensis	—	—	—	—	rrr	rr	ccc	cc	cc	cc	rrr	rrr	—	—	—	—	—	—
46 Trichocerca mycersi	rrr	rrr	rrr	rrr	—	—	—	—	—	—	—	—	—	—	—	—	—	—
47 " ruttneri	—	—	—	—	—	—	cc	cc	c	c	rr	rrr	—	rr	rr	—	—	—
48. " similis	c	c	—	r	r	—	—	—	—	—	—	—	—	—	—	—	rrr	rrr
49 Bdelloidea.	rr	rr	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	rrr
(c) Copepoda																		
50 Allodiaptomus Rao Kiefer	rr	rr	r	r	cc	cc	ccc	ccc	cc	cc	r	r	r	r	r	r	r	r
51. " cinctus (Gurney)	—	—	rrr	rrr	rrr	rrr	—	—	rrr	rrr	rrr	rrr	rrr	rrr	r	r	r	r
52 Mesocyclops leuckart deccanensis (Lindberg)	rr	rr	rr	rr	cc	cc	ccc	ccc	cc	cc	cc	cc	r	r	rr	rr	cc	cc
53 Nauplius larvae	r	r	r	r	c	c	r	r	c	c	ccc	ccc	rr	rr	rr	rr	rr	rr
54 Diaptomus	rr	rr	r	r	r	r	rrr	rrr	rrr	rrr	cc	cc	cc	cc	c	c	c	c
55 Helio-diaptomus cinctus Gur	rrr	rrr	—	—	—	—	rrr	rrr	—	—	—	—	rrr	rrr	—	—	—	rrr
56 Harpaticidae	—	—	rrr	rrr	rrr	rrr	—	—	—	—	—	—	—	—	—	—	—	—
(d) Cladocera.																		
57 Alona Baird	rrr	rrr	—	—	rrr	rrr	—	.	—	—	rrr	rrr	rrr	rrr	rrr	r	r	r
58 " Affinis	rrr	rrr	rrr	rrr	—	—	—	—		—	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr
59 " Cf Archeri	—	—	—	—	rrr	rrr	—	.		..	—	—	—	—	rrr	rrr	rrr	rrr
60 " Chydorus	—	—	rrr	rrr	—	—	—	—	rrr	rrr	—	—	-	-	rrr	rrr	rrr	rrr
61 " macrothrix	—	—	—	—	—	—	—	—	rrr	rrr	—	—	.	.	rrr	rrr	rrr	rrr
62 " verrucosa	—	—	—	—	—	—	—	—	—	—	..	..			rrr	rrr	rrr	rrr
63 " camboues	—	—	—	—	—	—	—	—	.	.	rrr	rrr			rrr	rrr	—	—
64. " intermedia	—	—	—	—	—	—	—	—	—	.	—	—	rr	rr	—	—	rrr	rrr
65 Alonella Karua	—	—	—	—	—	—	—	—	—	—	—	—	—	—	rrr	rrr	rrr	rrr
66 Bosminopsis cf Pomodi	rrr	rrr	—	—	—	—	—	—	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	r	r

1963 & 1964	24-1		25-3		28-4		11-6		24-7		28-8		25-9		24-10		27-11		18-12	
Time of collection	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Description	5.00	4.00	5.00	4.00	5.10	6.35	5.10	4.10	5.00	4.00	5.00	4.00	5.00	3.35	5.00	4.45	5.10	4.00	5.00	4.00
41. Pompholyx complanata	—	—	rrr	rr	—	—	—	r	r	r	r	—	—	—	—	—	—	—	—	—
42. Plygura furcata	r	r	cc	cc	rr	rr	rrr	—	—	—	—	—	rrr	—	—	rrr	—	—	rrr	—
43 Ptygura sp	—	—	—	rrr	rrr	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
44. Testudinella patina.	—	—	—	—	—	—	—	—	—	—	—	—	rrr	rrr	rrr	rrr	—	—	—	rrr
45 Tetramastix opoliensis	—	—	—	rrr	rrr	rrr	rrr	rr	cc	cc	rr	rr	rr	rr	—	—	—	—	—	—
46 Trichocerca mycersi	rr	—	—	rrr	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
47 " ruttneri		—	—	—	—	—	c	c	r	r	—	—	r	r	rr	rr	—	—	—	—
48. " similis	—	—	r	r	cc	cc	r	r	—	—	rrr	—	—	—	—	—	—	—	—	—
49 Bdelloidea.	—	—	rrr	rr	rrr	rrr	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(c) Copepoda																				
50 Allodiaptomus Rao Kiefer	rrr	rrr	rrr	—	c	c	ccc	cc	ccc	cc	c	c	c	c	r	r	r	rrr	rr	rr
51. " cinctus (Gurney)	rrr	rrr	rrr	rrr	rrr	rrr	rrr	rrr	—	—	rrr	rrr	rr	rr	rrr	rrr	r	r	rrr	rrr
52 Mesocyclops leuckart deccanensis (Lindberg)	rr	rr	rr	r	c	c	rr	rr	ccc	cc	ccc	cc	cc	cc	r	rr	r	r	rr	rr
53 Nauplius larvae	—	—	rr	rr	r	rr	rr	r	ccc	ccc	rr	rr	ccc	ccc	rr	rr	r	r	r	r
54 Diaptomus	rrr	rrr	rrr	rrr	r	r	cc	cc	cc	cc	c	c	r	r	r	r	r	r	c	c
55 Helio-diaptomus cinctus Gur	rrr	rrr	rrr	rrr	—	—	—	—	—	—	—	—	—	—	—	—	—	—	rrr	rrr
56 Harpaticidae	—	—	rrr	rrr	r	r	rrr	rrr	—	—	r	r	—	—	—	—	—	—	—	—
(d) Cladocera.																				
57 Alona Baird	rrr	rrr	rrr	rrr	rrr	—	rrr	rrr	—	—	rrr	rrr	—	—	rrr	rrr	rrr	rrr	rrr	rrr
58 " Affinis	rrr	rrr	rrr	—	—	—	rrr	rrr	—	—	—	—	rrr	rrr	—	—	—	—	—	—
59 " Cf Archeri	rrr	rrr	rrr	rrr	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60 " Chydorus	rrr	rrr	rrr	rrr	—	—	—	—	—	—	—	—	—	—	rrr	rrr	—	—	—	—
61 " macrothrix	rrr	rrr	rrr	—	—	—	..	..	rrr	rrr	rrr	rrr	—	—	—	—	rrr	rrr	—	—
62 " verrucosa	rrr	rrr	rrr	—	—	—	.	—	—	—	—	—	—	—	—	—	rrr	rrr	—	—
63 " camboues	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
64. " intermedia	—	—	—	—	—	—	..	..	—	—	—	—	—	—	—	—	—	—	rrr	rrr
65 Alonella Karua	—	—	—	—	—	—	-	..	—	—	—	—	—	—	rrr	rrr	rrr	rrr	rrr	rrr
66 Bosminopsis cf Pomodi	r	r	r	rrr	—	—	..		—	—	—	—	—	—	—	—	rrr	rrr	rrr	rrr

Table No XVI (contd): Periodicity of the Phyto and Zoo plankton Organisms in the Ajwa Reservoir at Baroda during 1963 & 1964

1963	24-4		24-5		21-6		19-7		30-8		25-9		24-10		29-11		20-12	
Time of collection	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Description	5 30	3 00	4 00	4 00	5 00	5 00	5 00	5 00	5 15	2 30	5 15	3 30	5 25	4 00	5 00	3 40	5.00	3 00
67 Cerodaphnia rigaudi Rich	–	–	rrr	rrr	–	–	–	rrr	–	–	–	–	–	–	rrr	–		
68 Chydorus Barroisi	–	–	–	–	rrr	rrr	–	–	–	–	–	–	r	r	rrr	rrr	rrr	..
69. Daphnia Lumnoltzi	rr	rr	rr	rr	cc	cc	ccc	ccc	ccc	cc	cc	cc	cc	cc	cc	cc	c	c
70 Diaphanosoma Sarsi/junosum Brehm	rrr	rrr	rrr	rrr			–	–	–	–	rrr	rrr	rrr	rrr	–	rrr	rrr	..
71. Dunhe vedia	–	–	rrr	rrr	.	–	rrr	rrr	–		–	–	–	–	rrr	rrr	rrr	rrr
72 Macrothrix Baird	–	–	–	–	–	–	rrr	rrr	–	.	–	–	rrr	rrr	rrr	rrr		
73 Moina dubia Rich	–	–	rrr	rrr	c	c	rrr	rrr	..	–	c	c	c	c	c	c	cc	cc
74 Sida sp	rrr	rrr	–	–	–	–	r	r	.		rrr	rrr	c	c	rrr	rrr	r	c
75 Megascolaris of Porifera	rr	rr	rrr	rrr	rrr	rr	rrr	rr	rrr	r	rr	rr	r	rr	rr	rr	rr	rr

1964	24-1		25-3		28-4		11-6		24-7		28-8		25-9		24-10		27-11		18-12	
Time of collection	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Description	5 00	4 00	5 00	4 00	5 10	6 25	5 10	4 10	5 00	4 00	5 00	4 00	5 00	3 35	5 00	4 45	5 10	4 00	5 00	4 [illegible]
67 Cerodaphnia rigaudi Rich	..	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
68 Chydorus Barroisi	–	r	rrr	rrr	–	–	–	–	rrr	rrr	–	–	–	–	r	r	r	r	r	r
69. Daphnia Lumnoltzi	–	–	rr	rr	c	c	c	c	c	c	cc	cc	cc	cc	cc	cc	r	r	r	r
70 Diaphanosoma Sarsi/junosum Brehm	r	r	rrr	..	–	–	–	–	–	–	–	–	–	–	–	rrr	rrr	–	–	–
71. Dunhe vedia	rrr	rrr	rrr	rrr	rrr	..	–	–	–	–	.	–	–	–	–	–	–	–	rrr	rrr
72 Macrothrix Baird	rrr	rrr	rrr	rrr	rrr	rrr	–	–	rrr	rrr	–	–	–	–	–	–	–	–	rrr	rrr
73 Moina dubia Rich	cc	cc	c	c	c	r	c	c	c	c	–	–	r	r	c	c	c	c	r	r
74 Sida sp	c	r	rrr	r	c	c	–	–	c	c	r	r	r	r	r	rrr	rrr	rrr	rrr	rrr
75 Megascolaris of Porifera	rr	rr	rr	rr	rr	rr	r	r	rr	rr	rr	rr	rr	rr	rr	rr	rr	rr	rr	rr

TABLE NO. XVII.

QUANTITATIVE ESTIMATION OF PLANKTON IN THE SURFACE AND BOTTOM LAYERS OF THE AJWA RESERVOIR ON FOUR OCCASIONS IN 1964

Year - 1964 Description	Date / Time of collection	24- 1 A.M. 5.00	24- 1 P.M. 4.00	28- 4 A.M. 5.10	28- 4 P.M. 6.25	24-10 A.M. 5.00	24-10 P.M. 4.45	18-12 A.M. 5.00	18-12 P.M. 4.00
(I) NUMBER OF ORGANISMS PER LITRE FOUND AT THE SURFACE									
A. PHYTOPLANKTON									
(a) Chlorophyta		11	10	101	110	61	71	10	50
(b) Euglenophyta		1	1	-	-	10	15	1	4
(c) Chrysophyta		20	18	29	69	34	65	107	107
(d) Cyanophyta		20	10	111	124	20	20	0	0
	T o t a l	52	39	241	303	125	171	118	161
B. ZOO-PLANKTON									
(e) Protozoa		12	12	30	20	2	2	3	3
(f) Rotifera		301	150	1840	1340	743	445	234	171
(g) Copepoda		14	16	311	161	161	121	182	172
(h) Cladocera		418	200	263	423	423	366	153	153
(i) Porifera (megascaleres)		10	15	25	50	50	60	10	10
	T o t a l	755	393	2469	1994	1379	994	582	509
(II) NUMBER OF ORGANISMS PER LITRE FOUND AT THE BOTTOM									
A. PHYTOPLANKTON									
(a) Chlorophyta		7	11	12	10	26	10	5	12
(b) Euglenophyta		4	5	32	46	22	26	36	4
(c) Chrysophyta		5	2	18	21	13	14	11	13
(d) Cyanophyta		10	5	0	0	4	2	6	4
	T o t a l	26	23	62	77	65	52	58	33
B. ZOO-PLANKTON									
(e) Protozoa		26	58	11	10	26	12	8	12
(f) Rotifera		524	742	3640	4260	1870	2010	829	1080
(g) Copepoda		120	250	164	380	179	158	58	110
(h) Cladocera		63	158	163	240	78	85	74	98
(i) Porifera (megascaleres)		400	510	350	320	360	400	127	210
	T o t a l	1133	1718	4328	5200	2513	2665	1096	1510

TABLE NO. XVIII

BACTERIOLOGICAL CONDITIONS IN THE SURFACE WATER OF THE AJWA RESERVOIR DURING 1963 & 1964

(Results expressed in MPN per 100 ml.).

1963	24- 4		24- 5		21- 6		19- 7		30- 8		25- 9		24-10		29-11		20-12	
Tests	A.M. 5.30	P.M. 3.00	A.M. 4.00	P.M. 4.00	A.M. 5.00	P.M. 5.00	A.M. 5.00	P.M. 5.00	A.M. 5.15	P.M. 2.30	A.M. 5.15	P.M. 3.30	A.M. 5.25	P.M. 4.00	A.M. 5.00	P.M. 3.00	A.M. 5.00	P.M. 3.00
Coliforms	43	43	23	23	30	30	39	150	43	93	3.6	23	43	23	43	23	75	23
E. Coli (Type I)	Nil	Nil	Nil	Nil	Nil	Nil	9.1	15	3.6	3.6	Nil	3.6	3.1	Nil	9.1	3.6	Nil	Nil
Faecal Strepto-cocci	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	3.0	3.0	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

1964	24- 1		25- 3		28- 4		11- 6		24- 7		28- 8		25- 9		24-10		27-11		18-12	
	A.M. 5.00	P.M. 4.00	A.M. 5.00	P.M. 4.00	A.M. 5.10	P.M. 6.25	A.M. 5.10	P.M. 4.10	A.M. 5.00	P.M. 4.00	A.M. 5.00	P.M. 4.00	A.M. 5.00	P.M. 3.35	A.M. 5.00	P.M. 4.45	A.M. 5.10	P.M. 4.00	A.M. 5.00	P.M. 4.00
Coliforms	39	23	43	23	30	3.6	15	3.6	15	3.6	23	29	43	93	3.6	9.1	23	23	3.6	7.[illegible]
E. Coli. (Type I)	3.6	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	23	3.6	3.6	9.1	Nil	Nil	23	Nil	Nil	Nil
Faecal Strepto-cocci	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	3.6	Nil	3.6	Nil	Nil	Nil	Nil	Nil	Nil