Thermal Characteristics of Mansar Lake, District Udhampur, Jammu and Kashmir

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ABSTRACT

Thermal characteristics of Mansar Lake located east of Jammu city in the Siwalik terrain is studied. Monthly surface water temperature from seven locations and depth-wise temperature from three locations at 3m depth interval (surface to bottom) during August 1998 to July 1999 were used in the analysis. Lake surface water temperature varies from minimum 14°C in January to maximum 31°C in the June/July. The depth versus temperature plots of the study period depict the seasonal and depth-wise changes in the temperature distribution in the lake.Temperature is found decreasing with depth from April to November, while uniform temperature conditions are observed during December, January and February. This variation in temperature at different depths reveals that Mansar lake undergoes two distinct stages namely complete mixed stage (December-Februrary) and a stratified stage of minimal vertical mixing (April – November).

INTRODUCTION

The response of each lake basin to external conditions (hydro-meteorological processes) is revealed in the first place by the thermal structures present in the water body. Temperature variation in lake is most important phenomenon. A study of monthly variations in the depth-wise temperature characteristics of any lake explains the process of vertical water movements within the lake. The vertical temperature profile of lake is a direct response to the penetration of solar radiation. In general the heat transfer at the water surface tends to raise its temperature during summer and lower during winter. Therefore, the temperature difference at the top and bottom develops stratification in the lake. The upper warm region, mixed thoroughly by wind to a more or less uniform temperature, is the epilimnion. At the bottom lies a colder region of heavier water little affected by wind action and therefore, traditionally considered stagnant. This is the hypolimnion. Separating the two lake regions of more constant temperature is an intermediate zone, where temperature drops rapidly with increasing depth. This is the thermocline or metalimnion. During winter when the top layers become cooler in comparison of deeper, the sinking process starts which has greater mixing effect. Thus, the lake of medium depth undergoes complete mixing process and remains well mixed during winters.

Many factors influence lake water temperature, including seasonal air temperature, water depth, groundwater inflow, stream flow, mixing due to wind and water currents,

and the amount of sunlight and shade. Water temperature plays an important role in aquatic ecosystems. It limits the migration, spawning, egg incubation, growth, and metabolism of aquatic organisms. Each aquatic organism has an optimal temperature range for its metabolism. Water temperature also affects lakes indirectly by influencing DO concentrations.

A large number of natural fresh water lakes exist in Himalayan region. These lakes are a source of water for a variety of purposes such as irrigation, drinking, pisciculture and recreation. Further, these lakes play a significant role in maintaining the hydrological, ecological and environmental balance of the region. In recent years, the impact of human activities on lakes has been acutely felt throughout the Himalayan region. Indiscriminate construction activities in the lake catchments and untreated disposal of waste and pollutants have accelerated the eutrophication process of the lakes, which is resulting in deterioration of water quality. Any change in the lake water, both in quality and quantity, will certainly hamper the development of the area.

Mansar Lake attracts religious pilgrim and tourists and is being used as a source of water for drinking and irrigation. In order to develop tourism in the area, a large number of construction activities have taken place in the lake catchment. Increasing impact of local residents and tourists is causing ecological imbalance due to deforestation in the lake catchment and inflow of domestic wastes etc. into the lake. In the present study, attempt has been made to study the thermal behaviour of Mansar lake.

STUDY AREA AND DATA USED

Mansar Lake (longitude 75° 05' 11.5" to 75° 5' 12.5" E and latitude 32° 40' 58.25" to 32° 40' 59.25" N) is located 60 km east of Jammu city at an elevation of 666m a.m.s.l. in the Siwalik terrain. The bathymetric survey of the Lake indicated that the Lake has a surface area of 0.59×106 m2 at present outflow level, has a maximum depth, length and width of 38.25m, 1204m and 645m, respectively. The lake mean width is 490m and mean depth is 21m. The mean slope of the lake floor is 0.14m.m-1. The storage capacity of the lake up to present outflow level is 11.57×106 m3 (Rai et al., 2002; Kumar et al.,2006). Climatically, the area is subtropical. Monsoon rains are received from June to September and the winter rains during January to March. The average annual rainfall is 1500mm; the air temperature varies between 3°C (minimum) in winter to 43°C (maximum) during peak summer. The lake has a small catchment area of 1.67×106 m2. Northern and eastern sides of the lake are covered by habitation, and some agricultural fields exist on western flank. The southern flank is covered by forest on a hill slope. There is no well-defined surface inflow channel into the lake. Rainwater enters the lake as overland flow. A piped outlet has been constructed near Sesnag Temple to drain the excess water from lake to a small tributary of the Tawi River. State Public Health Engineering Department pumps water from the lake for supply to the local habitation. Also, water drains out from the lake through five pipes inserted at different depths in the embankment. Lake water level varies between 1.5m to 2m in a year.

Geologically, the Mansar Lake catchment is composed of fine-grained sandstone alternating with silt stone, mudstone and clay of the Lower Siwalik. Both the Mansar and Surinsar (a nearby lake) lakes are located at the crestal part of the WNW-NW to ESE-SE trending sub-horizontal anticlinorium. Associated with upright fold plunging 5° towards S52°E, the NNE-SSW trending faults have displaced the anticlinorial axes at several places (Singh and Sharma 1999) and are responsible for the crushed nature of the Lower Siwalik. These crushed rocks form the porous and permeable zone for recharge of the lakes. Rai et al. (2007) have estimated the sediment rate of Mansar Lake.

Data set consists of Monthly surface water temperature from seven locations (S1 to S7 in Fig. 1) and depth-wise temperature from three locations (C1 to C3 in Fig. 1) at 3m depth interval (surface to bottom) during August 1998 to July 1999. This data was collected under J&K State Pollution Control Board, Govt of J&K sponsored project entitled 'Limnological study of the Mansar Lake, District Udhampur, J&K' carried by Western Himalayan Regional Centre of NIH (Rai et al., 2001). Monthly water samples from the lake were collected using Standard Water Sampler and In-situ temperature was measured using in-built thermometer of sampler.

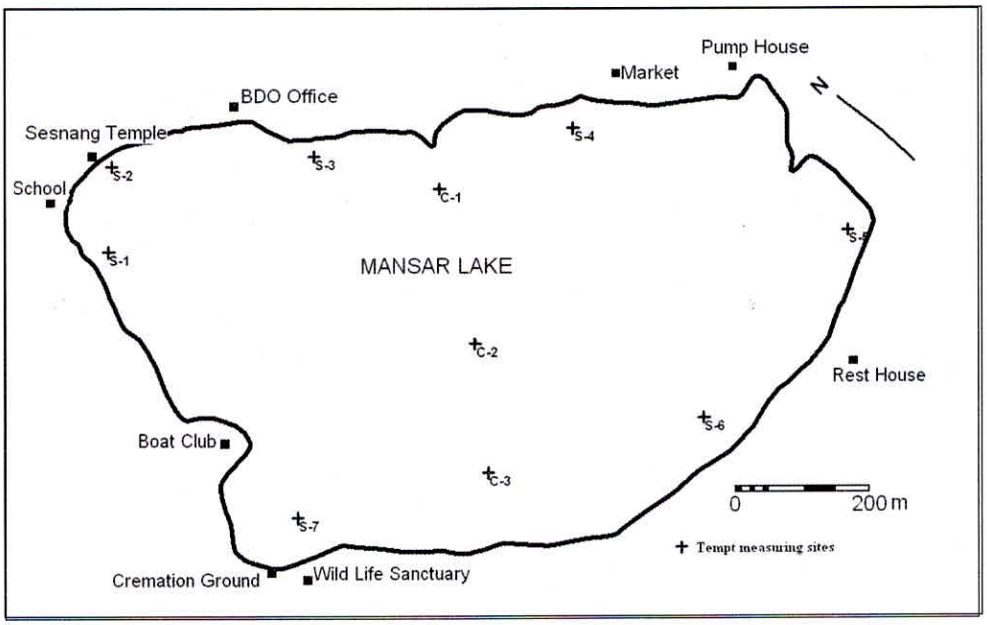

Fig. 1 : Location of temperature measuring sites in Mansar lake.

RESULT AND DISCUSSION

Fig. 2 shows the monthly variation of Lake surface water temperature. Lake surface water temperature varies from minimum 140C in January to maximum 310C in the June/ July. The surface water temperature starts decreasing from the month of September

onwards and continues dropping till January when it attains minimum tempearture. From the month of February onwards, it starts rising and continues rising till June/July. The maximum temperature was observed in the month of June/July. The month of August and September indicated almost same surface water temperature which is about 1-20C below the surface water temperature recorded in month of June/July.

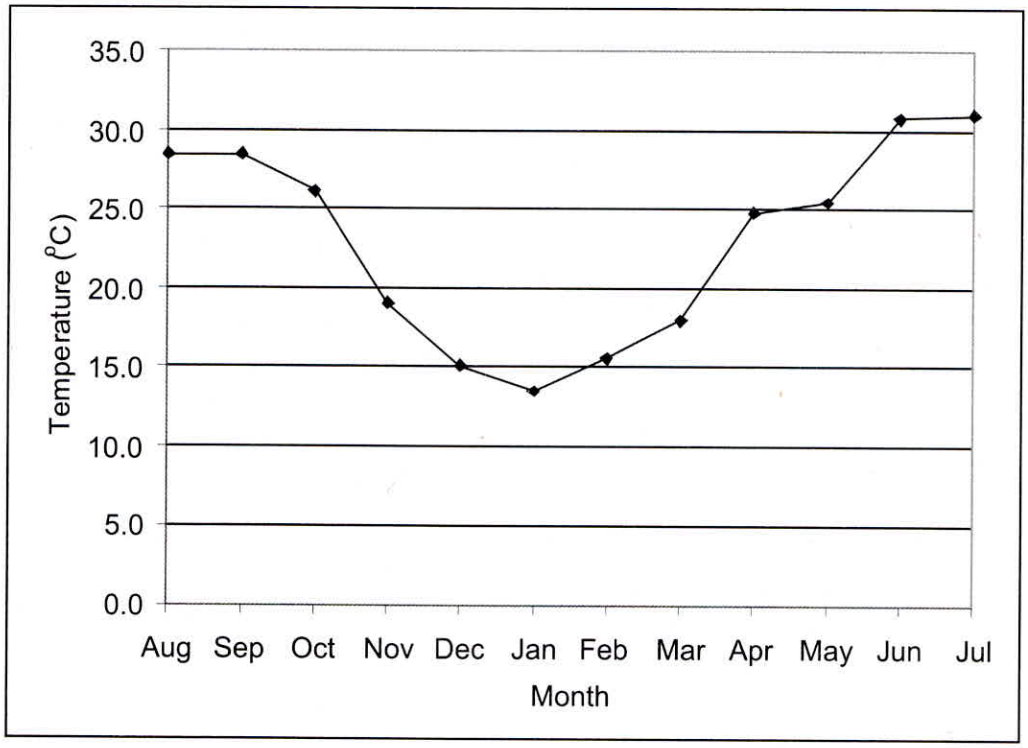

Fig. 2 : Monthly variation of surface water temperature in Mansar Lake

The depth versus temperature plots (Fig. 3 to 5) of the study period (August'98 to July'99) depict the seasonal and depth-wise changes in the temperature distribution in the lake. Depth-time isopleths of temperature of Mansar Lake are presented in Fig. 6. Table 1 gives the monthly variation of depth-wise temperature . Please note that the values in Table 1 are average temperature values of three sites. Depth-wise temperature variation reveals that temperature is decreasing with depth from April to November. In these months the upper, relatively warm and wind mixed layer called epilimnion occurs upto 6 m depth and below epilimnion, temperature decreases rapidly between 6 to 12 m depth and this plane of maximum temperature change is called thermocline. The zone lying below 12m depth, relatively cold layer that is not mixed by wind comes under the hypolimnion. The temperature difference of about 160C has been monitored from April to November from lake surface water to bottom. For a difference of 10 0C temperature between two depths in the water columns, the density difference would be 0.0018 (Bhar,

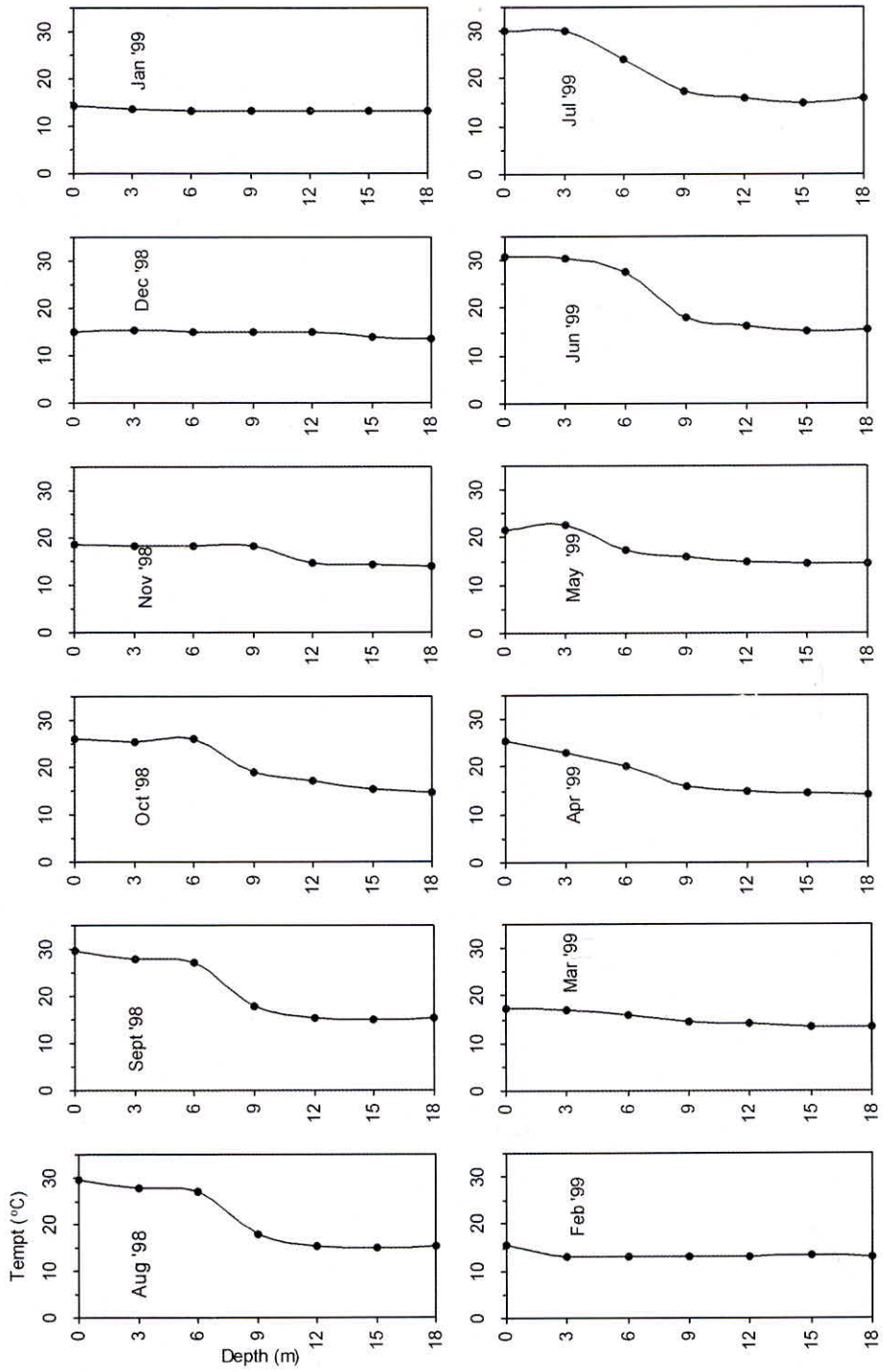

Fig. 3: Depth-wise Variation of Temperature in Mansar Lake at C1 Location

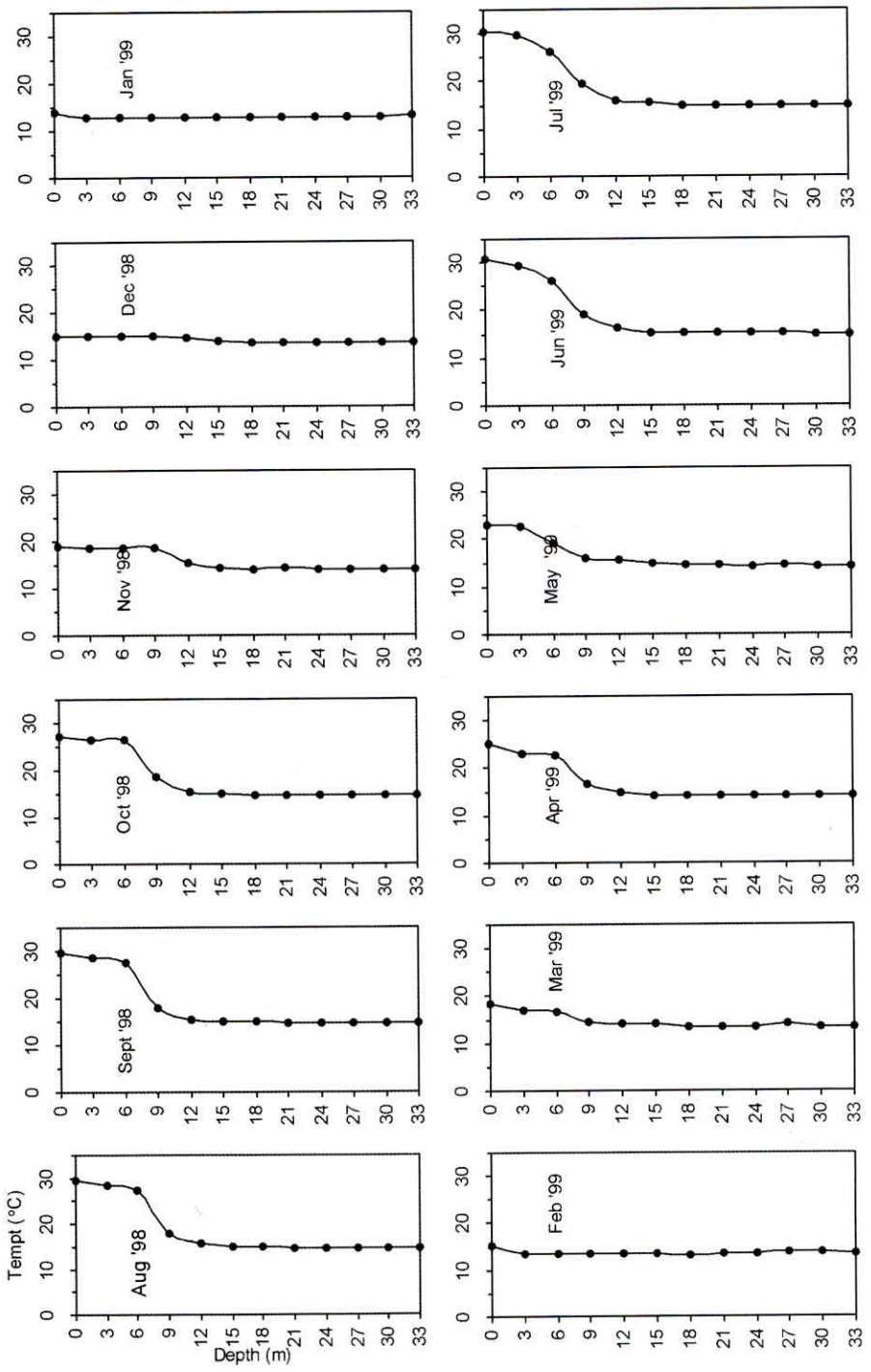

Fig. 4: Depth-wise Variation of Temperature in Mansar Lake at C2 Location

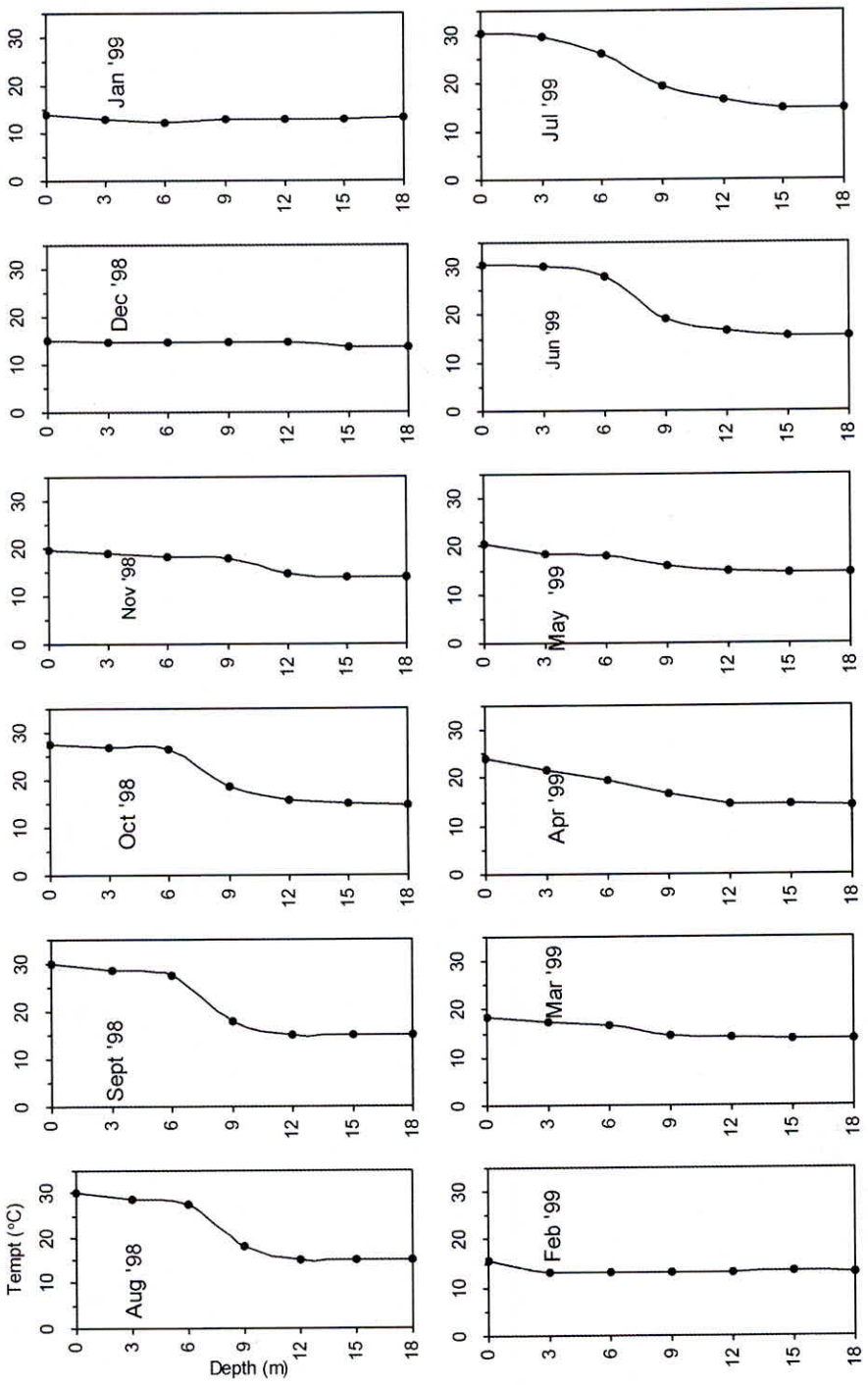

Fig. 5: Depth-wise Variation of Temperature in Mansar Lake at C3 Location

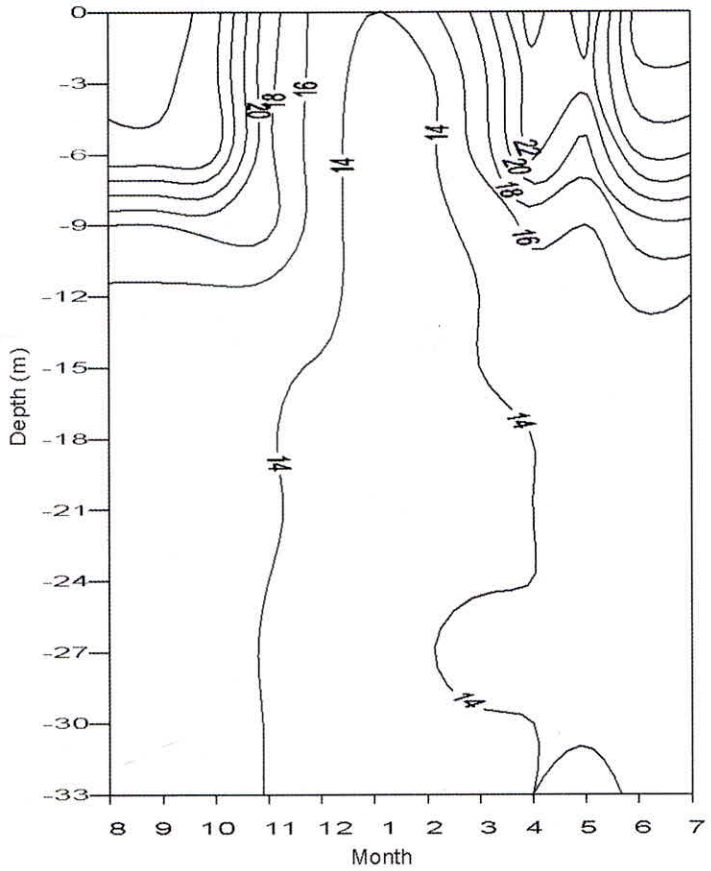

Fig. 6: Depth-time isopleths of temperature (C) of Mansar lake during Aug '98 to July '99

Table 1 : Monthly variation of depth-wise water temperature (^{0}C) in Mansar Lake

Depth (m)	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Avg
0	29.7	29.7	26.8	19.0	15.1	14.1	15.6	18.2	24.8	21.7	30.7	30.3	23.0
3	28.3	28.3	26.3	18.6	15.1	13.1	13.2	17.2	22.5	21.2	30.0	29.8	22.0
6	27.3	27.3	26.3	18.3	14.9	12.7	13.2	16.3	20.7	18.2	27.1	25.3	20.6
9	18.0	18.0	18.7	18.3	14.9	13.0	13.2	14.5	16.3	16.0	18.7	18.8	16.5
12	15.3	15.3	16.0	14.9	14.9	12.9	13.2	14.0	14.8	15.2	16.3	16.2	14.9
15	15.0	15.0	15.1	14.3	13.8	13.0	13.3	13.8	14.3	14.7	15.4	15.2	14.4
18	15.2	15.2	14.8	14.0	13.5	13.0	13.1	13.6	14.0	14.5	15.5	15.3	14.3
21	14.5	14.5	14.8	14.2	13.5	13.0	13.4	13.5	14.0	14.5	15.3	15.0	14.2
24	14.5	14.5	14.8	14.0	13.4	13.0	13.5	13.5	14.0	14.0	15.3	15.0	14.1
27	14.5	14.5	14.8	13.8	13.4	13.0	13.7	14.0	14.0	14.5	15.1	15.0	14.2
30	14.5	14.5	14.8	13.9	13.4	13.0	13.7	13.5	14.0	14.0	15.0	15.0	14.1
33	14.5	14.5	14.8	13.9	13.4	13.2	13.6	13.5	14.0	14.0	15.0	15.0	14.1

1995-96). This difference in density results into quite stable thermal stratification and lake remain stratified during April to November.

The stable stratification that persists during summer and monsoon months tends to become unstable during early winter (December), mainly due to falling of air temperature resulting in net heat loss from the lake. Uniform temperature conditions from surface to bottom in lake water during January and February reveal that during this period strong vertical mixing (convection) takes place and lake may be considered as well mixed as there is negligible difference in the temperature of surface and the bottom waters. The process of convection, coupled with the increased action of wind results in the deepening of surface layer (sinking of metalimnion) and complete mixing of lake takes place. This final phenomenon is called "winter overturn" which takes place in Mansar lake during January and February. During spring (March), as consequence of rise in air temperature thermal stratification starts and establishes in April (Fig. 3 to 5). With the advent of summer and increase in solar radiation, the stratification gets intensified. Therefore, Mansar lake undergoes two distinct stages namely complete mixed stage and a stratified stage of minimal vertical mixing and can be classified as warm monomictic.

CONCLUSIONS

Water temperature of a lake affects various factors such as dissolved oxygen, life of aquatic species and water quality. The formation of thermal stratification leads to decrease of dissolved oxygen in water especially at the bottom of the reservoir. If this stratification stabilizes for a long time, it will threaten the lake water quality. Temperature variation in the lake clearly shows that in winter months Lake become mixed and remains stratified from April to November. In these months, epilimnion occurs upto 6 m depth, thermocline between 6 to 12 m depth and the zone lying below 12m depth is the hypolimnion zone.

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