ENVIRONMENTAL IMPACT ASSESSMENT OF TOURISM :
A CASE STUDY OF DAL LAKE (KASHMIR)

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ABSTRACT : The paper studies the impact of tourism on the environment of Dal lake in Kashmir. The investigation includes physical setting, silting and areal shrinkage and the hydrological features of the lake which take into account the variable depth and volume of water and the changes in the environmental conditions of the lake. The quality of water is examined with respect to its temperature, transparency and pH value at different depths. There is a evidence of definite decline in the quality of lake water, heavy siltation and the shrinkage of the lake. Some remedial measures are also suggested.

The importance of ecological equilibrium has been increasingly realised during the present times when certain valuable natural resources have got extinct due to fast expansion of economic activities. Increasing population pressures and other allied forces have encroached upon various fragile ecosystems like water bodies, sensitive landscape, wildlife reserves and core forest zones which are more vulnerable to ecological modifications. It is therefore a matter of grave concern to evolve the conceptual framework into positive remedial action so as to manage the ecosystem rationally and have harmoneous growth of both economy and ecology. On this back/drop a study has been conducted for Dal Lake to assess the environmental changes that have occurred through various ongoing economic activities.

The valley of Kashmir has assumed tremendous importance for its innumerable natural fresh water bodies which are situated at an altitude varying from 1600 to 4500 metres. These are of great economic importance from fishery point of view, for their recreational value and for supplying portable water. In view of the socio-economic significance, detailed limnological studies of Kashmir lakes have been carried out by Hutchinson (1957), Das and Subla (1964), Zutshi and Vass (1970, 1977), Zutshi, et al., (1980), Subla, et al. (1984), Raza and Bano (1986) and Tiku (1989).

The lakes situated within the Jhelum basin are at an average altitude of 1850 metres receive large quantities of pollutants as a result of increase in human settlements, tourist pressure and other associated activities in their catchment areas. Some of the pollutants add disagreeable odour or taste to the water and others, significantly upset the ecological balance. One of the valley lakes that has been greatly disturbed is Dal lake.

Among the urban Himalayan lakes Dal Lake is one of the famous ones surrounded by lofty mountains and Moghal gardens which form a

nodal point for the tourist industry of Jammu and Kashmir. But due to its urban character, the lake has become the storage tank for all pollutants generated by neighbouring areas and those who live near and on the banks of lake, including the refuge of tourism. There are about 90 hotels ranging from two to five star, 370 four-bed-room and 164 two-bed-room houseboats, more than 2000 boats and about 65 diesel based motor launches dependent on lake tourism (Directorate of Tourism 1989). These are all in operation during the tourist season to cater to tourist services on the one hand and add contaminants to the lake on the other. Thus the study of assessing the degree of tourism impact on the water quality also becomes essential for the future planning.

The Dal lake is an ideal ecosystem for an environmental impact analysis of rapid economic development on micro scale. The lake though a small one yet plays an important role in the socio-economic life of the valley. It is one of the ingredients of valley's economy and has been exhibiting indications of complex deterioration. Already the lake has shrunk by half during the last 50 years and the present open water area of 11.7 km² is but a remnant of once extensive lake. It has been estimated that the lake receives about 64 acre feet of silt annually (Raza & Bano, 1984), thus aggravating further the problem of siltation. This sorry state of affairs has been brought about by purely anthropogenic factors, specially excessive and irrational exploitation of its resources. Some of these factors are :-

(i)   Deforestation of catchment hillsides and irrigational landuse practices.

(ii)   Agricultural activities on floating gardens and its resultant heavy nutrient loading.

(iii) Extensive soil erosion in the surrounding hillsides leading to siltation of the lake basin.

(iv)   Increasing population pressure requiring more reclamation of the lake.

(v)   Rapid urbanization of the foreshore area.

(vi)   Direct discharge of raw sewage from the houseboats and hotels.

(vii) Luxuriant and rapid weed growth and increasing bacterial activity.

Among various factors responsible for deterioration of the lake, the wash off dissolved compounds of different chemical fertilizers used in paddy fields of the peripheral areas of Habak, Telbal, Pazzalpora, Nishat, Brain and Jogilanker etc. (Kaloo, 1988) are most damaging. Besides the deterioration in the chemical properties of water, it also suffers from a high degree of micro-biological pollution. In breaking down organic matter, micro-organisms reduce the dissolved oxygen levels in water body (Smith, 1986) and would hence increase the biochemical oxygen demand (BOD). The increase of BOD and bacterial count renders the water unsafe for drinking purpose (Pawar, et al. (1987). The present study also attempts to examine the state of eutrophication in Dal lake in terms of certain components such as physical, chemical, biological and human that have directly or indirectly changed the economic and ecological viability of the lake. The indicators that have been used are :-

(a)   water quality as reflected in temperature, transparency, pH value and total alkalinity;

(b)   sedimentation and water level in terms of lake depth.

DAL-LAKE - PHYSICAL SETTING

The lake is situated in the north-east of

Srinagar, bounded on the east by Mahadev mountain range, on the south by Kohi-Sulaiman with the geographical co-ordinates of latitude 34° 07' North and longitude 74° 52 East. The lake is multibasined with a maximum depth   of 3.5 metres and open water area of 1100 hectares (Kawosa, 1988). It is being fed by a stream 'Telbal Nalla' from north which brings water from high altitude Marsar lake. During the downward journey, the stream collects large quantities of silt from the denuded catchment area and deposits it in the northern basin of the lake. Towards the south-western side an outflow channel discharges the lake water into a tributry of Jhelum river. A small canal 'Nalla Amir Khan' connects the dal with Anchar lake and acts as an additional outflow channel.

MORPHOMETERIC CHARACTERISTICS

The total catchment area of the lake is about 317 km² and can be divided into five sub-catchments. The major one is Dachigam-Telbal which alone is spread over 228 km², constituting about 72 per cent of the total area

followed by lake Hillside 14.83 per cent. Dal lake 6 per cent and Srinagar, North and South 4 and 3 per cent respectively.

Various degrees of encroachments have converted a large portion of the Dal lake into floating gardens, marsh lands and lands. This has also led to the bifurcation of the lake into four sub-lakes namely, Hazratbal, Bod Dal, Lokut Dal and Nagin (Table 1 : Fig.1).

AREAL EXTINCTION - SHRINKAGE

Dal lake has been shrinking vertically as well as horizontally at a steady rate during last few decades. As per the available records, the lake has shrunk from 24 km² in 1875 to 11.7 km² in 1978 with a net open water areal loss of 12.3 km2 (Drew, 1875) Gazetteer of Kashmir and Ladakh, 1872; Lawrence, 1995; Stein, 1899 and ENNEX, 1978).

The shrinkage of the lake is attributed to various encroaching forces that have emerged mainly in the form of agricultural sprawl in the lake activated on floating gardens and by the people who have commercialised the lake in the name of tourism. The former relates to those who have already occupied some space

Table I

Geographical divisions of Dal lake

Subdivision	Average depth (m)	Open water	Floating gardens	Marsh	Land
Hazratbal	1.5	5.6	1.5	1.3	0.4
Bod-Dal	3.0	4.5	2.4	1.3	0.01
Lokut Dal	2.5	1.6	-	-	1.0
Nagin	3.4	0.7	0.3	0.3	1.10
Total	-	12.4	4.2	2.9	1.51

Source : ENNEX (1978).

DAL LAKE – ITS ENVIRONS
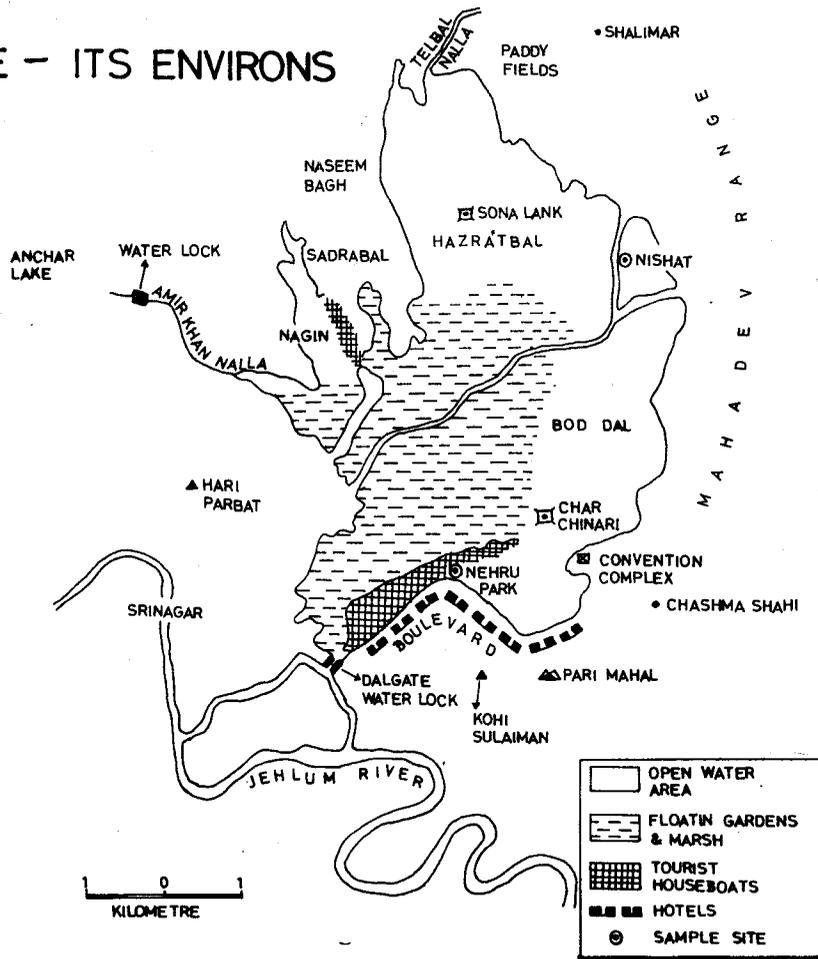
in the lake for residential purposes and are now exploting the lake thorugh various agricultural typologies, while the latter signifies that amount of space that has been converted into houseboat colonies, boat beats and other allied tourist activities.

HYDROMETERIC ANALYSIS AND SILTATION

Hydrological characteristics and hydrometric analysis is an essential component of aquatic ecosystem study as it helps in assessing the magnitude of the lake in terms of volume, water level, depth, recharge and discharge dynamics and process and rate of siltation.

Since the lake is multi-basined in nature, the ratio of open water area is highly varied among the various basins. The total volume of water in the lake is estimated at about 14.0 million cubic metres (Table II).

The lake is very shallow with an average depth varying from 1.5 to 2.0 metres, though at certain places viz; Nagin, Sadarbal, Sonalank and Karapur, it even exceeds 3.5 metres. It also fluctuates seasonally due to change in water level which is a function of amount of rainfall, silt load and stream flow (Table V). The monthly recorded observations reveal that a maximum depth of 3.1 metre was in

Table II :

Hydrological characteristics

Characteristics	Boulward	West of Bod-Dal	Gagri-bal	Bod-Dal	Hazrat-bal	Total
Open water	0.3	0.3	1.3	4.2	5.6	11.7
Average depth (metres)	2.0	2.0	1.9	1.7	1.5	-
Maximum depth (metres)	2.0	2.0	2.6	2.6	3.5	-
Volume (10^6 m^3)	0.6	0.6	2.5	7.1	3.4	14.0

Source : ENNEX - (1978).

June which corresponds to high water input through feeding stream and a minimum of 1 metre was observed in March which is due to low rate of water recharge during winters.

The correlation coefficients were computed between water level and its determinents which indicated a positive relationship for all variables, in which the rainfall was detected to be the main factor for three consecutive years with ($r_1 = 0.63, r_2 = 0.30, r_3 = 0.15$). Correlation values were tested and found significant at 5.50 and 50 per cent levels respectively. A positive links were also registered with the silt load ($r = 0.14$) and stream flow ($r = 0.42$) with a significance level of 50 per cent each at (n-2) = 10 degrees of freedom (Table VII).

Siltation is another factor which may fill up the lake gradually and convert it progressively shallower and would lead to a situation when lake may become totally marshy or disappear from the landscape. Eutrophication, the other process in which biomass would consequently increasse within the lake and give rise to vertical shrinking of the lake. As there are three major catchments feeding the lake viz., Dachigam-Telbal, Lake Hillside and Srinagar, north. The Dachigam Telbal Catchment alone accounts for about 72 per cent of the area. In the present study, the silt load has been estimated for the same catchment because it is most densely populated area and especially rural in character. The catchment receives high amount of silt load from the Dachigam side in addition to the high amount of impurities generated by the local dewellers through agricultural activities. It is estimated that about 80,000 tons (64 acre feet) of silt through Telbal Nallah enters annually into the lake. Computing the age of Dal on the basis of silt accumulation which results from Telbal nalla alone, the age works out to be 480 years. This is based on the assumption that all the parameters of the Telbal Nalla and Dachigam remain constant. The period will be further reduced if the role of other catchments is also considered.

CHEMICAL CHARACTERISTICS OF WATER

There are a number of processes active in water body especially eutrophication, siltation and sedimentation and input of sewage through sewers, which change the lake metabolism in one way or the other. During the present study, only the role of tourism has been

mainly assessed in changing the chemical characteristics of Dal waters.

The sample sites viz., Nehrupark and Nishat were selected from the main basins of Dal lake with reason that both are characteristically different from each other (Fig.1). The former was selected because of tourist dominated area while the latter site is relatively less affected by the tourists. Nehrupark is situated along Bouleward side where the degree of houseboat concentration is very high and maximum number of hotels with high bed capacity are located. Almost all special boat terminals are dotted on the same side near Nehrupark.

Water samples from the above two selected sites were collected monthly from September 1988 to August 1989 to assess the impact of tourist activities on lake water characteristics. The parameters selected were temperature, transparency, pH value and alkalinity. Further more, correlation coefficient was worked out for each variable with that of tourist influx so as to examine whether change in tourist flow does create any change in the chemical behaviour of water. Such relationship was computed only for one sample site that is mostly attected by tourist activities. The hypothesis was formulated as Y_1, Y_2, Y_3, Y_4, Y_5, Y_6 = f(x) where Y_1, Y_2, Y_3, Y_4, Y_5 and Y_6 represents temperature, transparency, pH(surface), pH (bottom), alkalinity (surface) and alkalinity (bottom) respectively, 'x' was considered as independent variable representing tourist flow. The 'r' vlues were computed using the Karl Pearson's method give by :

$$r = \frac{\Sigma xy - \dfrac{\Sigma x . \Sigma y}{N}}{\sqrt{\Sigma x^2 - \dfrac{(\Sigma x)^2}{N}} \times \sqrt{\Sigma y^2 - \dfrac{(\Sigma y)^2}{N}}}$$

and 't' test was applied to the computed 'p'

values given as

$$1 \, t \, 1 = r \sqrt{\frac{n-2}{1-r^2}} \text{ at } (n-2) \text{ degrees of freedom}$$

where (Y_1, Y_2.....Y_6) are dependent variables and 'x' the independent variable.

n = number of months taken into account.

After calculating the relationship coefficients, each parameter is discussed separately as under -

TEMPERATURE

Aquatic ecosystems are more vulnerable to change in its character if it assumes any thermal fluctuations. The temperature variations have very significant role to play in the biological organisation of the lakes by controlling the rate of photosynthesis and other ingredients of organic life. There is hardly any spatial change in temperature other than a temporal one that occurs during various seasons. There is only a difference of 1°c which is higher at tourist affected area and lower at tourist free area. Maximum temperature of 30°c was recorded in July at Nishat whereas at Nehrupark it was 31°c in the same month (Table III). This difference of 1°c in the temperature at two places can be attributed to the change in tourist influx, as the excessive number of tourists add more contaminants to lake water which in turn increase the water temperature by way of enhancing its density. Near Nehrupark the temperature depicts a positive correlation (r = 0.8255) with the tourist flow and is significant at 1 per cent level which corresponds to 99 per cent confidence interval (Table VIII).

TRANSPARENCY

The transparency of water is an important aspect of water quality especially because of

Table III

Indicateors of Water Quality Recorded at Sample Sites

S. No.	Months/ /year		Depth (meters)	Tempe- rature (°c)	Transp- arency (Secchi value)
1.	Sept. 1988	x	1.90	27	0.95
		y	2.30	29	1.0
2.	Oct. 1988	x	1.20	20	1.10
		y	2.00	20	1.25
3.	Nov. 1988	x	2.00	5	1.50
		y	2.15	5	1.50
4.	Dec. 1988	x	2.11	3	2.50
		y	1.75	3	2.80
5.	Jan. 1989	x	1.75	5	2.40
		y	1.30	3	2.45
6.	Feb. 1989	x	2.0	6	2.50
		y	2.10	7	2.00
7.	Mr. 1989	x	1.00	12	2.10
		y	1.00	12	2.00
8.	April 1989	x	2.00	20	1.75
		y	1.95	21	2.00
9.	May 1989	x	3.00	22	0.80
		y	3.25	23	2.00
10.	June, 1989	x	3.10	21	0.50
		y	3.18	29	1.50
11.	July, 1989	x	2.85	31	0.95
		y	2.90	30	1.20
12.	Aug. 1989	x	2.00	29	0.75
		y	2.00	27	1.40

x = Nehrupark, y = Nishat.

Table IV

Chemical Characteristics of Sample Water at two sites

S. No.	Months/ /year		Hydrogen-ion Conoentration		Total alkalinity (mg/1)	
			Surface	Bottom	Surface	Bottom
1.	Sep. 1988	x	7.2	8.7	65	102
		y	7.7	7.2	102	160
2.	Oct. 1988	x	8.5	8.8	72	101
		y	7.8	7.5	92	105
3.	Nov.1988	x	7.9	8.9	58	103
		y	7.9	8.2	98	102
4.	Dec. 1988	x	8.9	8.8	69	106
		y	8.6	8.0	86	95
5.	Jan. 1989	x	7.2	7.1	78	95
		y	7.2	8.1	92	105
6.	Feb. 1989	x	7.5	7.2	55	59
		y	7.8	8.0	57	80
7.	Mar.1989	x	8.2	9.2	62	70
		y	7.9	9.0	60	89
8.	Apr.,1989	x	8.5	9.0	70	89
		y	8.9	9.1	100	109
9.	May, 1989	x	8.9	9.1	65	87
		y	8.9	9.0	109	105
10.	June, 1989	x	8.5	9.0	68	105
		y	7.2	9.0	72	105
11.	July	x	9.0	9.2	125	102
		y	8.9	9.0	75	108
12.	Aug.1989	x	9.5	9.8	121	101
		y	9.0	9.2	82	92

x = Nehrupark, y = Nishat.

the reason that it determines the rate of photosynthesis on the one hand and water oriented sports on the other.

A major factor affecting this quality is the discharge from point sources particularly sewage in terms of waste carried by sewers. It contains in addition to suspended silt load in water, household domestic waste, water from housesboats, hotels, other commercial establishments and run off from the streets. The transparency value of Dal lake undergoes a change both spatially as well as temporally. Secchi values fluctuated within the period of one year at both the sites. The highest value of 2.80 metres was observed during December at Nishat and 2.50 metres at Nehrupark (Table III). These values were found to be lower at tourist free area than tourist affected area.

From the above observation it looks that tourist flow has a direct bearing on the water transparency as there is a consequent decrease in secchi value with the increase in tourist flow (Table VI). A strong negative correlation ($r = -0.9819$ was found between the two variable and the values were significant at 1 per cent level (Table VIII).

HYDROGEN ION CONCENTRATION (PH)

pH value is one of the strong indicators of water quality which represents interrelated result of a number of chemical equilibria (Hem, 1970). It is the indicator of pollution by waste products and may produce adverse effect on

Table V

Dal Lake - Water Level and its determinents

Months	Water level (cm)			Rainfall (mm)			Silt load $\times 10^6$ m^3	Average streamflow (cusecs)
	1974	1975	1976	1974	1975	1976		
	y^a	y^b	y^c	x_1^a	x_1^b	x_1^c	x_2	x_3
Jan.	210	213	225	58.2	26.4	58.5	1.0	81
Feb.	210	216	237	70.8	28.1	131.8	1.3	116
Mar.	219	237	255	62.4	126.0	143.2	2.7	159
April	237	246	252	50.6	107.8	62.2	6.4	624
May	231	270	249	78.9	159.6	56.2	7.4	601
June	234	252	246	139.2	29.6	91.8	5.9	512
July	237	240	243	77.8	137.3	53.1	5.2	396
Aug	219	240	237	35.6	262.2	230.6	5.7	472
Sept.	210	222	240	12.8	84.4	85.5	3.4	311
October	210	222	231	18.2	11.2	60.2	1.6	132
Nov.	210	222	219	27.6	10.2	10.2	1.1	96
Dec.	210	222	210	36.3	0.8	19.9	0.7	60

aquatic life by altering the availability of plant nutrients. Standards have been suggested for acceptable pH levels for different uses. For drinking purpose the pH should be in the range of 7 to 8.5 (Prasad and Ayer, 1983). pH level less than 6.5 or more than 9.2 makes the water excessively acidic or alkaline for human consumption. A range of 5.0 to 9.0 has been suggested for primary contact recreation and public water supply intake. For fresh water aquatic life a range of 6.0 to 9.0 and for areas extensively used for bathing a ranging of 6.5 to 8.3 have been recommended.

On an average, Dal lakes suffers from high range of pH ranging from 7.0 to 9.8 and varies from basin to basin. The lake has also assumed vertical stratification in terms of pH as it shows fluctuation from surface to bottom. The study revealed an alkaline pH range throughout the present investigation. Hydrogen ion concentration of surface and bottom waters at Nehrupark fluctuates within a range of 7.0 (January) to 9.5 (August) and 7.1 (January) to 9.8 (August) respectively. At Nishat surface and bottom value of pH range from 7.2 (January) to 9.0 (August and 7.2 (September) to 9.2 (August) (Table IV). Therefore, it becomes evident from the above that the tourist affected area is more alkaline. Comparing with the standard scale, it warns that if used for drinking purpose will increase the rate of morbidity especially the incidence of jaundice, indigestion and gastric troubles (WHO, 1978 a). Also the hardness of water

Table VI

Tourist flow and Chemical Characteristics of water

Months	Tourist flow	Monthly tourists	Tempera ture (°c)	Trans- parency Secchi value	pH value Surface/	Bottom	Total Alkalinity mg/l Surface/	Bottom
Sep. 88	58563	1.90	27	0.95	7.2	8.7	65	102
Oct. 88	47613	1.20	20	1.10	8.5	8.8	72	101
Nov. 88	43906	2.00	5	1.50	7.9	8.9	58	103
Dec. 88	11562	2.11	3	2.50	8.9	8.8	69	106
Jan. 89	22441	1.75	5	2.40	7.0	7.1	78	95
Feb 89	16948	2.0	6	2.50	7.5	7.2	55	59
Mar. 89	31645	1.0	12	2.10	8.2	9.2	62	70
April	38535	2.0	20	1.75	8.5	9.0	70	89
May	69234	3.0	22	0.80	8.9	9.1	65	87
June	80497	3.10	21	0.50	8.5	9.0	68	105
July	64346	2.85	31	0.95	9.0	9.2	125	102
Aug 89	70694	2.0	29	0.75	9.5	9.8	121	101

Table VII

Correlation coefficients of water level and siltation.

Variable	'r' value	Computed 't' (t_c)	Tabulated 't' (t_t)	Degree of freedom $(n - 2)$	Level of significance $(\%)$
x_1^a	0.6387	2.6268	2.23	10	5
x_1^b	0.3001	0.9493	0.700	10	50
x_1^c	0.1506	0.4817	0.700	10	50
x_2	0.1415	0.4520	0.700	10	50
x_3	0.1328	0.4237	0.700	10	50

Table VIII

Correlation Coefficients of Tourist Flow and water quality.

Variable	'r' value	Computed 't' (t_c)	Tabulated 't' (t_t)	Degree of freedom $(n - 2)$	Level of significance $(\%)$
Y_1	0.8255	4.6255	3.25	10	1
Y_2	−0.9819	16.3878	3.25	10	1
Y_3	0.4346	1.5260	0.700	10	1
Y_4	0.6226	2.5159	2.23	10	5
Y_5	0.4213	1.4690	0.700	10	50
Y_6	0.4266	1.4916	0.700	10	50

due to presence of calcium and magnesium causes rheumatism and urinary infection (WHO, 1978 b). Thus, if the present trend continues, there would be imbalance of scale in the lake where the environmental losses will exceed the economic gains from the tourism. It was also observed that pH value in the lake has a positive association with that of tourist flow, giving the correlation coefficient for (surface, r = 0.4346 and bottom, r = 0.6263) and significant at 50 and 5 per cent level respectively (Table VIII).

TOTAL ALKALINITY

High concentration of alkalinity in the water trigers the rapid depletion of dissolved oxygen which is most essential for organic life. In general an excess of dissolved oxygen in water causes no problems in organising the aquatic biota whereas a serious defieiency of dissolved oxygen in water will kill fish and other animals. Such deficiencies induced by plant respiration are usually associated with the generation of an excess of respired carbon dioxide present in the surrounding water. Therefore, more alkalinity due to input of sewage does not only reduce the oxygen level directly but has a multiplier effect through depleting the aquatic biota.

The range of alkalinity in the Dal lake varies from surface to bottom as well as between two

sample sites. At Nehrupark it ranged from 55 mg/1 to 125 mg/1 for surface water and for bottom the range was 70 mg/1 to 106 mg/1 (Table IV). The maximum value was recorded in May and minimum in February. Hence, the Nehrupark area shows the high rate of alkalinity on surface water. Simultaneously, the level of alkalinity increases with the increase in tourist traffic. It become more clear from its correlation coefficient (r = 0.44213 surface and r = 0.4266 bottom). The estimation is significant at 50 per cent level of significance with (n − 2) degrees of freedom (Table VIII).

CONCLUSION

Thb preceeding text reveals that Dal lake is seriously affected in terms of its water quality, weed growth, siltation and encroachment. It has greatly restructured the lake, deshaped its appearance and has further resulted in reduction of recreational carrying capacity.

The indicator of water transparency shows that the sewage and the disposal of solid wastes by hotels, houseboats and other small boats have polluted the lake water beyond any doubt. This has not only resulted in the deterioration of the lake beauty but also in the lake metabolism by reducing the photo-synthesis. The pH value reveals that the water around the Nehrupark has become highly alkaline which if used by nearby dewellers for drinking purpose can affect their health. Another problem which has been examined in the study is the process of siltation through the feeding catchmenets. It is the most serious among all factors and reduces the lake area physically. The present study has also established that there is definite change in the overall equilibrium of Dal lake ecosystem as a result of tourist influx. However, there are several other factors responsible for disturbing the fragile ecosystem of the lake, but these are small in terms of number and magnitude. Hence, ecology of the lake could be only kept in balance by curbing the pollutant generators originating from various sources of domestic as well as other commercial establishements. Management of waste disposal and sanitation of house-boats within the lake is very essential for both hygenic conditions and safer environment. Optimization of tourist influx can also help in regulating the ecology of the lake.

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