Vidyodaya J. of Sci, Vol 7. pp 33 - 42

TROPHIC STATUS OF BEIRA LAKE

Charmalie Nahallage and Swarna Piyasiri
Department of Zoology,
University of Sri Jaywardenapura
Nugegoda, Sri Lanka

Received on 03. 09. 96
Accepted on 12. 02. 97

Abstract

Beira Lake is located in the heart of the city of Colombo and in an highly urbanized catchment of 432 ha. Beira Lake covers 65.4 ha and comprises four main basins the East Lake, the Galle Face Lake, the West Lake and the South West Lake. The objective of the study was to determine the trophic status of the lake using the, physical, chemical and biological properties of the water.

The mean water transparency depth of the lake was 15.2±9.2 cm. The euphotic zone was approximately 41.8 cm. Water temperature ranged from 26 ^{0}C to 32 ^{0}C. Conductivity ranged from 212 to 500 µS. pH value ranged from 7.2 to 9.8 Dissolved Oxygen, BOD and Orthophosphate values of the lake ranged from 7.82 to 14.41 mg/1, 33.45 to 68.35 mg/1 and 0.014 to 0.08 mg/1 respectively. The highest and lowest Sulphate values recorded were 4.04 ppm and 2.33 ppm. The Chloride content ranged from 29.02 to 53.09 mg1.

The phytoplankton community of the Biera Lake composed of the dominant blue green algae and the green algae. Blue green algae represented 99 percent of the total phytoplankon population. The major zooplankton groups observed were cladocerans, Copepods and Rofiters. Copepods were the most dominant zooplankton group.

According to the physical chemical and biological properties obtained for Beira Lake, it is at the advanced stage of eutrophication process.

Key words: Beira Lake, trophic status, eutrophication

1. Instroduction

The Beira Lake is a distinctive land mark in the city of Colombo. It has reportedly been in existence for nearly five, centuries and once was a larger and deeper body of water which had a strategic relevance to the ancient fort of Colombo. The lake has been gradually reduced to its present extent of about 65.4 ha from an estimated original. extent of 162 ha mainly due to reclamation carried out for construction of warehouses.

Beira lake is a man-made shallow body of water connected to the Colombo Habour via the McCallum lock gates, to the Kelani Ganga via the st. Sebestian Canal and to the Indian Ocean by a semicircular spill-way (Fig.1)

Table - The morphometric characteristics of Beira Lake.

Lake Basin	Data source	Surface area(ha)	Maximum depth(m)	Volume (mcm)
East Lake	Roche, 1993	43.26	5.6	0.945
Galle Face Lake	SLPA, 1989	2.65	3.4	
West Lake	SLPA, 1989	8.10	3.4	1.795
South West Lake	SLPA, 1989	11.44	2.9	0.163
Total		65.45		2.903

(Source - Beira Lake Restoration study Interim. Report).

The objective of the present study is to asses the present trophic status of Beira lake.

The total surface area of the Beira lake is estimated as 65.4 hectares (NARA, 1985). The four sub basins constituting the Beira Lake can clearly be identified. They are the East Lake, the Galle Face Lake, the West Lake and the South West Lake. The East Lake is the largest basin (46.2 ha) and accounts for more than 60% of the total lake surface area. The Galle Face Lake (2.7 ha) is adjacent to both East and West Lakes and the lake discharge (spillway) is located of the Westernmost section of this basin with a surface area of only 8.1 ha the West lake consists mostly of a narrow passage that connects the Galle Face lake to the South West lake. The surface area of the latter basin is approximately 11.4 ha and a small island is located at it's center.

2. Materials and methods

Fig 1. Illustrates the sampling locations and the study area of the lake. Sampling locations were selected in order to cover the four lake basins as indicated in Fig. 1. Water samples were collected using a 4 litre plastic bucket tied to a synthetic rope. Sampling was done on the surface water layer and was carried out twice a month between 9.00 am to 11.00 am for a period of nine months from April to December 1994.

Secchi depth values, temperature, conductivity and pH values were measured using a secchi disc, thermometer (Griffin) Battery type pp), Corning M 90 conductivity meter and OSK 14830 pH meter. Dissolved Oxygen and Biological Oxygen Demand were measured using the Winkler's method. Alkalinity; Water Hardness, Chloride and Dissolved sulphide were measured using titrimetric methods. (Zahradnik, 1981) Sulphate was measured using the gelatine turbidimetric method (Tabitabus, 1974). Orthophosphate was measured using spectrophotometric method (Murphy and Riley, 1962) using a CE 373 Linear Grading Spectrometer (Series II). Chlorophyll-a concentrations were measured using a spectrometric method. Plankton samples were collected using a plankton net (40µm mesh size) and transferred into plastic bottles and fixed in 5% formalin Identification and enumeration of plankton were done in the laboratory.

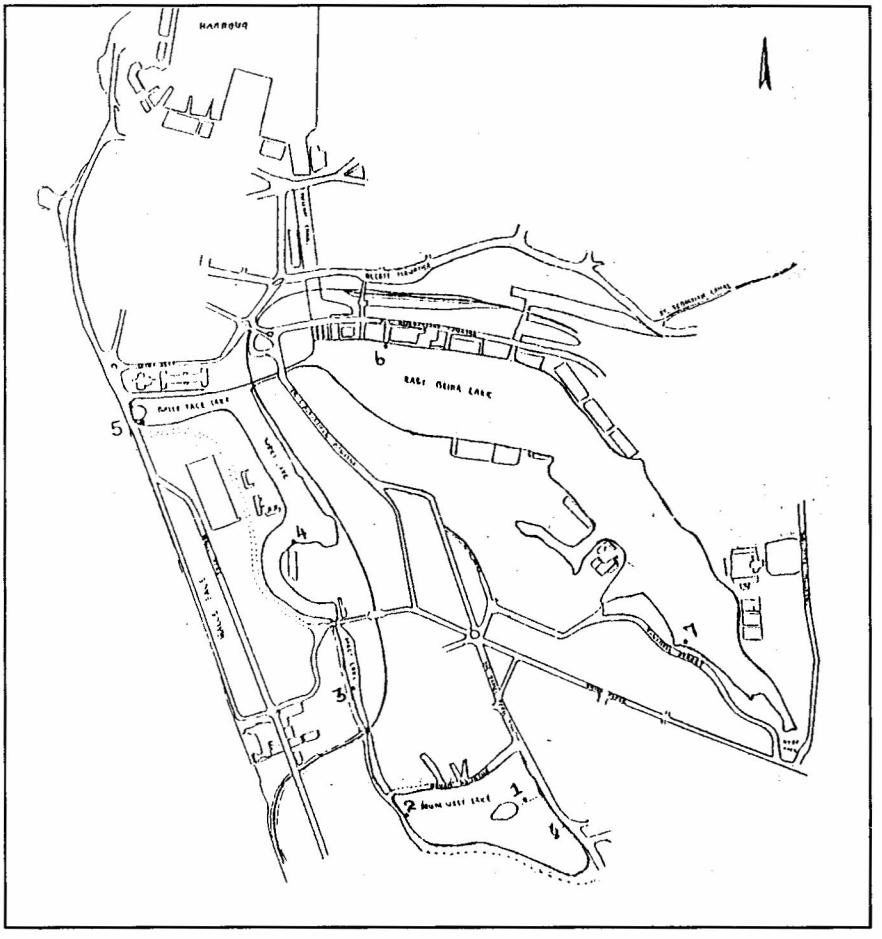


FIG. 1 - Beira Lake - Study Area

Location of the Selected stations
Stations 1 and 2 (South West Lake)
Stations 3 and 4 (West Lake)
Stations 5 (Galle Face Lake)
Stations 6 and 7 (East Lake)

3. Results

The water transparency was low in Beira lake. This was clearly shown from the secchi disc values. The mean water transparency depth of Beira Lake was 15.2±9.2cm. The lowest secchi disc value was recorded in station 3 (West Lake) and it was highest in station 5 (Galle Face Lake). This variation was due to the variation in the algal density. The euphotic limit calculated from mean secchi depth value was approximately 41.83 cm.

Water Temperature

In general there were no substantial spatial or seasonal variation in temperature. The highest mean water temperature was recorded during May (31.6±1 ^{0}C) and the lowest during November. (26.7±1.5 ^{0}C) Water temperature in Beira Lake ranged from 26 ^{0}C to 32 ^{0}C with an overall mean water temperature of 29.1±1.3^{0}C.

Conductivity

There was a great deal of variation in the conductivity of Beira Lake, waters during the study period. The highest mean conductivity was recorded in April (418±61μS) It was also high in June. The lowest was recorded in December (245±56μS) Conductivity of the Beira Lake ranged from 212 to 500 μS with the mean of 336±57μS. Generally the mean conductivity was higher in station 5 (Galle Face Lake) Station 6 and station 7 (East lake). The lowest was recorded in station 2 (South West Lake).

pH values

Though there was no marked seasonal variation, the mean pH was higher in the mouths of May (9.2±0.7) and December (8.2±0±4) than the rest. During the study period highest pH was recorded in May in all the stations and lowest was recorded in June. Station 6 has the highest pH value which ranged from 7.3 to 9.4 with the mean of 9.0±0.8. Other than that there was no marked spatial variation low pH values were observed in station 4.

Dissolved Oxygen (DO)

Throughout the study period DO content measured during mid - day (9 am - 11am) was higher than the value of the normal freshwater. The DO content vary with water temperature and monthly precipitation. Low DO values were recorded in station 3 and station 4. The highest DO values was recorded in station 1 and it ranged from 7.00 to 20.40 mg/1 with the mean of 15.02 ± 4.30 mg/1. The lowest DO value was recorded in station 4 with the mean of (6.96±5.36) mg/1.

Biological Oxygen Demand (BOD)

Normally high BOD values were observed in Beira Lake. The highest mean BOD value was recorded in May (68.35±3.77 mg/1). The values were high in June, July and October. The lowest value was recorded in November in all the stations. BOD increased with the increasing water temperature. There was a great deal of variation in the BOD at different stations. In most months high BOD values were observed in Station 1, station 2, and in Station 6. The highest was recorded in station 2 and ranged from 40.00 to 110.00 mg/1 with the mean of 71.50±5.0 mg/1. The lowest mean BOD was recorded in Station 4. (32.55±5.0 mg/1).

Total Hardness

Normally low hardness values were recorded in Beira Lake. There was no substantial seasonal or spatial variation in total hardness. Major fluctuations were not recorded in the hardness. The mean hardness value was 0.00071 mmo 1/1. High values were obtained in July and October. The lowest was recorded in May. There was a slight increase in the hardness in station 5 and station 7 than in the rest.

Sulphate.

There was a little variation in the sulphate content. High values were recorded in April, June and December. The mean sulphate concentration ranged from 2.33 to 4.57 mg/1. The highest value was recorded in December and the lowest in September. Out of the seven stations highest value for mean sulghate was recorded in Station 5.

Chloride:-

There was a wide fluctuation in the Chloride content. The highest value for chloride was recorded in August 53.09 ± 5.38 mg/1 Lowest value was recorded in November (29.62 ± 2.45 mg /1). There was no marked spatial variation but chloride content was slightly high in station 6 and 7. It was lowest in Station 2.

Orthophosphate:-

Orthophosphate concentration was high in dry months such as in July and August. High othophosphate values were observed in station 1 to 4. The highest was recorded in station 1 and it ranged from 0.01 tp 0.31 mg1. Algal density was also high in Station 1 and 4.

Chlorophy11-a:

High Chlorophyll-a (ch-a) values were recorded when the temperature was high. The highest Ch-a values were recorded in station 1 in all months. It ranged from 25.186 to 76.404 µg/1. The lowest value was recorded in station 7. High Ch-a values were observed in Station 1 to Station' 4, the algal density was also high in these stations.

Plankton

Phytoplankton

The phytoplankton community of the Beira Lake composed of the dominant bluegreen algae and the green algae. The phytoplankton species found were *Microcystis aeruginosa, Spirulina* sp. *Merismopedia* sp., *Pediastrum* sp, *and Ankistrodesmus* sp., These bluegreens were responsible for the algal blooms which frequently occured in the lake. In all the lake basins bluegreen alga greatly out numbered green algae, and reached very high densities. They represent more than 99 per cent of the plankton community. The highest density was recorded in station 5 and lowest in station 7.

Zooplankton:-

Total number of 10 species of zooplankton were recorded which belong to the orders Cladocera, Copepoida and Rotrifera. There were 6 rotifer species, *Brachionus, ungularis B. Nilsoni, Keratella tropica, Cephalopoda* sp., *Lecane* sp. *Filina longiseta,* three Cladoceran species *Diaphanasoma* sp., *Moina* sp. and *Ceriodaphnia* sp. and one Copepod species and Nauplii stages. *B. ungularis* was the dominant rotifer species and found in abundance in all the stations. *Keratella, Lecane* and *Ceriodaphnia* sp. were not distributed in all the stations and their densities also were low. The rotifer population was high in station 1 and 2 and lowest in station 7. Copepods were the dominant of the three zooplankton groups found in the Beira Lake. Normally it contained high numbers of nauplii stages than the adult form. Cladocerans were the least abundant zooplankton group. Of the three species *Diaphanasoma* and *moina* were the dominant forms but they were not distributed equally in all the stations. The density of *Moina* sp. was higer than the *Diaphanasoma* sp. The *Ceriodaphnia* sp. was not found in the first three stations. The density of all these zooplankton groups especially rotifers and to a lesser extent cladocerans show very significant population variation with the green algae population. Their population was high when green algae was high. Nevethelss low values were observed with low green algal densities and also with the increase of bluegreen algal density,

FIG 3(A) MONTHLY MEAN VARIATION OF THE ZOOPLANKRON GROUPS INTHE LAKE

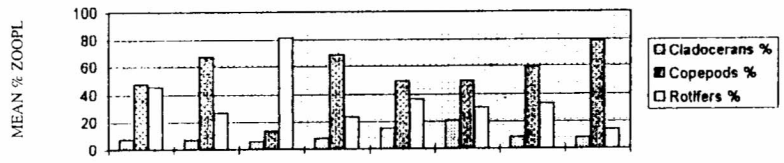


FIG 3(B) MONTHLY MEAN VARIATION OF THE TOTAL PHYTOPLANKRON NUMBER WITH THE BLUE GREEN ALGAL NUMBER

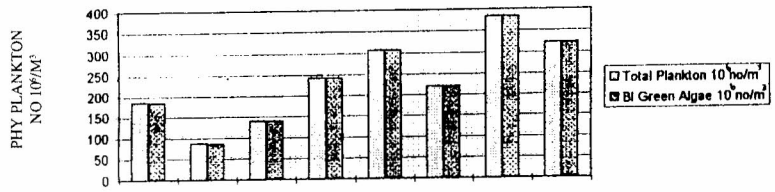
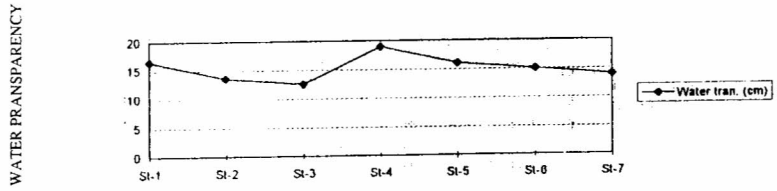


FIG 1 SPATIAL VARIATION OF THE WATER TRANSPARENCY OF THE BEIRA LAKE



4. Discussion

Tropic status is a statement about the nutrient concentrations within the water body. A young lake is usually oligotrophic and contain few nutrients and due to the input of nutrients mainly allochthonus input can change the lake trophy from oligotrophic to eutrophic. Location of any water body along this scale from oligotrophy to eutrophy is called trophic status of a lake. One of the prominent features of the Beira Lake is the colour of the water. It is green and is primarily due to the high algal density. The low transparency is resulted as recorded during the present study. Formation of thick surface mat by this algae reduce the light penetration. In upland reservoirs water transparency is influenced mainly by the suspended materials as in Kotmale and in Victoria reservoirs (Piyasiri, 1987) and similar phenomenon was observed in Parakrama Samudra (Dokulil et al, 1983) However, in Beira Lake it was mainly due to the algal density. This could be measured in increase of Chlorophyll-a density. In oligotrophic lakes the mean summer concentration of Ch-a in the epilimnion is in the range of 0.3-2.5 mgm-3.

(Vollenweider, 1986). In Beira Lake it ranged from 9.86 to 20.6 According to OECD (1982) in Oligotrophic lakes Ch-a ranged from 0-4 mgm-3, in mesotrophic lakes 4-10 mgm-3 and in Eutrophic lakes it 10-100 mgm-3. The mean secchi disk depth of the Beira Lake was 15.2 ± 9.2 cm. According to the OECD (1982) in Oligotrophic lakes this valus is greater than 6m. In mesotrophic lakes it is 3.0-6.0 and it is less than 3.0 m in eutrophic lakes. K otmale shows a trophic plasticity. In 1989 secchi depth value of 0.5 m in 1991. (Piyasiri, 1995) The calculated euphotic zone for the Beira Lake was 41.83 cm. Observed values for Mahawelli reservoirs were 5.0±30m Victoria and 5.10±0.39 m for Kotmale. (Piyasiri, 1992) According to Brige and Juday (1930) the water transparency is very low in high stained water causing shallow euphotic zone. Fig. (2) illustrates the spatial distribution of water transparency in Beira Lake.

Lakes in tropical climates have a temperature and light regime which is suitable for phytoplankton growth. In Beira Lake water temperature and light ranged from 26 ^{0}C to 32 ^{0}C. This temperature along with the high nutrient content recorded must be responsible for the excessive plankton growth.

In upland reservoirs the conductivity is said to be lower than the low-land reservoirs. The conductivity in Beira Lake is not completely due to being a lowland reservoir but also due to the entry of sea water from the harbour. This also explains the high values recorded in the water hardness and chloride content in Station 6 and 7 which are close to the harbour. In the Beira Lake the pH value ranged from 7.1 to 9.8 during the study period. The pH values were highest in all the stations in May and secondly in December. The high pH values must be due to the high productivity of the algae which produce carbon dioxide. Similar conditions were observed in Victoria (Piyasiri, 1987/1988). Lowest pH was recorded in June and the lowest plankton density also was recorded in June.

During the study period the Dissolved Oxygen content in the Beira Lake ranged from 7.83 to 14.41 mg/1 The high algal density may be responsible for the increase in DO. Accordingly to the Interim Report (1993), the intense algal production leads to an excessive production of oxygen in the surface waters of Beira Lake and it's depletion in the lake bottom.

BOD gives very fair measure of the purity of water. Very clean water have BOD of 1 ppm. If the BOD is 5 ppm the quality of the water is doubtful. Polluted water contain 10 ppm of BOD. Mean BOD of Beira Lake range from 33.45 ± 5.37 to 68.35 ± 3.37 to 68.35 ± 3.37 mg/1. This shows that the water is polluted.

The sulphate concentration ranged from 1.09 to 5.35 ppm. This amount must be due to the discharge of industrial effluents and also due to the decomposition of the high algal density.

The orthophoshate value recorded were 0.01 to 0.319 mg/1 High dissolved phoshorus in freshwater lakes cause the promotion of algal blooms resulting in high productivity leading to problems of eutrophication.

The present trophic status of the lake could be clearly described by the change in the phytoplankton community. The change from oligotrophy to eutrophy involves a great inctrease in the amount of plankton. Oligotrophic lakes have few phytoplankton composed largely of desmids, as fertility increased they were replaced by diatoms then by green algae and finally bluegreen algae appear. In Beira Lake in 1970 there were 14 spp. of green algae, 6 sp. of bluegeen algae and 3 diatoms (Costa and De Silva, 1978) and green algae were dominant. In 1990 there were 5 spp. of algae, 7 spp. of bluegreen alga and 5 diatoms species, bluegreen algae greatly out numbered the green algae (Perera, 1993). At present there are only 3 green algae and 3 spp. of bluegreen algae and diatoms were not recorded. The bluegreen algae comprised 99 per cent of the phytoplankton community. This clearly indicates that the lake is eutrophic. Fig. (3) illustrates the seasonal and spatial distribution of plankton in Beira Lake, From the above mentioned physical, chemical and biologpcal properties of the Beira Lake, it is clear that the Beira Lake has undergone eutrophication. This was confirmed by comparing some of the properties used in this study with values given by the OECD programe for the assessment of trophic status of the lakes. Also according to the Dillon- Rigler regression (1980). The mean Ch-a concentration and total phosphorus values (Ch-a 14.32 mg m^{-3} Total phosphorus 38.18 mg m^{-3}) were found in the eutrophic region. Also according to the investigation carried out by NBRO and CEA (1993) it was indicated that the lake is at an advance stage of eutrophication.

Where trophic status is concerned, present study also reveals that Lake is in between Eutrophic-Hypertrophic range.

5. Acknowledgment

Authors are greatful to Professor J. Jinadasa, Head, Department of Zoology. University of Sri Jayawardanapura for providing facilities for above work. Mr. Wijenayake, technician of the Zoology Department, is acknowledged for taking photographs . We are also greatful for Miss N. M. P. Perera for helping us in various ways during the study period.

6. References

Beira Lake Restoration Study Interim Report (1993). Report complied in collaboration with National Building Research Organization, Colombo Mùnicipal Council, Central Environmental Authority, National Houn Development Authority, Sri Lanka Land Reclamation and Development Corporation and Urban Development Authority. pp3-84.

Birge and Juday (1930) *A second report on Solar radiation and Island Lakes.* Trans Acad. Sci. Arts Let. 26±: 383-425.

Costa, H.H. and De Silva, S. S. (1978) *Hydro bjology of Colombo Lake III Seasonal fluctuations of plankton.* Spolia Zeylanica 32(II): 35-53.

Dokulil et al (1983) *An assessment of the phytoplankton biomass and primary productivity of parakrama Samudra. A shallow man-made Lake* in Sri Lanka. Schimer F. (ed). Limnology of parakrama Samudra Sri Lanka. Dr W. Junk Publishers. The Hague, ISBN 90 6193 763.

Murphy and Relay (1962) *Determination of Orthophosphate Anal* Chem. Pp 27-31.

National Aquatic Resources Agency (1985) Beira Lake. *Report of a Preliminary Study of the Beira Lake.* Report compiled in collaboration with Urban Development Authority, Sri Lanka, Ports Authority, National Archives. Colombo Municipal Council, Survey Department, Central Environmental Authority.

OECD(1982) *Eutrophication of waters: Monitoring Assessment & Control:* 154 pp. Final report OECD cooperation programme on Monitoring of Island waters eutrophication control, Organization for Economic. Cooperation & Development publication, Pairs.

Perera, M.P. (1993) *Micro organisms of selected fresh water bodies with a note on potential pollution indicators.* Open University of Sri Lanka. Pp.54-56.

Piyasiri, S. (1987/88). *Annual Report Limnology project at Mahaweli.* reservoirs Department of Zoology, University of Sri Jayawardenapura. Nugegoda.

Piyasiri S. (1991). *Limnology Project at Mahaweli Reservoirs I Some physical, and chemical properties of Kotmale, Victoria and Randenigala reservoirs.* Vidyodaya Jornal of Science, Vol. 3 No. 1, pp 155-166.

Piyasiri S. (1995) *Eutrophication and bluegreen algal bloom problem of Kotmale reservoir in Sri Lanka* K. H. Timotius. F. Goltenboth (eds). Tropical Limnology Vol II. Satya Wacana University press. Salatiga Indonesia. Pp. 1-8.

Tabitabus, M. A. (1974). *Determination of sulphate in water samples.* The Sulpher Institute Journal Vol 10, No. 02.

Vollenweider, R. A. (1986) *Scientific fundamentals of the eutrophication of lakes and flowing waters with particular reference to nitrogen and phophorus and factor in eutrophication.* Paris rep. Organization of Economic Coporation and Development. DAS/CSI 68. Pp 27-192.