A LIMNOLOGICAL ASSESSMENT OF THE VOLTA GRANDE RESERVOIR, MINAS GERAIS/SÃO PAULO, BRAZIL*

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ABSTRACT

This study describes certain limnological aspects of the Volta Grande Reservoir, located in the middle reaches of the river Grande, on the boundary of the states of Minas Gerais and São Paulo in Brazil. Sampling was carried out through a stretch of approximately 100 km between the Jaguara dam and Volta Grande. The methodology differed according to three habitats identified. The lacustrine zone was sampled randomly, with physico-chemical and biological parameters being determined at two depths. The transitional and riverine zones were sampled at just one depth at predetermined points located along the river Grande and its main affluents. Temperature was measured at one metre intervals along the water column (lacustrine zone). No stratification was observed. Other physico-chemical parameters measured showed values typical of other South American waters. High densities of phytoplankton were found. Rotifers were the dominant element of the zooplankton.

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THE VOLTA GRANDE RESERVOIR

The Volta Grande Reservoir was constructed on the river Grande, on the boundary of the states of Minas Gerais and São Paulo, to provide hydroelectric power. At its fullest, the geographical coordinates are as follows: 19°57'52"–20°0'11"S to 48°25'00"–47°35'00"W. The lake, of 200 km^2, lies in the region of upland sandstone basalt of the Paraná river basin, with its characteristic plateaus covered by Bauru Cretacic sandstone. There are a number of soil types, with oxisols of varying fertility being predominant, and resulting in dense to open cerrado (bush savanna), a vegetation typical of the central highlands of Brazil. The climate is tropical, with wet "summers" and dry "winters". Annual mean temperature is approximately 22°C, with a range of only 5°C. Annual average rainfall is 1635 mm (Brazil, IGA, 1979).

METHODOLOGY

Three habitats (zones) were considered according to the rate of water flow (FIG. 1). The lacustrine zone, with the slowest rate of water flow, extends from the Volta Grande dam to the town of Miguelópolis. There the lake is about 1.5 km wide, and the shores are used for soybean agriculture and cattle-raising. Although subject to floods, the transitional zone has a rate of water flow higher than the lacustrine zone. It extends from Miguelópolis to the FEPASA II bridge, and includes the Industrial district of Uberaba, in Minas Gerais. Agriculture there is dominated by sugarcane, and includes a sugar mill. There is also an industry extracting sand, and a local predilection for sport fishing. The riverine zone is distinguished by rapids and a rocky stream bed. It extends from the end of the Volta Grande Reservoir to the Jaguara dam. The banks of the river are dominated by sugarcane plantations and cattle pasture, as well as gallery forests.

Sampling regimes were different for each of the zones. Sampling was random in the lacustrine zone, and physico-chemical and biological parameters were determined at two depths. The transitional and riverine zones were sampled at regular intervals, and at only one depth.

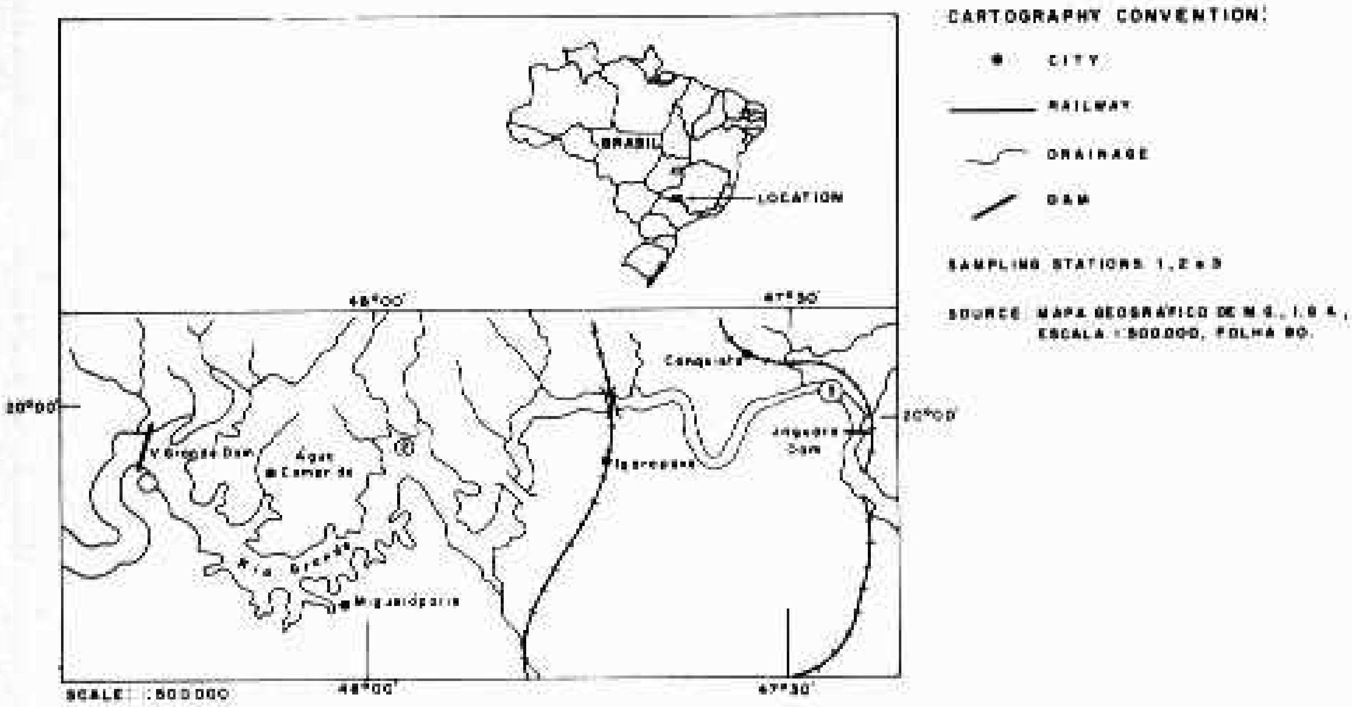

Fig. 1. Stations sampling localization.

RESULTS AND DISCUSSION

LACUSTRINE ZONE

Volta Grande, as with a number of other tropical lakes, has no defined thermal stratification pattern. Mixing appears to be caused chiefly by wind and, sometimes, seasonal changes. Stratification is assumed to be more or less permanent only if a thermocline is found below the superficial temperature gradient. According to Froenlich et al. 1978, cited in van der HEIDE, 1982, a thermocline is "a temperature discontinuity located below the level of diurnal warming and nocturnal cooling, and sufficient to constitute an effective barrier to mixing" (discussing the Americana Reservoir in Brazil). Consequently, the depth of the epilimnion could be indicated only arbitrarily, a similar situation to that observed by van der HEIDE (1982) for Lake Brokopondo, Suriname (see FIG. 2 and 2A).

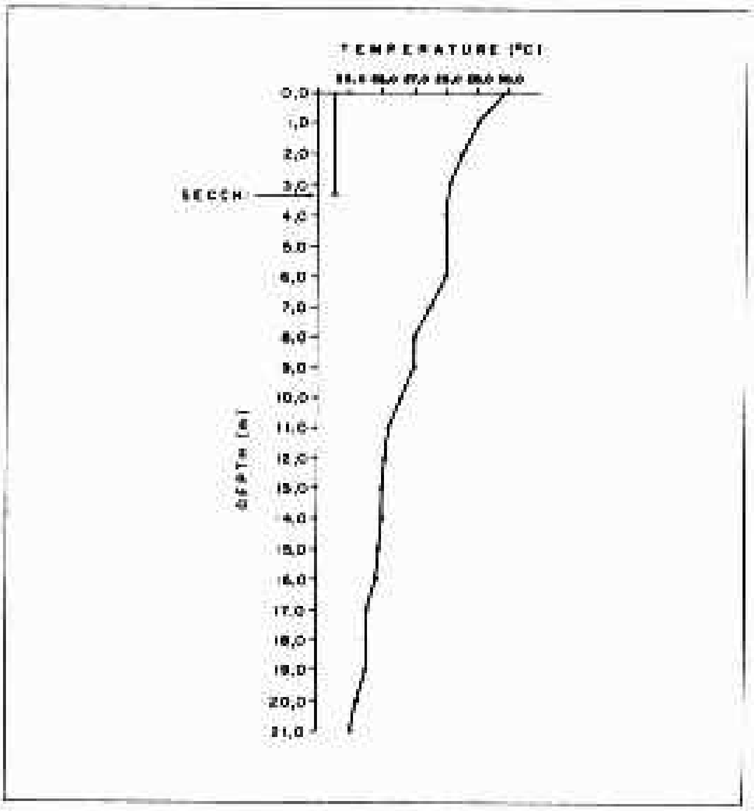

Fig. 2. Vertical gradients of temperature and Secchi disc visibility depth at Volta Grande Reservoir. Jan/88.

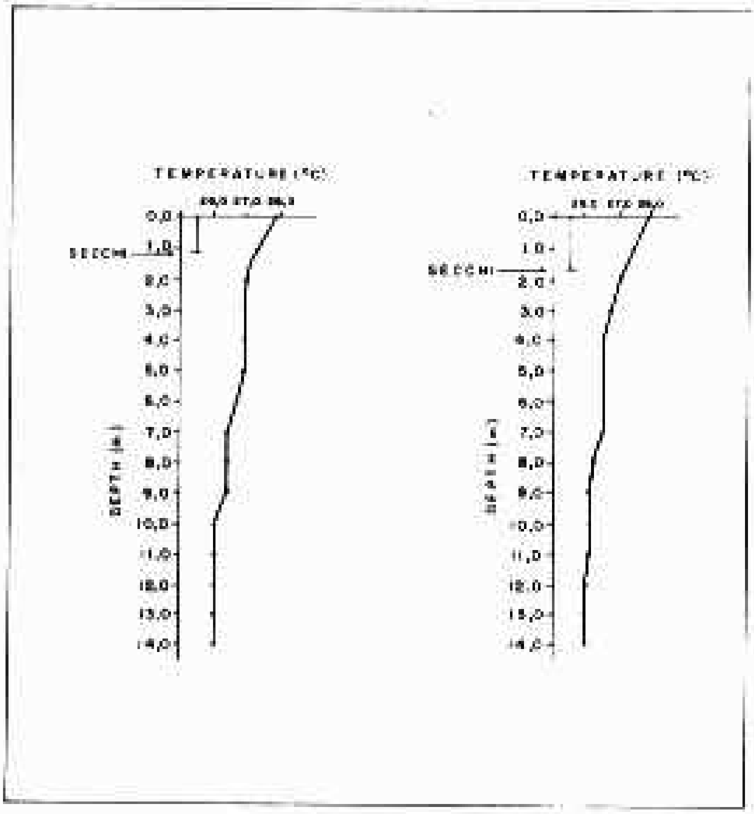

Fig. 2A. Vertical gradientes of temperature and Secchi disc visibility depth at Volta Grande Reservoir. Jan/88.

Water transparency showed a yearly flutuation between higher values in "winter", and lower ones in "summer" (TABLE 1). No statistical relationship was found to connect plankton density and transparency (TABLE 1). The fact that transparency presented the same seasonality as temperature, conductivity and dissolved oxygen (DO) indicates that it depends mainly on the rate of vertical exchange, as suggested by van der HEIDE (1982) for Lake Brokopondo. The lowest transparency values were obtained in June, when a mixing was observed (FIGS. 3 and 3A). Electrical conductivity presented seasonal changes, and the lowest means were observed in the hypolimnion. This was probably due to an oxidized hypolimnion which prevented ion exchange between the sediment and the water. The highest mean conductivity was observed in the epilimnion in January, probably as a result of summer rains. The pH values were neutral during the dry season ("winter") at both depths, and no regular pattern of fluctuation was detected. The highest values occurred in the epilimnion in August, and the lowest in the hypolimnion in January, the range being from 5.7 to 7.4, with slightly acid waters during the wet season ("summer").

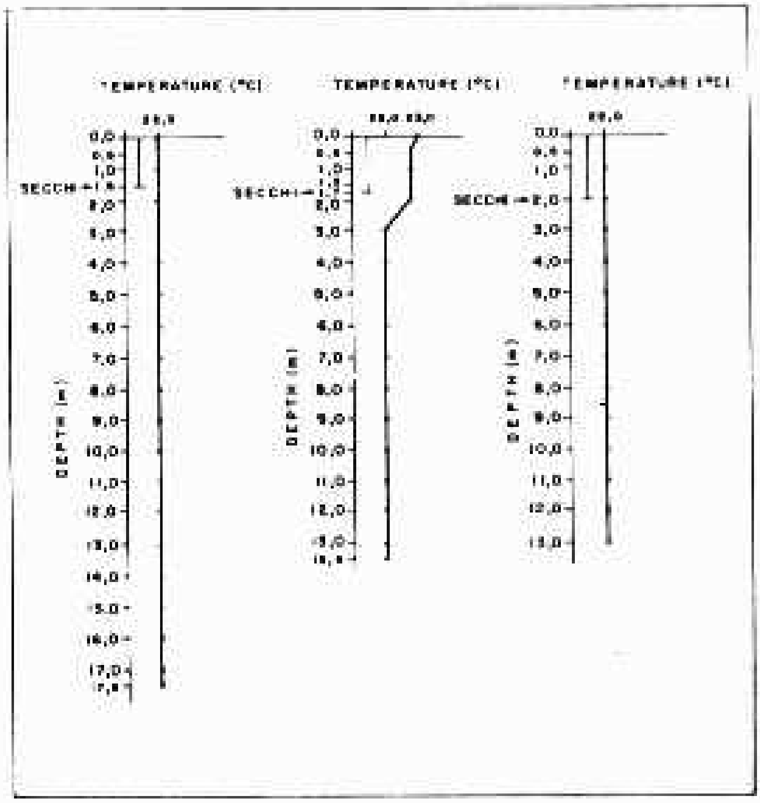

Fig. 3. Vertical gradientes of temperature and Secchi disc visibility depth at Volta Grande Reservoir. Jun/87.

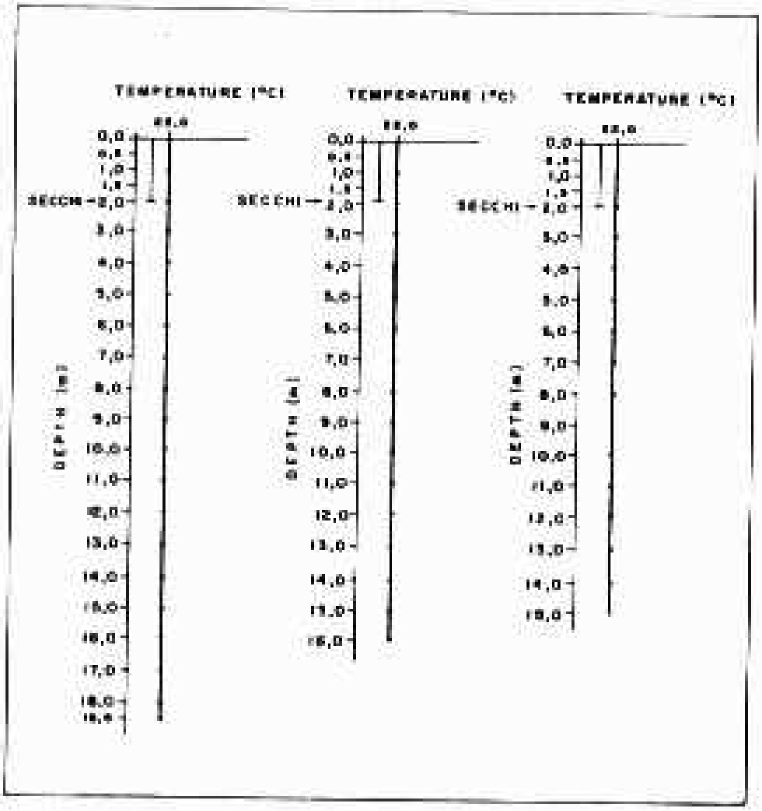

Fig. 3A. Vertical gradientes of temperature and Secchi disc visibility depth at Volta Grande Reservoir, Jun/87.

The thermal stratification in the Volta Grande Reservoir resulted in the formation of chemoclines which accompanied the thermal cline, and providing a difference between the epi- and hypolimnion. Oxygenation levels showed saturation at both depths throughout the year. There was a relationship between DO and phosphorous, although values showed little change during the year. The range was from 13 to 23 μg/l, and the reservoir was considered mesotrophic according to the classification of Vollenweider (in WETZEL, 1983). Nitrate presented low levels throughout the study, always being below 1.0 mg/l.

The phytoplankton community was dominated by Chlorophyciae (58%), followed by Pyrrophyta (17%) and Chrysophyta (16%). In spite of representing only 9% of the phytoplankton recorded, Cyanophyta are a significant element because of their toxicity. Densities were lowest in October (562 org./ml), and highest in August (1807 org./ml) (TABLE 1). These values are typical of temperate mesotrophic lakes according to the ARCEIVALA (1981) classification or according to MARGALEF (1983) who took phytoplankton densities between 102 and 104 org./l.

The zooplankton consisted mainly of rotifers, crustaceans and protozoans (7%). The total zooplankton density showed an average of 196 org./l. An abundance of rotifers characterizes water of high trophic levels.

TRANSITIONAL ZONE

Physico-chemical and biological parameters measured for the transitional zone are shown in TABLE 2. A Water Quality Index (Brazil, CETESB, 1986) was calculated for this zone, ranging from 68% in June to 91% in October. Measured pH levels varied from slightly acidic in October to neutral in August, and monthly mean water temperatures ranged from 22^{o} to 27^{o} in August and January, respectively. Dissolved oxygen was saturated or supersaturated, maintaining, as such, good conditions for aquatic organisms. Nutrient levels (nitrate and phosphorous), although poor, were typical of South American waters.

Phytoplankton communities were dominated by Chlorophyta and Chrysophyta, but varied somewhat according to season. In June, Chlorophyta were predominant (68.5%), followed by Cyanophyta (6.7%) and Pyrrophyta (6.3%). In August, Chrysophyta were marginally dominant, comprising 46.2%, followed by Chlorophyta (40%), Cyanophyta (8%) and Pyrrophyta (5.8%). In October, Chlorophyta were again dominant (38%), followed by Chrysophyta (33%), Cyanophyta (19.2%) and Pyrrophyta (9.5%).

As in the lacustrine zone, Rotifera were the dominant group in the zooplankton community. Protozoans recorded were principally thecamoebae, better adapted to faster flowing water. According to WILLIAMSON (1983), these organisms comprise a substantial portion of the annual biomass, and are importan dietary component for fish larvae and invertebrates. Crustacea were represented by 16 taxa, including predators (Calanoida) and small filter feeders (Cladocera), similar to rotifers. Densities were low, however, with an average of 2.8 org./l, and mainly comprised of the genus *Bosmina*. Total densities in the lacustrine zone were six times higher (TABLE 1).

RIVERINE ZONE

The results obtained for this zone are summarized in TABLE 3. It was characterized by low turbidity along the 45 km surveyed. The highest values were recorded during the wet season ("summer"). Electrical conductivity varied from 29 to 58 µS/cm, with an average of 37 µS/cm; considered to be low and indicating that it is poor in major elements, and certainly not eutrophic. Dissolved oxygen (DO) was always higher than 7.0 mg/l, indicating supersaturation. Nitrate and total phosphorous were low as in the other zones (see GOLTERMAN, 1986). The Water Quality Index (Brazil, CETESB, 1986) indicated good conditions, mean values ranging from 74% to 81% during the study.

Plankton densities were higher than in the other two zones. The phytoplankton community included 88 taxa of five groups: Chlorophyta (65%), Chrysophyta (21%), Cyanophyta (11%), Pyrrophyta (1%) and Euglenophyta (phytoflagellates — 1%). A Similarity Index demonstrated a considerable likeness to the microflora of the lacustrine zone of the Volta Grande Reservoir (approximately 65%), probably because of the Jaguara dam upstream.

A total of 124 taxa were recorded for the zooplankton community, including Protozoa, Rotifera, Crustacea, Insecta, Nematoda and Coelenterata. As in the other zones the dominant group were the rotifers (47%) and protozoans (35%). As with the phytoplankton community, there were many elements typical of lenthic environments, undoubtedly because of the proximity of the Jaguara dam (similarity index between this zone and the lacustrine zone was 73%). Densities were also influenced by the Jaguara dam, being higher than in the other two zones and also aseasonal, except for the appearance of high densities of *Codonella* sp. in August.

CONCLUSIONS

1. The lacustrine zone has no defined thermal stratification, and mixing appears to be influenced by weather conditions.

2. Nutrients (phosphorous and nitrogen) showed consistently low values in all zones, and indicate mesotrophic conditions (according to the classification of Vollenweider, cited in WETZEL, 1983). Values are considered normal for South American waters.

3. Planktonic organisms were recorded at low densities in the lacustrine zone, also indicating a mesotrophic lake.

4. The transitional and riverine zones had high quality water according to the index of CETESB (Brazil, CETESB, 1986). No index was calculated for the lacustrine zone.

5. Planktonic densities were lowest in the transitional zone, and were highest in the riverine zone.

6. The plankton communities of the riverine zone and the lacustrine zone were very similar, probably resulting from the influence of the lacustrine zone of the Jaguara dam upstream of Volta Grande.

7. Dissolved oxygen (DO) was high in all three zones.

REFERENCES

ARCEIVALA, S.J. *Wastewater treatment and disposal.* New York: Marral Dekker, 1981.

BRAZIL, CETESB. *Qualidade das águas interiores do Estado de São Paulo.* São Paulo: 1986.

BRAZIL, IGA. *Uberaba, mapa municipal com monografia.* Belo Horizonte: Secretaria de Estado de Ciência e Tecnologia, 1979.

GOLTERMAN, H.L. *Seminar Limnology.* NUFFIC, Delft., 1986.

MARGALEF, R. *Limnologia.* Barcelona: Omega, 1983.

VAN DER HEIDE, J. Lake Brokopondo. Filling phase limnology of a man-made lake in the humid tropics. Amsterdam: Vrije Universiteit, 1982.

TABLE 1 – Monthly mean values of electrical conductivity, pH, Sechi disc transparency, dissolved oxygen (DO), total phosphorous, phytoplankton and zooplankton in the lacustrine zone of the Volta Grande Reservoir.

Parameter	Zone	April	June	August	October	January
Conductivity (μ s)	E	41,56	33,22	32,33	42,56	42,78
	H	39,44	29,22	32,33	41,78	40,44
pH	E	6,97	7,33	7,40	6,93	6,82
	H	6,70	7,29	7,23	6,80	5,79
Transparency (m)	–	2,17	1,80	3,30	3,38	2,33
DO content (mg/l)	E	7,29	7,27	8,76	8,58	9,84
	H	4,87	7,16	7,56	6,89	9,19
Phosphorus (μg/l)	E	21	20	16	13	21
	H	22	23	17	17	18
Phytoplankton (Org/ml)	E	1.222,44	1.656,89	1.806,78	562,38	1.647,89
Zooplankton (Org/l)	E	149,44	177,44	248,63	126,50	277,11

Obs.: E = Epilimnion
H = Hypoliminion

TABLE 2 — Monthly mean values of electrical conductivity, pH, dissolved oxygen (DO), total phosphorous, phytoplankton and zooplankton in transitional zone of the Volta Grande Reservoir.

Parameter	June	August	October	January
Water temperature °C	23,80	22,00	25,50	26,88
Conductivity (μ s)	29,60	30,00	42,33	38,75
pH	7,3	7,4	6,6	6,7
DO content (%)	107	97,61	100,67	12,50
Phosphorous (μs/l)	14,00	11,00	10,67	24,00
Phytoplankton (Org/ml)	1950	600	370	(*)
Zooplankton (Org/l)	20	56	38	40
Water quality Index %	68	90	89	70

Obs.: (*) Data unavailable.

TABLE 3 – Monthly mean values of electrical conductivity, pH, dissolved oxygen (DO), total phosphorous, phytoplankton and zooplankton in the Riverine Zone of Volta Grande Reservoir

Parameter	February	May	June	August	October	December
Water Temperature °C	27,60	27,50	24,67	21,67	25,0	25,14
Conductivity (µs)	39,83	46,33	37,67	34,50	33,0	30,43
pH	7,2	7,8	7,4	7,5	7,5	7,0
DO content (%)	105,00	112,00	95,50	98,80	90,90	95,00
Phosphorous (mg/l)	58,33	11,67	15,00	13,33	20,00	18,57
Phytoplankton (org/ml)	6.200	3.400	5.700	5.800	3.900	3.950
Zooplankton (org/l)	225	180	80	750	460	425
Water quality Index %	75,50	75,00	74,00	80,33	81,90	79,70