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The limnochemical conditions of the northern portion (Yeji area) of the Volta lake thirty years after impoundment

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Since the formation of the Volta lake in 1964 there has been a sizeable increase of the human population in the lake's watershed with corresponding increase in anthropogenic activities. For instance, the lake now serves other purposes including water supply, transportation, fishing and recreation, in addition to hydroelectric power. These activities, may have led to changes in the quality of the lake's water. The present article provides a description of the lake's limnochemistry on its present state in the northern portion (Yeji area), and gives an assessment of the long-term changes in the water quality of the lake. The changing limnochemical conditions observed in the lake could be mainly due to the increasing anthropogenic activities in the lake's watershed.

The tropical Volta lake in Ghana (1°30′ W, 0°20′ E, 6°15′ N, 9°10′ N) is by its surface area of 8,729 km², one of the largest man-made lakes in the world. The length of the lake is about 400 km and runs in a north-south direction. There are four seasons of the area. The first wet season starts in April till July with a short dry spell in August. The second wet season start in September till October. The long dry season starts from November till March. Six sampling stations were chosen at Blackiekope, Sabongida, Yeji, Makango, Avorkope and Adakope (Fig. 1). Observations were restricted to the mid-lake region as far as possible where influence by local runoff from agriculture or settlements was insignificant. The lake was 15 m (mean) and ranged from 14 m to 19 m deep in the study area.

Water samples were collected with a 1.7 L Ruttner sampler from various depths into clean 1L plastic bottles. Separate samples were collected into plain glass bottles for Dissolved Oxygen (DO) determination. Samples were usually collected between 10.00 and 14.00 hours. Water samples were obtained bi-monthly, and for each month of sampling the samples were collected within the period 17th-20th day of the month. Sampling from two adjacent stations took an average of two hours and as a result some diurnal changes were observed. The samples were kept in a refrigerator at Yeji until they were transported (in a cold box) to Accra. In Accra the samples were kept refrigerated until the analyses were completed (within 14 days of sample collection). Methods of analysis were the same as those outlined in "Standard Methods for the Examination of Water and Wastewater" (APHA-AWWA-WPCF 1989).

The mean temperature of the lake was high and varied between 29 °C (bottom) and 31 °C (surface). According to Obeng (1981, reported in Frempong 1995) surface temperature measured along the axis of the lake over an eight year period did not exceed 33 °C and the bottom temperature did not fall below 23 °C in any season. Seasonal changes have an impact on water temperature. During the rainy season the water surface cooled (mean temperature of 29.5 °C). Cooler water en-

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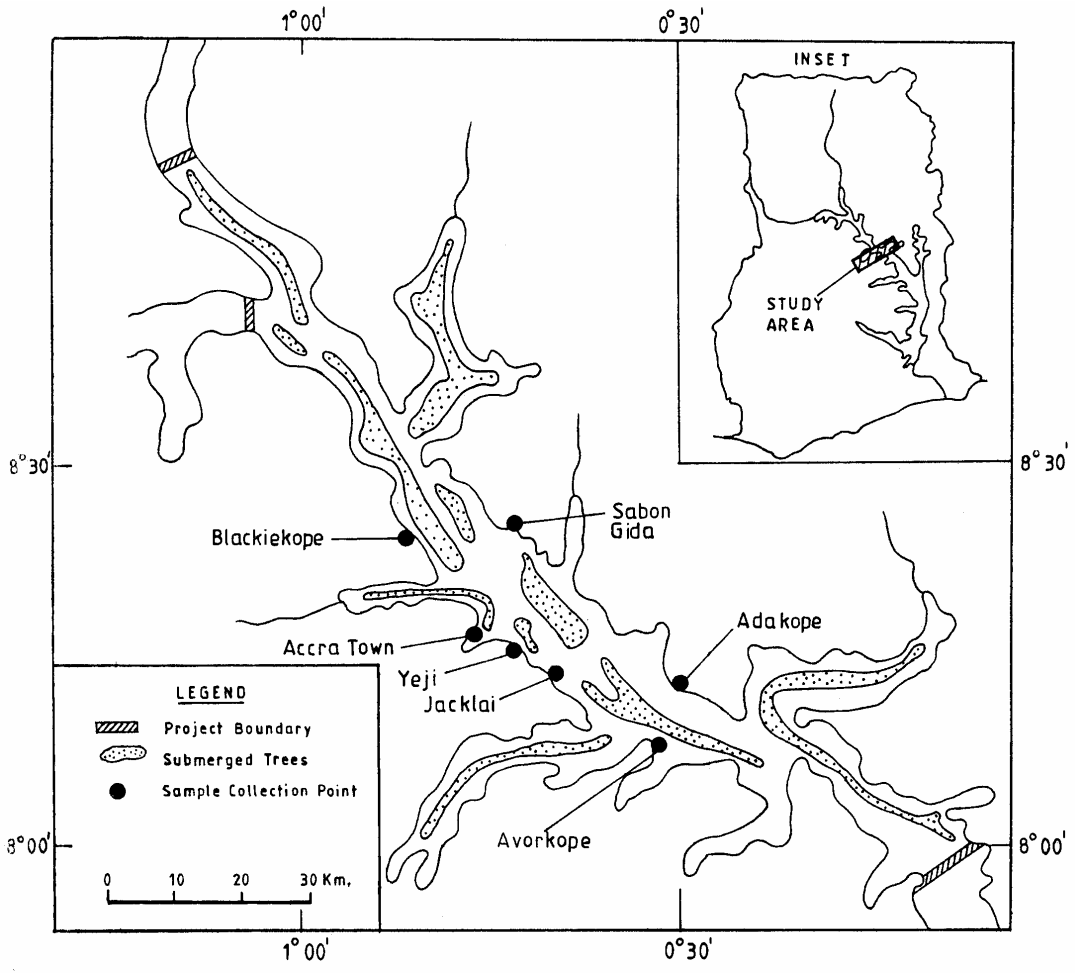

Fig. 1. Map showing sample collection points.

tered the lake with floods from the north where large rivers are situated. The dry season was characterized by hot weather, resulting in the warming up of surface water (mean temperature of 32 °C). In 1995, according to our measurements, the oxygen content in the study area was above 5 mg l^{-1} all the year round, and to the 14 m depth. The highest mean oxygen concentration (8.1 mg l^{-1}, 108.9% saturation) was recorded in the rainy season and at the surface. Water turbulence and wind were the factors, which influenced the oxygen supply of the lake. The inflow from the upper reaches of the lake (Black and White Volta) caused constant turbulence in the lake, and this was noticeable especially in the rainy season. Although wind speeds were not measured, sufficiently high wind speeds were observed on the lake at each sampling period. Ewer (1966) and Viner (1966, Unpublished, reported in Entz 1969) have shown that the well-oxygenated zones of the lake – suitable habitats for fish life – were restricted to the uppermost 5 to 10 m deep strata. No large seasonal variation in the oxygen content was also noticed.

Transparency of the Volta Lake measured in this study (mean of 50 cm) had decreased, compared with previous years. For instance, Ofori-Danson & Antwi (1994) recorded 220 cm for the Gorge area in 1990. At the Yeji area (also called Stratum VII), transparency measurements for the period July 1968 – July 1980 ranged from 35 cm to 260 cm with a mean of 134 cm (FAO 1971). Viner (1990) also recorded a transparency of 50 cm in the lake at Stratum VII. The reason for this decrease in transparency over the years might be progressive increase in colloidal suspended particles as a result of introduction of sediment arising from an-

thropogenic activities. The transparency of the lake varied with season. With the start of the first wet season in April, large quantities of suspended, dissolved and colloidal organic matter, which entered the lake with the turbid river water, reduced transparency (to a minimum of 21 cm in October). Later, there was a gradual increase in transparency (reaching a maximum of 81 cm in February) as the dry season set in, suggesting a gradual loss of suspended matter as they settled onto the lake bottom. The transparency was further increased by the loss of the seasonal algal blooms in the dry months.

The relative proportions of solutes and their total concentrations in the lake had changed over the years. While Entz (1969) measured for instance Na^+, 1.2-6.8 mg l^{-1}; K^+, 1.5-6.0 mg l^{-1}; Ca^{++}, 3.4-10.2 mg l^{-1}; Mg^{++}, 2.4-7.1 mg l^{-1} and HCO_3^-, 20-70 mg l^{-1} between 1967 and 1969, in our study in 1995, we recorded: Na^+, 9.6-12.1 mg l^{-1}; K^+, 7.6-9.6 mg l^{-1}; Ca^{++}, 9.3-11.1 mg l^{-1}; Mg^{++}, 1.5-2.0 mg l^{-1} and HCO_3^-, 47-54.1 mg l^{-1}. These could be due to anthropogenic activities in the catchment.

An important feature of the chemistry of the lake is the nutrient level, which was generally low. Early researchers, for instance Ewer (1966), Entz (1969) and Ofori-Danson & Antwi (1994) reached the same conclusion for the lake. For instance only traces of nitrite were recorded. Ammonia was found irregularly with depth and in small quantities (0.33-0.83 mg l^{-1}). Nitrate was found in concentrations of 0.51-0.97 mg l^{-1} across the depth of the lake and showed a gradual decrease with depth. Total phosphate was found in concentrations of 0.34-0.50 mg l^{-1} across the depth of the lake. Silica was found in the range 12.5-13.5 mg l^{-1}. Seasonally, nutrient concentrations did not follow any clear pattern over the years.

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