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Inorganic Nitrogen Uptake and River Inputs in Northern Lake Tanganyika

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ABSTRACT. *Northern Lake Tanganyika is characterized by an almost permanently stratified water column which causes severe nutrient depletion in surface waters. Any external N source to surface waters, therefore, is of importance in sustaining primary production. This study attempted to quantify riverine input of dissolved inorganic nitrogen (DIN) to the extreme northern end of Lake Tanganyika (surface = 900 km^2) as well as the DIN uptake by surface phytoplankton. Results showed that riverine DIN inputs (1,930 tons of N/year) were of similar importance to atmospheric deposition (1,520 to 1,720 tons of N/year) and were maximal during the dry season. Moreover, seasonal DIN variations in river and lake waters showed maximum concentrations during part of the dry season (May to July 1999) probably due to high atmospheric inputs. Phytoplanktonic nitrate and ammonium uptake rates were measured during nine cruises and varied from 0.01 to 19.3 nM/h. These values suggest that uptake by phytoplankton in the surface waters could represent a DIN sink of about 14,400 tons of N/year, thereby utilizing all available DIN coming in from external sources. External DIN sources represent approximately 25% of the annual phytoplankton N requirements, showing the major importance of unquantified N sources in sustaining primary production in the northern basin of Lake Tanganyika. These sources could include organic N present in the external sources, and internal N supply.*

INDEX WORDS: *Lake Tanganyika, Burundi, Nitrogen uptake, DIN, rivers, Rusizi River.*

INTRODUCTION

Lake Tanganyika (Fig. 1) is one of the world's largest freshwater lakes. Located in central Africa, this lake is 677 km long, 50 km wide (average), and exhibits a total area of 32,900 km^2. With a maximum depth of 1,470 meters, it is the world's second deepest lake. Lake Tanganyika receives water from rainfall as well as a large watershed which drains western Rwanda and Burundi, eastern R. D. Congo, Tanzania, and northern Zambia (Fig. 1). The outlet of Lake Tanganyika is the Lukuga River, a tributary of the Congo River. Given the extremely large volume of the lake (ca 18,000 km^2), the hydraulic re-

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tention time exceeds thousands of years (Coulter and Spigel 1991). Recently, growing attention has focused on the ecology of the lake with large research projects supported by international organizations like the United Nations' Food and Agriculture Organization (FAO) and Developing Program (UNDP). These and other research projects have highlighted the general nutrient regime in the lake (Hecky *et al.* 1991; Edmond *et al.* 1993; Vandelannoote *et al.* 1996; Kimbadi *et al.* 1999; Vandelannoote *et al.* 1999; Langenberg *et al.* 2003a and b). This nutrient regime is strongly linked to internal water circulation characteristics.

The main hydrological characteristics of this lake were studied by Coulter and Spigel (1991) and more recently by Plisnier *et al.* (1999), Chitamwebwa (1999), Naithani *et al.* (2002 and 2003), and Naithani and Deleersnijder (2004). At the end of the rainy season (January to April), the water column is stable and highly stratified from north to south with surface waters depleted in nutrients and anoxic nutrient rich deep waters. During the dry season (May to September), strong southerly winds induce surface water circulation from south to north resulting in (1) the development of an upwelling region in the southern part, with nutrient-rich deep waters reaching the surface, and (2) in a marked (60 to 70 m) deepening of the nutrient-depleted epilimnion in the northern part of the lake, where the water column stays stratified. At the end of the dry season and beginning of the rainy season, southeast winds cease, and the south-north tilted epilimnion oscillates back toward equilibrium. These oscillations induce and/or reinforce small upwelling zones along the west coast which propagate cyclonically around the lake like internal Kelvin waves. Oscillations and internal waves result in nutrient pulses to the surface layers and in the north, around October-November, deep waters move back toward the surface as a secondary upwelling period.

At the whole lake scale, the importance of nutrient inputs from rivers, rainfall, and vertical mixing on sustaining the primary production were estimated by Langenberg *et al.* (2003a). This study demonstrated that at lake scale, rainfall seemed to be the most important external DIN source (83% of total external sources) compared to rivers. Estimates deduced from lake primary productivity, however, showed that these external sources only represented 1% of nutrients used by phytoplankton. This meant that 99% of primary productivity was supported by nutrients arising from deep nutrient-rich water layers. The Langenberg *et al.* (2003a)

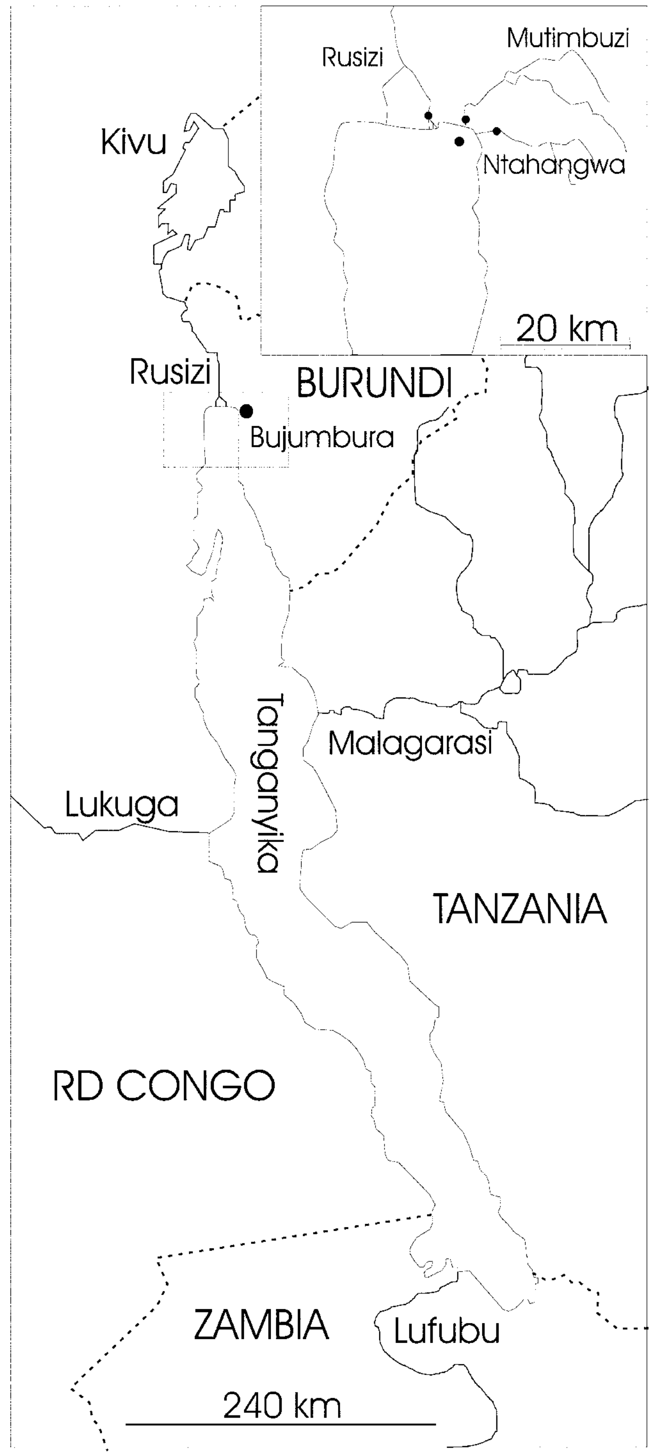

FIG. 1. Lake Tanganyika and its inflows. Black dots represent sampling locations on the Rusizi, Ntahangwa, and Mutimbuzi rivers and in the lake.