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BIOMASS COMBUSTION AND INPUT OF BLACK CARBON AND NUTRIENTS IMPACT PRIMARY PRODUCTIVITY IN LAKE VICTORIA

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Introduction

Black Carbon (BC) is a product resulting from incomplete combustion of carbonaceous material such as biomass and fossil fuels (Hammes et al. 2007). Biomass burning is the largest contributor of small carbonaceous particles consisting of fine ash and volatile elements to the troposphere, and it has a major effect on climate, primary productivity in water bodies and human health. It is likely that atmospheric deposition and catchment erosion contribute to the increase in nutrient content and BC in Lake Victoria. Hence, the objectives of this study are to: 1) indicate the distribution of BC in catchment and in mid-lake sediments within the last 100 years in order to establish a historical profile of BC deposition, and 2) establish if biomass combustion increased eutrophication in Lake Victoria based on the distribution of nutrients and BC. The three sites in the Lake Victoria catchment in Kenya were Kisumu, Busia and Siaya while lake sediments were collected from the Bavuma channel in Uganda.

Results

The sediment cores retrieved from the sites were dated using ^{210}Pb chronology. Black carbon was measured using the chemothermal oxidation method (Gustafsson et al. 1997a). In the catchment sites, mean BC flux during the period 1900-1960 was 2.64 ± 0.87 g/cm^2/yr, 0.85 ± 0.33 g/cm^2/yr, and 0.55 ± 0.17 g/cm^2/yr for Kisumu, Busia and Siaya, respectively. The mean BC flux increased during the period 1960-2012 to 4.53 ± 1.19 g/cm^2/yr, 0.84 ± 0.33 g/cm^2/yr and 3.74 ± 1.70 g/cm^2/yr for Kisumu, Busia and Siaya, respectively. The development of Kisumu as a major industrial hub in the Lake Victoria catchment is related to the doubling of BC flux after 1950. Clearing of wetlands and rise in vehicular emissions most likely increased the deposition of BC in Kisumu. Likewise, the Yala swamp in Siaya has undergone extensive reclamation for agriculture and resettlement. In the Bavuma channel, the BC concentration decreased from 1.35 to 0.82 mg/g dw from 1908-1917 before reaching maximum concentration in 1945 (1.7 mg/g dw).

We correlated the BC flux with diatom counts from the Bavuma Channel to establish the role of BC input and eutrophication. A causal relationship between BC accumulation and increase in primary productivity is evident in the sediment core (Fig. 1). For example, *Navicula zanoni* showed a similar trend as the BC flux, which increased towards the beginning of the 20th century. The transition from *Aulacoseria* to *Nitzchia* was attributed to nutrient loading (Hecky 1994; Stager et al. 2009) that is perhaps related to increase in biomass combustion in the catchment Accumulation of BC can lead to anoxic conditions during its decomposition in deeper waters, which causes N to become limiting and promotes cyanobacterial growth (Hecky et al., 1994). Atmospheric deposition accounted for ~94% and 90% of nitrogen and phosphorous input to Lake Victoria (Scheren, et al. 2000), making it a possible pathway for BC input too. Combustion-derived input into the lake is also supported based on the presence of phenanthrene that increased since the 1970s (Stager et al. (2009). Notably, atmospheric

input of nutrients increased during the wet periods coinciding with higher phytoplankton productivity (Lung'ayia, et al., 2001).

Conclusions

Increase in eutrophication in Lake Victoria is evident from cyanobacteria and pelagic diatom populations. Using the data on diatoms and BC analysis in the same core, we were able to show a causal link between primary productivity and BC accumulation in sediments. Further, analyses of nutrients, BC, polycyclic aromatic hydrocarbons and diatom counts in surface sediments are proposed to confirm the relationship between biomass burning and increase in eutrophication in the lake.

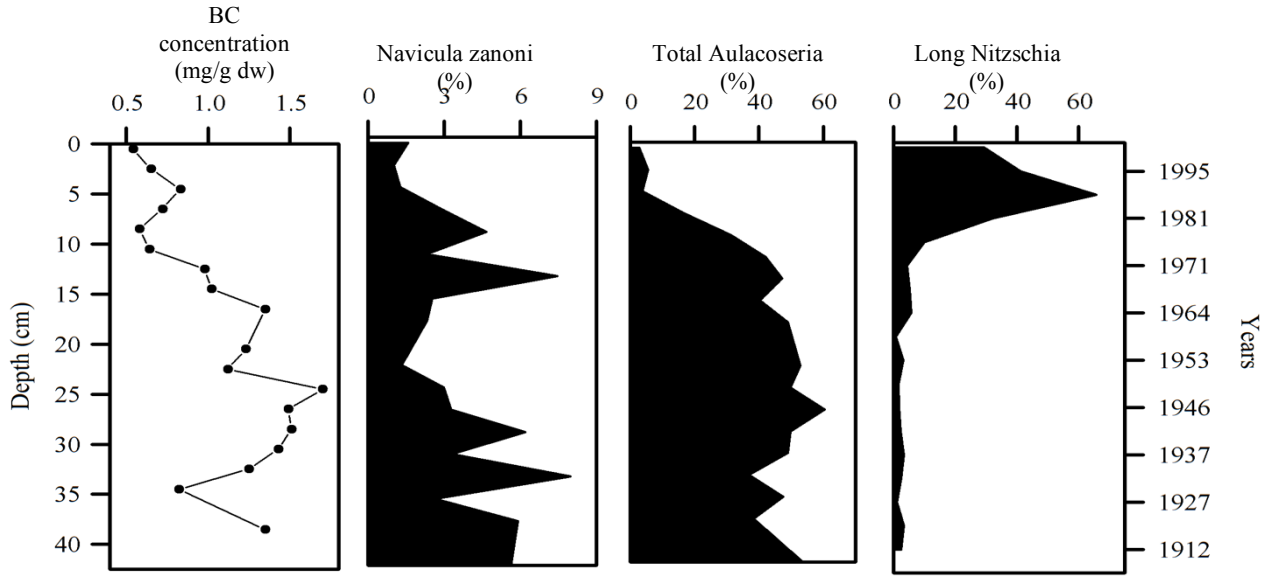

Figure 1:Distribution of diatoms and BC concentration in the Bavuma channel, Lake Victoria

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