Aquatic Botany 134 (2016) 18–25

Contents lists available at ScienceDirect

Aquatic Botany

journal homepage: www.elsevier.com/locate/aquabot

Aquatic macrophytes in Ethiopian Rift Valley lakes; Their trace elements concentration and use as pollution indicators

Yetneberk A. Kassaye*, Lindis Skipperud, John Einset, Brit Salbu

Norwegian University of Life Sciences (NMBU), P.O. Box 5003, 1432 Aas, Norway

ARTICLE INFO

Article history:
Received 2 January 2013
Received in revised form 27 May 2016
Accepted 7 June 2016
Available online 13 June 2016

Keywords:
Macrophytes
Ethiopian Rift Valley lakes
Trace elements
Pollution

ABSTRACT

Trace elements (TEs) uptake from water and sediments to 10 aquatic macrophytes in the Ethiopia Rift Valley lakes Koka, Ziway and Awassa was investigated to evaluate pollution of these lakes. Concentrations of Cr, Co, Ni, Cu, Zn, As, Se, Cd, Pb and Mn have been determined in leaves of macrophytes, water and sediment, using ICP-MS (Inductively Coupled Plasma–Mass Spectrometry). Principal component analysis showed an existing variation in TEs concentration in leaves of aquatic macrophytes. High concentration of Mn (1.6×10^3 and 1.2×10^3 mg kg^{-1} dw) was found in *Aeschynomene elaphroxylon* of Lake Ziway and *Eichhornia crassipes* of Lake Koka, respectively. Cr concentration in low molecular mass (LMM) fraction of water and total sediment (4.9 μg L^{-1} and 95 ± 4 mg kg^{-1} dw, respectively) was higher in Lake Koka compared to lakes Ziway and Awassa. Some of the studied macrophytes can accumulate high level of trace elements concentration compared to the surrounding, showing their potential to be utilized as pollution indicators. Most TEs in macrophytes used as animal feed, such as *Echinochloa stagnina* (Retz.) P. Beauv, were sufficiently low.

1. Introduction

Macrophytes have been used as bioindicators and/or biomonitors of trace element pollution in aquatic systems. Pfeiffer et al. (1986) used stems and leaves of water hyacinth as biological monitor for critical trace metal elements discharged in Paraiba do Sul River in Brazil. Roots of water hyacinth were also used as a biological indicator of metal pollution in the basin of the River Saguala Grande, Cuba (Gonzalez et al., 1989). Concentration of trace metal elements in the roots, rhizome, stems and leaves of *Phragmites australis* and corresponding water and sediment were studied from mouth area of the Imera Meridionale River in Sicily, Italy (Bonanno and Lo Giudice, 2010). Positive linear relationship between trace metal elements concentration in the organs and those in water and sediment indicates potential use of such organs for pollution monitoring in water and sediments. Bonanno (2012) tested roots, stems and leaves of *Arundo donax* from Acquicella stream in Catania, Italy, as potential biomonitors of trace elements contamination in water and sediment. The study showed that trace elements concentration decrease with a pattern of roots > leaves > stem.

Both natural and human activities have affected the water quality of lakes in the Ethiopian Rift Valley (ERV) region. Warm climate, volcanic activity (tectonics), drought, rugged terrain which result in soil erosion and hence poor vegetation cover were mentioned from the natural factors (Zinabu et al., 2002b). Human activities such as industrialization, agriculture and urbanization together with increasing human population around and near the lakes have also been reported having their influence on water quality through elevated level of contaminants (Zinabu, 1998; Zinabu and Pearce, 2003; Masresha et al., 2011).

Previous research activities in the Ethiopian rift valley lakes region focused on soil, water, sediment and fish tissue samples to assess the extent of pollution with regard to selected trace elements (Zinabu, 2002; Zinabu and Pearce, 2003; Masresha et al., 2011). However, trace elements enrichment in macrophytes from water and sediments in the Ethiopian Rift Valley Lakes (Koka, Ziway and Awassa) was not investigated.

Uptake of trace elements in aquatic macrophytes takes place via their roots from sediments and via their shoot from the water (Denny, 1980) and different aquatic macrophytes tend to take up trace elements in different amounts and transport them from root to shoot to varying degrees (Greger and Kautsky, 1993). In an aquatic ecosystem factors governing the bioavailability of trace elements to aquatic macrophytes include pH, redox potential, temperature, salinity, ambient element concentrations, elements

* Corresponding author at: Norwegian University of Life Sciences (NMBU), Department of Environmental Sciences (IMV), P.O. Box 5003, 1432 Aas, Norway.
E-mail addresses: yetneberk.kassaye@nmbu.no, yetneberkk@yahoo.com (Y.A. Kassaye).

http://dx.doi.org/10.1016/j.aquabot.2016.06.004
0304-3770/

competition for binding sites, concentration of ligands and growth form of a plant (Sparling and Lowe, 1998; Fritioff et al., 2005; Mazej and Germ, 2009).

There are no documented records of the use of aquatic macrophytes as feed for animals around the studied ERV lakes (Koka, Ziway and Awassa). However, local people around these lakes move their herds close to the shores to make use of the accessible temporary pasture resulting from retreating lakes, especially during long dry seasons (personal observation). Therefore, bioaccumulation of trace elements in animals as a result of feeding contaminated forage aquatic macrophytes can be a possibility.

The hypothesis of this study is that in the studied ERV lakes (Koka, Ziway and Awassa) water and sediment may act as source for trace elements and aquatic macrophytes in these lakes can indicate trace element pollution of these aquatic systems. Therefore, the objective of this study was to investigate the concentration of trace elements in lakes water, sediment and aquatic macrophytes, and assess the extent of trace element pollution of the studied lakes using macrophytes as indicators.

2. Materials and methods

2.1. Description and characteristics of the study sites

Lakes Koka, Ziway and Awassa are among the chain of lakes found in the central and southern part of the ERV. These lakes are situated at an elevation of 1660, 1636 and 1680 m above sea level, respectively. The ERV includes three major water basins from the northeast to the southwest, where Lake Koka belongs to the Awash basin, Lake Ziway to the Central Ethiopian Rift and Lake Awassa to the Southern basin (Alemayehu et al., 2006).

The average annual rainfall (RF) at Koka, Ziway and Awassa is 880 mm (Kibret et al., 2009), 734 mm (Hengsdijk and Jansen, 2006) and 960 mm (Ayenew and Gebreegziabher, 2006), respectively. According to the classification given by Smith (1984), these areas are in the sub-humid climatic zone (700–1000 mm RF) of the ERV. The ERV areas are dominated by volcanic rocks which can be natural sources of trace elements such as As and Mn.

Lake Koka is a habitat for widely spread aquatic macrophytes such as *Eichhornia crassipes* (Mart.) Solms (water hyacinth), which is a free-floating perennial aquatic macrophyte, and *Echinochloa*

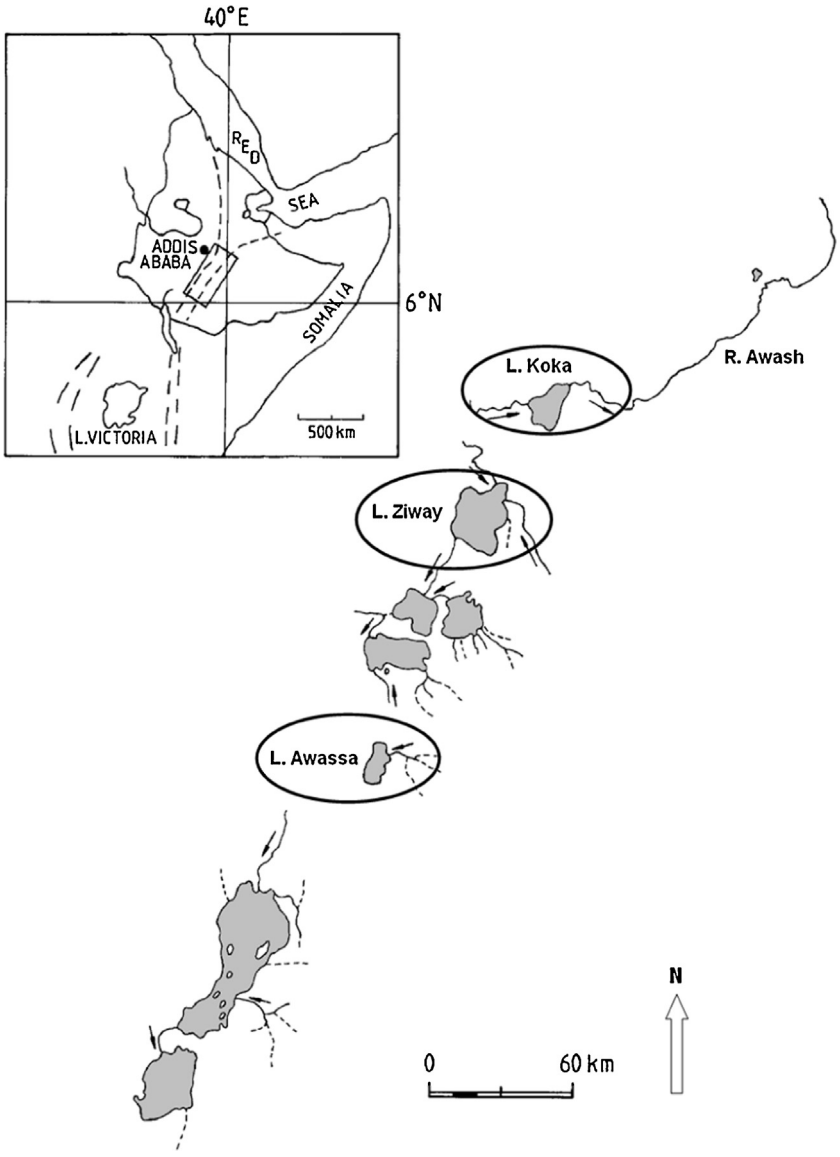

Fig. 1. Sampling sites of water, sediment and macrophytes (ERV Lakes: Koka, Ziway and Awassa are circled). Modified after Kebede et al. (1994).