Arabian Journal of Geosciences (2018) 11:773
https://doi.org/10.1007/s12517-018-4127-9

ORIGINAL PAPER

Secondary dispersion of trace elements in bottom sediments of the High Dam Lake, South Egypt and North Sudan

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Received: 27 March 2015 / Accepted: 29 November 2018

Abstract
Thirty-four chemical elements, pH, total nitrogen, and total organic carbon were determined in 49 bottom sediment samples from the whole High Dam Lake in order to improve our understanding of geochemical characteristics of these sediments and geochemical patterns of trace elements and related feeding sources. The present study revealed that the lake were clearly discriminated into three portions in accordance with the sediment geochemistry and geographic position. Likewise, the analyzed elements in the entire lake sediments were classified into six geochemical association patterns that are indicative of the contributing geogenic and anthropogenic sources. As has been noted here, mineralogy, anthropogenic inputs, pH, and organic matter had significant roles in controlling the behavior, concentration, dispersion, and geochemical patterns of the trace elements in the lake sediments. Consequently, the elevated concentration of Bi, Cd, Co, Cr, Cu, Fe, Ga, Mn, Mo, Ni, Sc, V, Y, and Zn posed moderate contamination level in the sediments. At the same time, the enhancement of Ag, Se, and Te levels caused contamination up to very high levels. Admittedly, the contamination levels were generated by natural and human activities that are coming from the Nile basin countries. Despite progressive deterioration of these sediments, they still have economic applications.

Keywords Secondary dispersion · Statistical techniques · Trace elements · High Dam Lake · South Egypt and North Sudan

Introduction

The lake sediments are considered as the secondary environment for trace elements dispersion, composed of transport materials derived from the watershed (Ng and King 2004), and they undoubtedly are a representative of upstream lithology (Ranasinghe et al. 2009). The composition of lake sediments allows us to understand the fate of transportation of the terrestrial materials into the basins and the factors that control both the distribution and geochemistry of sediments (Hedges and Keil 1995; Bianchi et al. 2002). In addition, the lake sediment data have been used to study the historical record of heavy metal input to the lakes, evaluate background concentrations, and assess relative increases in concentrations because of large-scale anthropogenic influences (Jin et al. 2006). Consequently, these sediments play a significant role in exploration and environmental geochemistry (Ranasinghe et al. 2009). In the present study, large volumes of the sediments sunk and accumulated in the intact High Dam Lake, which exists beyond the High Dam body, as a result of the sudden decreasing in speed of feeding water of the Sudanese Main Nile due to collision with a huge water mass of this lake. In the entire lake, the amount of sediments was estimated at 125 million tons yearly (Entz 1974), reached 518.2 million m^3 in a period between 1987 and 1992 (El Dardir 1994), increased to 6000.2 million m^3 in 2007, and enhanced to reach 7 milliard m^3 in 2012 as estimated by the Egyptian High Dam Authority. Since more than 70% of the Nile flow sediments were deposited in the upstream part near Wadi Halfa in Sudan (El-Shabrawy 2009), a new Nile delta (ca. 200-km long, mostly subaqueous) was generated between Dal Cataract and Abu Simbel (Mancy and Hafez 1983; El Dardir 1994). Sedimentation processes and related problems and patterns, the progress of the delta formation, and the effects of drought period 1979/1987 in the whole High Dam Lake have

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s12517-018-4127-9) contains supplementary material, which is available to authorized users.

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Published online: 14 December 2018