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Ecological implications of heavy metal concentrations in the sediments of Burullus Lagoon of Nile Delta, Egypt

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ABSTRACT

This paper examines the spatial and temporal distribution of heavy metals (Fe, Al, Cu, Zn, Mn, Cd, Pb and Ni) from three short sediment cores collected from Burullus lagoon of the Nile delta, Egypt. ^{210}Pb and ^{137}Cs measurement is applied to understand sedimentation rate and related chronology. Remarkably low isotopic activities and intensive bioturbation in the lagoonal sediments rendered age determination difficult. Samples with detectable ^{137}Cs in the upper core sediments together with sediment lithology could help infer a sedimentation rate of about 2.0 mm yr^{-1}, thereby indicating post-dam (after 1964) sedimentation of the upper 10-cm core sediments. Our results demonstrate that most heavy metals in the surficial sediments after normalization to Al decrease seaward, showing a function of distance to the sewerage outlet on the inland lake coast. Also, there is an upwardly increasing trend of normalized heavy metals, especially in the upper 10-cm core sediments. Relevancy analysis has identified Mn, Pb and Cd as the diagnostic heavy metals in Burullus lagoon, most likely derived from Tanta and Kafrelsheihk, the major downtowns in the central Nile delta plain, from where wastewaters are directly discharging into the lake via canal networks. Although Burullus lagoon is presently least affected by pollution as compared to other major lagoons of the Nile delta, the increasing quantities of diagnostic metals, especially Mn, are extremely toxic, as they are potentially linked to the risks of digestive issues and pancreatic cancer reportedly. The situation calls for a rational planning for sewerage treatment in the protected Burullus coast.

1. Introduction

The delta coasts of the world are densely populated and highly industrialized during the past century. This has discharged a large quantity of wastewaters into the estuaries, leading to severe pollution of the wetlands and the associated social issues in relation to degraded environment (Abdel-Moati and El-Sammak, 1997; Soliman et al., 2006). Heavy metals of anthropogenic origin are toxic pollutants, which are able to transfer hierarchically into human society through the food chain (Farmer, 1991), and some of which, under certain circumstances, can be further transformed into more toxic compounds (Chen et al., 2000). Analyses of spatial and temporal distribution of heavy metals in the delta coasts are useful to recognize the degradation processes of wetlands and trace sources of pollutants for better environmental assessment and management.

Environmental issues of the Nile delta coast have become more prominent recently due to increasing population and intensifying industry (Abdel-Moati, 1998; El-Rayis, 2005). Four large coastal lagoons are being ecologically degraded owing to the discharge of untreated wastewaters into the lakes. For example, sewerage output has extended to Mariut lagoon from Alexandria on the northwestern Nile coast and that from Port Said, Damietta and Matariya to Manzala lagoon on the northeastern coast, where heavy metals are significantly enriched in the water and sediments. Cu and Cd in Manzala lake have gone up almost 60% and Zn has increased almost twofold since last decades (Abdel-Moati, 1998). Nowadays, Mariut and Manzala lagoons are the most polluted and Idku and Burullus follow behind. Presently these two lakes are facing critical environmental pressures from local industries and urbanization with the increasing pollutants being expelled towards the lake coast (Kamal and Magdy, 2005).

Heavy metals and related environmental conservation of the Nile coast calls for more attention. Many projects implemented have targeted heavy metal distribution and transportation in relation to aquacultural health and societal response. Abdel-Moati

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and El-Sammak (1997) found that Cd and Pb expelling into the lagoons has increased by 8–70 times during the past 25 years. Pancreatic cancer risk in the Manzala region seems to be closely associated with cadmium concentration (Soliman et al., 2006). Siegel et al. (1994) stated that Pb, Zn Hg and Cu enriched in Manzala lagoon were primarily due to cheaper power generators after High Aswan dam emplacement in 1964. This has considerably degraded aquacultural products both in quantity and quality in the Manzala region, where it has long been the most important aquacultural base, by providing more than 50% of aquaculture products for Egyptian.

Burullus lagoon of the central Nile delta is a UNESCO-protected area (Fig. 1). Burullus is chosen as the study area with an aim of establishing a useful heavy metal database for this relatively less polluted lake, where the existing ecological information is very limited when compared to that of other lagoons in the region. This paper examines the spatial and temporal variations in distribution of heavy metals in the lake sediments, assisted by ^{210}Pb and ^{137}Cs measurements, which has not been substantially attempted in the previous studies. Through this analysis, we defined the diagnostic heavy metals and discussed the potential sources of pollution, calling for an urgent attention on ecological safety.

2. Regional setting

The Nile delta lies at the southern coast of the Mediterranean Sea (30°00′–31°40′ N and 30°00′–32°30′E; Fig. 1A), which is under an arid climate with annual precipitation of <100 mm (Appleby et al., 2001). After the construction of the Aswan High dam in 1964, the annual runoff entering the sea has been dramatically reduced from 85×10^9 m^3 to $<60 \times 10^9$ m^3 (Frihy and Lawrence, 2004). Accordingly, sediment load has decreased from 178×10^6 t yr^{-1} to $50–60 \times 10^6$ t yr^{-1} (Inman and Scott, 1984), which affected sedimentation rates on the delta coast from the previous >1.0 cm/yr to the recent <0.20 cm yr^{-1} (Siegel et al., 1994; Appleby, et al., 2001), triggering wide-spread erosion along the delta coast.

Although the coast is a microtidal environment (<1.0 m), the strong littoral currents induced by huge winter storm surges prevail in the region and drive the sediments primarily eastward along the shoreline. This has been largely responsible for shaping the coastal topography. Strong marine invasion into inlands has substantially sustained the development of brackish lagoonal wetlands on the Nile coast (Hamza, 2006).

Four large lagoons occur on the Nile coast, i.e., Manzala, Burullus, Idku and Mariut from east to west (Fig. 1A). Burullus lagoon of the

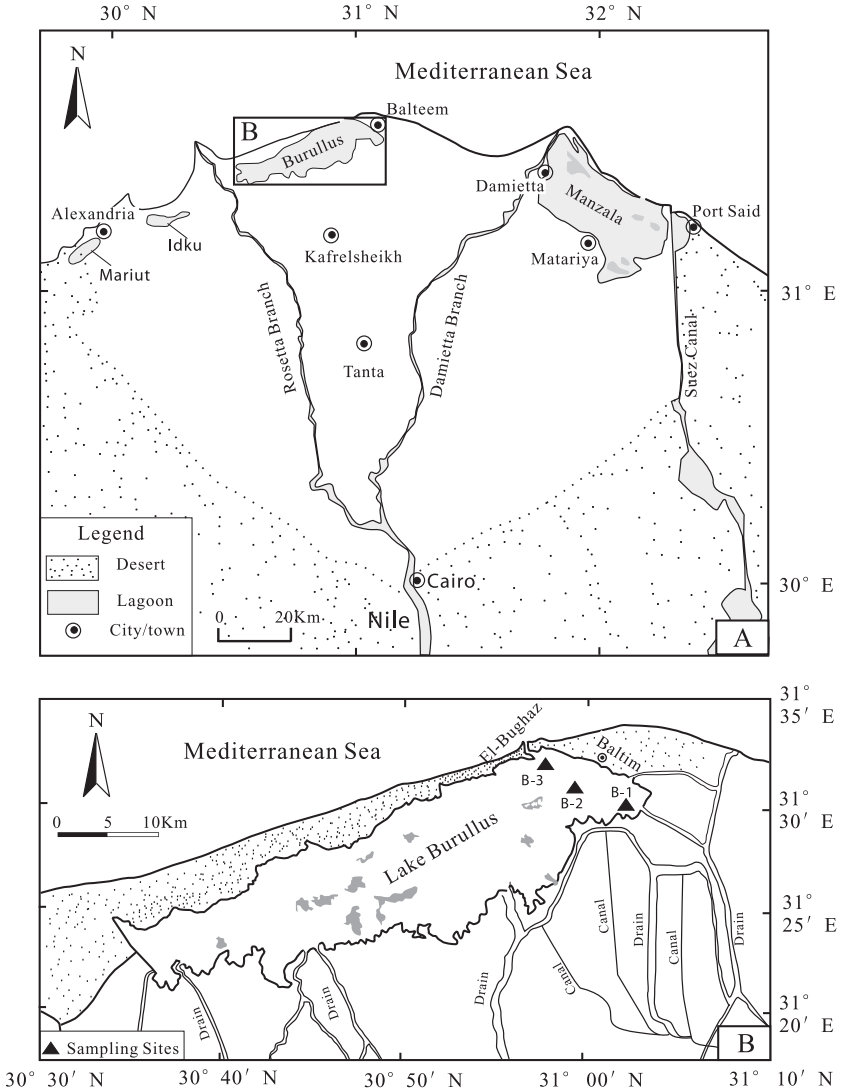

Fig. 1. A) Geographic site of the Nile delta, Egypt; B) sampling sites (B-1, B-2 and B-3) in Burullus lagoon. Note, canal networks with sewerage discharge are spread on the inland coast of the lagoon.