Estuarine, Coastal and Shelf Science 177 (2016) 31–40

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

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

Geochronology and historical deposition of trace metals in three tropical estuaries in the Gulf of Guinea

Edem Mahu [a, b, *], Elvis Nyarko [a], Samuel Hulme [b], Peter Swarzenski [c], Daniel K. Asiedu [d], Kenneth H. Coale [b]

[a] Department of Marine and Fisheries Sciences, University of Ghana, Ghana
[b] Moss Landing Marine Laboratories, California State University, USA
[c] United States Geological Survey, Santa Cruz, USA
[d] Department of Earth Science, University of Ghana, Ghana

ARTICLE INFO

Article history:
Received 3 February 2015
Received in revised form
5 May 2016
Accepted 7 May 2016
Available online 10 May 2016

Keywords:
^{210}Pb
^{137}Cs
Trace metals
Sediment cores
Estuaries
Ghana

ABSTRACT

The depositional histories of trace metals (Pb, Cu, and Zn) in sediment cores from three Ghanaian estuaries were reconstructed using radioisotope-derived (^{210}Pb and ^{137}Cs) geochronologies. A core collected from each of the Amisa, Sakumo II and Volta estuaries was analyzed for trace metals and radionuclides. Lead-210 and ^{137}Cs dating via gamma spectroscopy, and trace metal analysis via inductively coupled plasma mass spectrometry (ICP-MS) were used in deriving sedimentation rates, geochronologies and accumulation trends of trace metals. The sedimentation rates in all three estuaries (in the range of 0.54–0.83 cm yr^{-1}) were greater than the predicted sea level rise (~0.33 cm yr^{-1}) for the Accra Coast of Ghana. The ^{210}Pb depositional rates of 6.83 dpm cm^{-2} y^{-1}, 2.74 dpm cm^{-2} y^{-1} and 1.75 dpm cm^{-2} y^{-1} estimated for the Amisa, Sakumo II and Volta estuaries, respectively, are higher than those recorded in other latitudes. Trace metal analysis revealed differences in the concentrations of Cu, Pb and Zn between deeper and surficial layers of each core to be in the range of 10–20%, which is well within the natural variations attributed to geochemical factors. Relative to the Amisa and Volta estuaries, the temporal profiles of Al-normalized metal concentrations and estimated fluxes suggest anthropogenic processes augmented the natural fluxes of trace metals, particularly Zn into the Sakumo II estuary during the last 7 years.

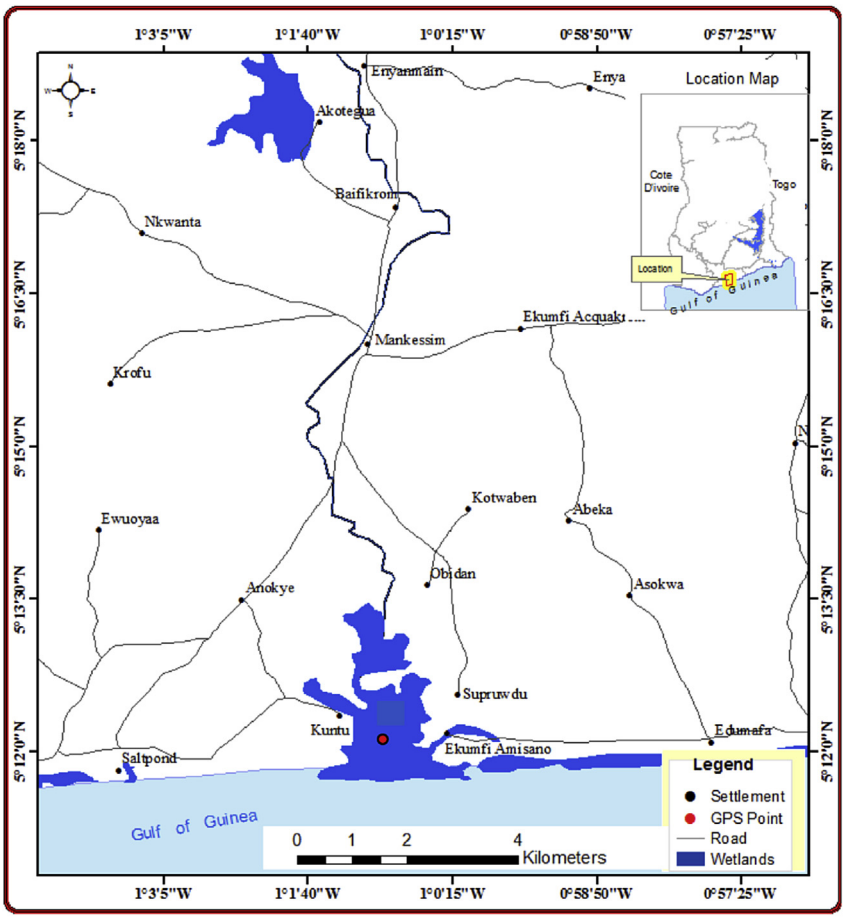
1. Introduction

Estuaries act as transition zones in which continental materials are trapped, and through which some land-based materials are transported to the open sea (Hatje et al., 2001). By virtue of their nature and position between terrestrial and marine environments, they have become the focal point for a wide variety of human activities including the siting of major ports, industries, residential and other recreational developments (Ridgway and Shimmield, 2002). As a result, estuaries have evolved to become the ultimate repositories for anthropogenic contaminants discharged through industrial activities and by residents living along them (Mil-Homens et al., 2009). Toxic contaminants such as metals and organic pollutants have placed increasing pressures on the ecological health of coastal and estuarine ecosystems globally, and the sediment accumulative potential of estuaries further exacerbates this problem.

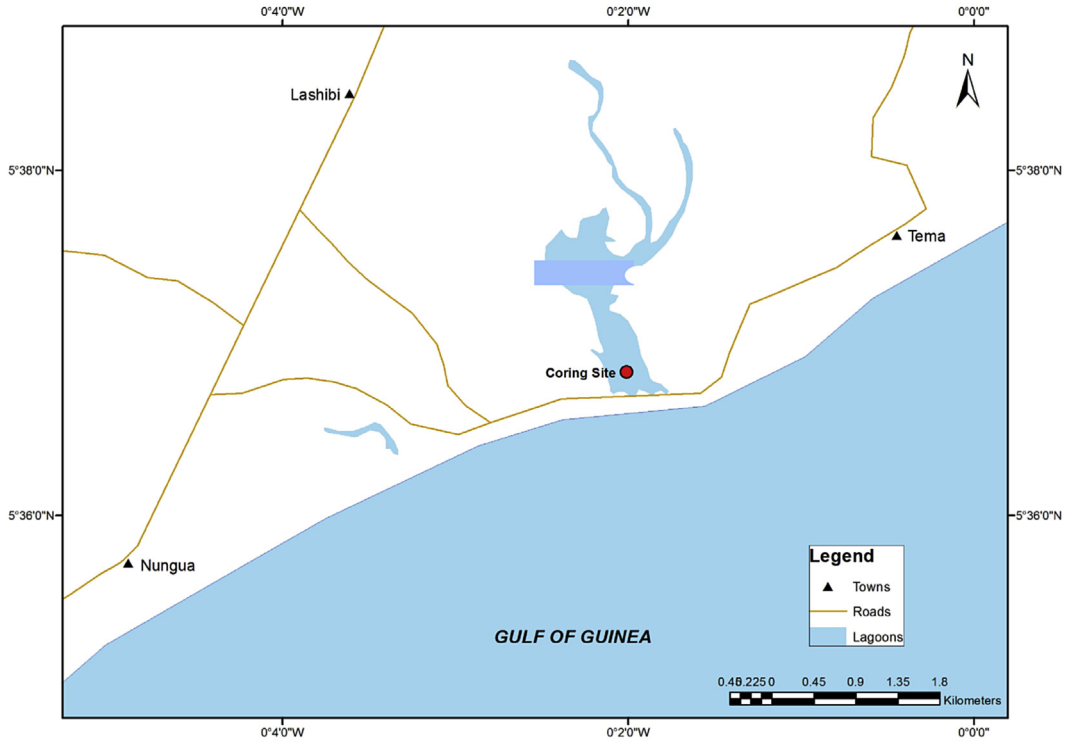
The historical reconstruction of anthropogenic impacts in coastal environments can be inferred from the record of sediment cores dated using ^{210}Pb and ^{137}Cs radioisotopes (Ruiz-Fernández et al., 2009; Díaz-Asencio et al., 2009; Hung and Hsu, 2004; Ruiz-Fernández et al., 2004; Cundy et al., 2003). Lead-210 ($T_{1/2}$ = 22.3 years) is a naturally occurring radionuclide from the ^{238}U decay series, commonly used to establish the chronology of recent (past 100–150 years) sedimentary deposits (Appleby and Oldfield, 1978). Since anthropogenic factors and changes in biological, geochemical and hydrodynamic processes could alter the ^{210}Pb record in sediments, the ^{210}Pb-derived chronology is verified with other dating tracers such as artificial radionuclides (^{90}Sr, ^{137}Cs, ^{239,240}Pu and ^{241}Am) (Smith, 2001). Cs-137 for instance, is present in the marine environment due to the testing of nuclear weapons during the

* Corresponding author. Department of Marine and Fisheries Sciences, University of Ghana, Ghana.
E-mail address: edemmahu@gmail.com (E. Mahu).

http://dx.doi.org/10.1016/j.ecss.2016.05.007
0272-7714/


1°3'5"W
1°1'40"W
1°0'15"W
0°58'50"W
0°57'25"W
5°18'0"N
5°16'30"N
5°15'0"N
5°13'30"N
5°12'0"N
Enyanmain
Enya
Akotegua
Baifikrom
Nkwanta
Location Map
Cote D'Ivoire
Togo
Location
Gulf of Guinea
Ekumfi Acquaku
Mankessim
Krofu
Kotwaben
Abeka
Ewuoyaa
Obidan
Asokwa
Anokye
Supruwdu
Kuntu
Edumafa
Ekumfi Amisano
Saltpond
Legend
Settlement
GPS Point
Road
Wetlands
Gulf of Guinea
0 1 2 4
Kilometers

(a)


0°4'0"W
0°2'0"W
0°0'0"
5°38'0"N
5°36'0"N
N
Lashibi
Tema
Coring Site
Nungua
GULF OF GUINEA
Legend
Towns
Roads
Lagoons
0.45 0.9 1.35 1.8
Kilometers

(b)