

Assessment of Heavy Metals in Surface Sea Water, Suspended Particulate Matter and Surficial Sediment at Tema Port

Albert Fleischer
2011

ABSTRACT

Fifty (50) years after the construction of the Tema Port, no comprehensive study has been undertaken to assess heavy metal pollution at the port. This study therefore aimed at investigating the spatio-temporal distribution of heavy metals iron (Fe), zinc (Zn), nickel (Ni), chromium (Cr), cobalt (Co), manganese (Mn), copper (Cu), cadmium (Cd), arsenic (As) and vanadium (V) in surface seawater, suspended particulate matter (SPM) and surficial sediments. Determination of the levels of Mn, V, Cu, As and Cd was done using Instrumental Neutron Activation Analysis (INAA) and levels of Fe, Cr, Zn, Ni and Co were determined by Atomic Absorption Spectrophotometry (AAS). In order to ascertain their relationship with other environmental variables, physico-chemical parameters were also measured.

Seawater samples were collected using the Nansen bottle and the surficial sediments were collected using the orange peel grab. Physico-chemical parameters in seawater such as temperature, pH, salinity, conductivity and total dissolved solids (TDS) were measured using conductivity temperature and depth (CTD) SONDE while turbidity was measured using Lamotte2020 turbidimeter. Total organic carbon (TOC), pH and particle size distribution of sediment were determined in the laboratory. The results indicate that the physico-chemical parameters during the dry season ranged between 26.8 - 27.5 °C for temperature, 8.01 - 8.43 for pH in seawater, 7.7 - 8.6 for pH in sediment, 32 - 34 ppt for salinity, 47.76 - 51.72 mS/cm for electrical conductivity, 0.04 - 6.46 NTU for turbidity, 33.00 - 36.77 g/L for total dissolved solids, and 0.1 - 2.9% for TOC while during the rainy season physico-chemical parameters ranged between 27.8 - 27.8 °C for temperature, 8.01 - 8.51 for pH in seawater, 7.7 - 8.5 for pH in sediment, 32 - 34 ppt for salinity, 47.7 - 50.9 mS/cm for EC, 32.07 - 36.77 NTU for turbidity, 32.0 - 34.0 g/L for total dissolved solids, and 7.5 - 8.5% for TOC.

Heavy metals in seawater during the dry season ranged between 0.180 - 0.500 mg/L, 0.010 - 0.500 mg/L and 0.040 - 0.217 mg/L for Fe, Mn and Co respectively while during the rainy season concentrations ranged between 0.377 - 0.700 mg/L, non-detection (ND) - 0.08 mg/L, ND - 0.170 mg/L, ND - 0.099 mg/L and 0.063 - 0.900 mg/L for Fe, Mn, Cu, Cd and Co respectively. The lowest levels of heavy metals measured were in suspended particulate matter (SPM). Metals in SPM during the dry season ranged between 8.13 - 123.17 ng/L, ND - 5.62 ng/L, 0.09 - 1.90 ng/L, 2.26 - 6.09 ng/L, ND - 0.33 ng/L, 0.22 - 1.39 ng/L, 0.04 - 0.41 ng/L and 0.01 - 0.06 ng/L for Fe, Mn, Cu, Zn, Cd, Ni and As respectively while during the rainy season concentrations ranged between 5.81 - 316.31 ng/L, ND - 0.080 ng/L, 0.06 - 3.0 ng/L, 0.528 - 31.15 ng/L, 0.60 - 0.70 ng/L, ND - 0.025 ng/L and 0.06 - 0.12 ng/L for Fe, Mn, Cu, Zn, Cr, Cd and Ni respectively. The highest concentrations of metals at the study were recorded in sediments. During the dry season, heavy metals in sediment ranged between 1910 - 6784 mg/Kg, ND - 253.000 mg/Kg, ND - 5.685 mg/Kg, ND - 40.300 mg/Kg, ND - 95 mg/Kg, 2.5 - 49.7 mg/Kg, ND - 3.00 mg/Kg and ND - 356 mg/Kg for Fe, Mo, Cu, Zn, Cd,

Ni, As and V respectively while during the rainy season concentrations were between 2561 - 7107 mg/Kg, 2 - 51 mg/Kg, ND - 89.0 mg/Kg, 1.0 - 119.0 mg/Kg, ND-22.5 mg/Kg, 27 - 82 mg/Kg, ND - 2.50 mg/Kg and ND - 419 mg/Kg for Fe, Mn, Cu,

Significant inter-relationships existed between the concentrations of Cd and pH in seawater during the rainy season. In the suspended particulate matter, Ni correlated negatively with salinity during the dry season while Cd and Fe correlated negatively with salinity during the rainy season. In sediment, negative correlations were between Fe, Cu and Zn with pH while it correlated positively with TOC during the dry season. During the rainy season Mn and As correlated positively with TOC. The partitioning coefficient, K_d, decreased with SPM while it increased with sediment concentrations. The cluster analysis (CA) on the studied parameters showed that in seawater and suspended particulate matter, turbidity and pH influenced the spatio-temporal distribution of the heavy metals. This was different for the case of sediment where pH influenced the distribution of Fe during the rainy season while TOC influenced the distribution of Cd and Ni for both seasons. Nevertheless TOC also influenced the distribution of V during the rainy season. The cluster analysis on the sampling stations revealed that the canoe basin was distinct from the rest for both seasons and stations at the outer and inner fishing harbours were distinct during the dry season for seawater, suspended particulate matter and sediment. This might suggest similar environmental factors prevailing as these stations were located at the fishing harbours. The Enrichment Factor, Contamination Factor, and Geoaccumulation Index revealed a heavy pollution by Cd in sediments while the other heavy metals seemed to reflect background concentrations. A very high degree of contamination was observed in the open sea area using contamination degree index. In general the levels of heavy metals in seawater were below the Australian and New Zealand Environment Conservation (ANZECC) guidelines. Heavy metals in sediments were below the effects based guideline values proposed by National Oceanic and Atmospheric Administration (NOAA) and Florida Department of Environmental Protection (FDEP) except for Cd and Ni. Comparison of heavy metals level at the Tema port with other harbours around the world shows that seawater contamination was mostly above the reported ranges while the sediment results were similar to the results obtained for the other ports. The study further shows the need to improve the management of waste due to urbanization around the Tema Port and to continuously monitor heavy metal pollution and other contaminants.

Supervisors

Dr. Nyarko E

Mr. Armah A