BIOGEOCHEMISTRY OF LEAD IN A COASTAL BAY OFF ALEXANDRIA

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In addition to industrial discharge, the coastal waters of Alexandria receives huge amounts of agricultural runoff from the Nile delta lagoons as well as untreated sewage discharge from main metropolitan stations. As a consequence of the growing industrialization and human activities in recent years, the task of lead pollution in the coastal waters of Alexandria arise to be a major problem. The ultimate sink of most of metals derived through land-based sources is the semi-enclosed basins like harbors and bays surrounding the city. The present work is an attempt for evaluating the sources, behavior and fate of lead in a coastal ecosystem, to understand the degree of the metal impact on its environment. Mex bay, located west of Alexandria city, have a surface area of 19.4 km^2 and a mean depth of 10 m. The bay receives 2.2 x 10^9 m^3 y^{-1} of agricultural drainage water through Umum drain (bearing industrial wastes discharging into Lake Mariut), 0.12 x 10^9 m^3 y^{-1} of industrial water discharge from a Chlor-alkali plant as well as 1.13 x 10^9 m^3 y^{-1} from the Western harbor of Alexandria. Three factories (cement, petrochemicals and petroleum refinery) are located in the vicinity of the bay.

During 1992-1993, subsurface and near bottom sea water from 10 stations were sampled by pumping during low and high discharge periods from Umum drain. Water samples were collected in pre-acid cleaned, DDW washed and filtered sea water rinsed teflon bottles.

After filtration, Adsorptive Cathodic Stripping Voltammetry in the differential pulse mode was used for determination of labile (untreated) and total dissolved lead (acidified + UV irradiated) at pH 7.7 using 0.01 M HEPES as a buffer and 8 x 10^{-6} M oxine as chelator (VAN DEN BERG, 1986).

Labile lead values ranged from 8.6 nM Kg^{-1} near discharge points and 1.5 nM kg^{-1} seaward, constituting between 60-80% of total dissolved metal. With respect to salinity, lead behaved nonconservatively during transport from discharge points seaward showing 43-72% and 28-52% removal during high and low discharges from Umum drain. Suspended and bottom sediments were digested using the sequential method of TESSIER *et al.* (1979) followed by measurement on GFAAS. Due to the huge suspended matter discharged from landbased sources, suspended lead dominated the total metal in water constituting between 59 and 81% during low and high flow periods, respectively. Lead was enriched in Mex bay sediments sampled opposite to Alexandria Petroleum Company outfall reaching 171.2 µg g^{-1} while opposite to Umum drain, Chlor-alkali plant and Western harbor/Mex bay connection area levels were: 89.6, 34.7 and 48.2 µg g^{-1}, respectively, compared with offshore levels of 18.7 µg g^{-1}. Most of lead in sediments appeared in the organic and Fe/Mn hydroxides fractions.

Atmospheric transport is of major consideration in lead cycling. Wet and dry depositions contributed to about 2.1 ± 0.7 T y^{-1} and 0.8 ± 0.4 T y^{-1} of lead to Mex bay. However, this amount accounts for no more than 24% of total lead input to the bay through landbased sources. Sedimentation rates data (corrected for organic matter decomposition but not for resuspension) using sediment traps, deployed in the bay for two weeks, were 21.7 ± 6.3 g m^{-2} d^{-1} and 9.5 ± 1.8 g m^{-2} d^{-1} for Mex bay inshore and offshore waters, leading to an average total sedimentary flux of about 1.3 T y^{-1}.

An imbalance between the in/out fluxes of lead in Mex bay accounting to about 2.24 T y^{-1} indicate its accumulation in the water column. The standing stock of lead in the bay is 1.3 T. Phyto- and zooplankton contributed to about 0.16 ± 0.07 T and 0.3 ± 0.2 T of the lead present in the bay. Representatives of the food web showed lead accumulation in different parts of demersal rather than pelagic living organisms. Bivalves (*Donax trunculus*) and the macroalgae (*Ulva rigida*) recorded elevated accumulation factors (range 1200-4000) indicating high accumulation rates. Although the lead contents of the flesh for most common commercial fish species sampled in the bay was consistently low (< 0.3 µg g^{-1}) accumulation in liver and kidney is much higher i.e. range 10-22 and 6-13 µg g^{-1},respectively. Assessing the quantitative contribution of fish, bivalves and algae to the biogeochemical cycle of lead in the bay needs further investigations concerning their stocks and periodicity.

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BENTHIC RECYCLING OF PHOSPHORUS IN THE COASTAL WATERS OF ALEXANDRIA

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Since the cessation of the Nile flood by the erection of Aswan High Dam completed in 1965, the discharge of nutrients through the Nile to the S.E. Mediterranean has drastically declined. Landbased sources including agricultural runoff from coastal lagoons, industrial and sewage discharges substituted, with a lower magnitude, the Nile water discharge. However, the productivity of the coastal waters are still dramatically affected. Most of the recent studies (DOWIDAR and ABDEL-MOATI, 1990), indicated that phosphorus is the key limiting nutrient regulating such productivity.

Being an important component of the biogeochemical cycles and flow of energy, benthic communities become progressively an important partner in marine ecosystems. Examining the functional aspects of such communities is an attempt to understand their active role in marine environment, especially the regeneration of nutrients. The purpose of the present study was to quantify the nutrient regeneration role of benthos using *in situ* measurements of net sediment/water flux of phosphorus.

Three locations were selected in the coastal waters of Alexandria during the period July - December 1992 (depth range 5-7 m), for measuring sediment/water nutrient flux. Quantitative samples were taken to characterize the communities while sediment samples were analyzed for grain size and organic matter. Station A was characterized by coarse sand and amphipods dominating the biotic community (organic matter 1.5%). A sandy silt bottom characterized station B (organic matter 4.5%) dominated by polychaetes and bivalves. Station C was on a sandy silt base (organic matter 4.1%) dominated by hatchet foot pelecypods.

Net exchanges of dissolved substances across the sediment/water interface was determined by entrapping a known water volume exposed to a known sediment area in a bottom chamber and monitoring phosphorus concentrations over time. Three opaque PVC pipe cut chambers 120 cm long x 30 cm diameter having a bottom area : volume ratio of 90 cm^2 l^{-1}, were carefully placed in each location by SCUBA divers. Simultaneously, dark bottles filled with bottom waters were incubated beside the chambers for correction of oxygen and nutrient changes caused by plankton inside the chambers.

The mean oxygen uptake by sediments and associated benthos was 45.6, 38.9 and 40.1 mg m^{-2} h^{-1} for different locations. The range for the *in situ* inorganic phosphorus flux in the three stations was -0.63 to 47.98 (av. 16.4 ± 8.5), -2.44 to 36.3 (av. 8.1 ± 6.3) and -10.7 to 18.4 (av. 5.3 ± 4) µM m^{-2} h^{-1} at the sampling sites, respectively, with an overall mean of 10.3 ± 4.8 µM m^{-2} h^{-1}. Replicate variations between chambers at the same site did not exceed 10%. Phosphorus release at all stations showed a highly significant correlation with temperature and oxygen uptake giving rise to the regression equations: P flux = -10.4 + 1.66 T ($r = 0.89$, $p < 0.01$) and P flux = -6.23 + 0.03 O_2 uptake ($r = 0.69$, $p < 0.05$). The slope and intercept for station A were significantly greater ($p < 0.05$) than B and C, while the intercepts but not the slopes of B and C were significantly different ($p < 0.05$). The overall correlation between released phosphorus and that present in the overlying water was positive ($r = 0.73$) in the whole area indicating that sediments are not buffering phosphorus concentrations in water. Organic matter content of sediments showed an association with increased phosphorus fluxes. The relationship between phosphorus release at the three localities with numerical abundance appeared to be stronger than with biomass.

The mean O:P ratio (atoms) for the three studied locations was 192 ± 86, 385 ± 190 and 421 ± 292, respectively. This ratio generally increased with decreasing temperature showing a significant ($p < 0.05$) O:P ratio on temperature.

Due to the intermittent appearance of anoxic conditions in some areas off Alexandria coast, specially during summer time, a long term measurement (96 hr) at station B during July showed an initial increase in phosphorus concentration after which it tended to level off as the concentration gradient between interstitial and overlying waters decreased. When DO become near depletion (0.8 ml l^{-1}), phosphorus release rate increased gradually towards the end of the experiment reaching 108 µM m^{-2} h^{-1}. The sudden increase resulted as response to anoxia indicating nutrient desorption to the overlying water.

Compared to previous estimates in area B performed using lab experiments (DOWIDAR *et al.*, 1990), the present phosphorus fluxes were nearly 10 times higher than previous records. Consequently, it seems likely that the contribution of benthic fluxes during maximum regeneration can supply a substantial amount of phosphorus requirements of phytoplankton. Further evidences of benthic releases indicating a phytoplankton bloom are needed.

Although discrepancies regarding considerations of bottom currents and sediment resuspension leading to underestimates of actual fluxes, results must be regarded as a preliminary attempt to assess the relative importance of benthic regeneration in the area.

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