Flux of Phophorus and Nitrogen in a sewage-impacted coastal sediments of a South-Eastern Mediterranean Basin

Tarek A. ABOUL-KASSIM[1,2], Naim M. DOWIDAR[2] and Fatma E. EL-NADY[2]

1- Environmental Organic Geochemistry Group, Oregon State University, College of Oceanography, CORVALLIS (U.S.A.)
2- Oceanography Dept., Faculty of Science, University of ALEXANDRIA (Egypt)

Introduction

In shallow coastal marine environments, there are good evidences that the bottom sediments play an important role in nutrients supply to the photic zone. Some workers estimated that the flux of nutrients from sediments may make up between 30% and 100% of nutrient requirements of the phytoplankton in the photic zone (ROWE *et al.*, 1975; HARGRAVE and CONNOLLY, 1978).

In this paper, our goal is to conduct laboratory experiments to study the flux of phosphorus and nitrogen (nitrate and ammonia) from the sewage-impacted sediments of the Eastern Harbor (E.H) of Alexandria and to calculate their contribution to the nutrients cycles in the study area.

Material and Method

The study area is a semi-circular shallow bay (Eastern Harbor), surrounded by Alexandria city, connected to the Mediterranean through two openings. The basin is subjected annually to about $35x10^6$ m^3 of unprocessed sewage, rendering its flushing time to be 5 months. Representative bottom sediment samples were collected from 3 stations in the Harbor basin. The flux of nutrients in the harbor basin was measured using two methods:

1- Calculating the flux using concentration gradients between constituents of interstitial water and overlying water column.

2- Measurement of the nutrient flux by laboratory experiments under static conditions. Following the method of HARGRAVE and CONNOLY (1978), a small portion of sea floor was cut out with some overlying water (2 liters) from the same stations and incubated in glass basins without disturbance under controlled conditions in the laboratory. For each station, the sediment sample was placed in three identical basins, two with sea water and the other with distilled water. Samples were taken from these basins above the sediments without disturbance at time intervals of 5 days for one month and analyzed. The flux (F) of dissolved material into or out of undisturbed sediments can be calculated as ug at/m2/day, using the following equation:

$$F = \frac{V\,(C_o - C_t)}{A} \times \frac{10^4}{T}$$

Where V: is the volume of water over the sediments (liters); Co & C_t: are the dissolved nutrient concentration (per liters) before and after time (T); A: is the sediments area (cm^2) enclosed. The experiment requires that the water be homogeneously mixed, that changes in concentration are known or assumed to be linear over time and that dissolved material is only exchanged at sediment surface.

Results and discussion

Results indicated that maximum phosphorus released from sediments was attainted during the first five days (Figure 1). An overall average of about 206 kg PO_4-P/Km^2 was estimated. In other words, 520 kg PO_4-P were added annually to the overlying water body in the E.H via flux from sediments. This amount is about 52% of the total input of DIP in the harbor marine environment.

In the case of nitrogen, experiments indicated that the highest flux of ammonia occurred during the first five days, after that the rate of reflux decreased gradually (Figure 1). Several workers found that nitrogen flux from sediments is mainly in the form of ammonia, and the highest rate was measured during the first 17 hours of incubation (DUGDALE *et al.*, 1977). On the other hand, the rate of nitrate flux was much smaller and irregular (figure 1). The average amount of the flux of nitrate-nitrogen and ammonia from bottom sediments amounted to 1.78 and 3.77 kg/Km2, respectively. The annual averages estimated for the E.H. area were 4.50 and 9.49 Tons, respectively. In other words, both nitrate and ammonia fluxes represented about 60% and 186% of their annual input to the harbor water. respectively (ABOUL-KASSIM, 1987).

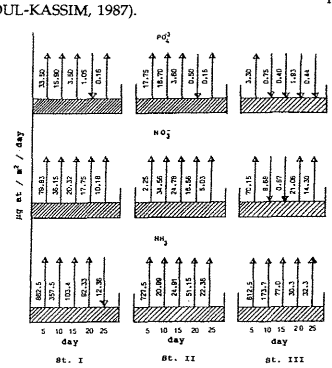

Figure 1: Flux of phosphate, nitrate and ammonia into or out the harbor sediments at stations I, II, and III (µg at/m2/day)

The high contribution of both phosphorus and nitrogen concentrations to the overlying water column of the harbor environment via flux from sediments is a characteristic feature for the sewage-impacted coastal marine environment of Alexandria with a short flushing time (i.e. 5 months), even when compared with other heavily polluted areas in the Mediterranean region (ABOUL-KASSIM, 1987).

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Impact of sewage pollution on nutrients uptake rate by Phytoplankton in a South-Eastern Mediterranean Basin

Tarek A. ABOUL-KASSIM[1,2], Naim M. DOWIDAR[2] and Fatma E. EL-NADY[2]

1- Environmental Organic Geochemistry Group, Oregon State University, College of Oceanography, CORVALLIS (U.S.A.)
2- Oceanography Dept., Faculty of Science, University of ALEXANDRIA (Egypt)

Phosphorus and nitrogen compounds play key roles in plant photosynthesis. Phytoplankton normally satisfy their nutrient requirements by their direct assimilation. Phosphorus and nitrogen uptakes are virtually confined to the euphotic layer of the sea, since they are a photosynthetic processes. Although all forms of nitrogen and phosphorus can be assimilated by most species of phytoplankton, nitrate, ammonia and orthophosphate are usually used preferentially (GLIBERT *et al.*, 1991; KROM *et al.*, 1991). According to GARSIDE (1981), autotrophic bacteria are also able to assimilate nitrogen. These resemble green plants in their ability to build carbohydrates and proteins. Some of these, known as photosynthetic, possess coloring material, or bacteriochlorin and use radiant energy in building up protoplasm, while others, known as chemosynthetic, derive their energy from the oxidation of various inorganic compounds.

Anthropogenic nutrients input plays an important role in the high productivity and biomass of the coastal zone of Alexandria (Egypt) relative to its continental shelf. The amount of production depends on the external supply of nutrients (allochthonous input) and the internal nutrient regeneration rate (ABOUL-KASSIM, 1987). The relationship between variable nutrient supply, the capacity for its utilization by different classes of phytoplankton, and ultimately the amount of recycling and export of nutrients from Alexandria coastal waters are not well understood. Our objective in this paper is to study carefully the nutrient uptake rates of phytoplankton (light and dark uptakes) in the sewage-impacted water of the Eastern Harbor (E.H), Alexandria.

The study area is a semi-circular shallow bay, surrounded by Alexandria city, connected to the Mediterranean through two openings. The basin is subjected annually to about $35x10^6$ m^3 of unprocessed sewage, rendering its flushing time to be 5 months. The uptake rates of orthophosphate, nitrate and ammonia by phytoplankton were determined according to EPPLY *et al.* (1969). Five liters of the harbor water were collected and divided into 5 portions, each of one liter. These portions were enriched with increasing concentrations of:

(1)- phosphorus (2.5, 5, 10, 15, 30 ug at/l) using an A.R. standard KH_2PO_4,
(2)- nitrate (2.5, 5, 10, 15, 30 ug at/l) using an A.R. standard KNO_3, and
(3)- ammonia (5, 10, 20, 30, 40 ug at/l) using NH_4SO_4.

Aliquots of 300 ml from each sample were placed in dark and light stoppered bottles and incubated *in situ* for 4 hours at about 25 cm below the surface. After incubation, the initial and final nutrients concentrations in each sample were determined and the rate of uptake rate/hour was calculated.

Results showed that the light and dark uptake rates of orthophosphate (Figure 1) increased gradually by increasing phosphorus concentrations, reaching maximum at 17.5 ug at/l after which they decreased. The annual rate of phosphorus (light) uptake by phytoplankton was calculated to be 860 kg/year.

The annual rate of ammonia and nitrate light uptake rates were found to be 83.0 and 41.5 Tons/km^2 or about 210 and 105 Tons/year, respectively. However, the greater part of these amounts is probably due to bacterial uptake (ABOUL-KASSIM, 1987). MAHMOUD (1985) gave a value of 43.4 and 30.7 Tons/Km^2 for ammonia and nitrate uptake in El-Mex Bay of Alexandria (affected by agricultural run-off, i.e. $2.57x10^6$ m^3/yr from Umom drain, ABOUL-KASSIM, 1990). This might indicate the enhancement effect of sewage disposed in the harbor basin on the uptake rates by phytoplankton. The difference of ammonia uptake in dark and light bottles is less significant than that of nitrate and phosphate (Figure 1). Likewise, a dark and light uptake was also observed in the case of nitrate. These high uptake rates are mostly due to the high bacterial biomass (measured by the adenosine tri-phosphate method) in the Eastern Harbor; i.e. average 0.46 mg C/l (ABOUL-KASSIM *et al.*, 1992). Statistically, high significant correlations occurred between both light and dark nutrients uptake rates, and the regression equations relating these variables are:

1- for orthophosphate:	Light uptake = - 0.12653 + 2.2449 Dark uptake	(r^2 = 0.800).
2- for nitrate:	Light uptake = 0.86835 + 1.1433 Dark uptake	(r^2 = 0.964).
3- for ammonia:	Light uptake = 0.57913 + 1.0010 Dark uptake	(r^2 = 0.996).

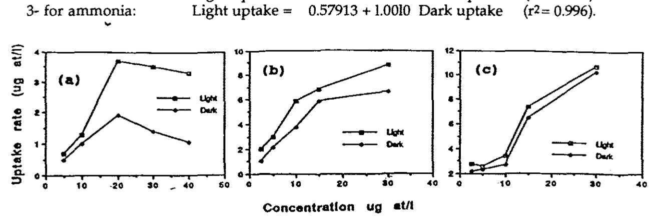

Figure 1: Uptake of a)- orthophosphate, b)- nitrate and c)- ammonia by phytoplankton at both light and dark bottles.

In conclusion, the high light and dark uptake rates of nutrients in the E.H. of Alexandria compared with other polluted areas in the Mediterranean area (ABOUL-KASSIM, 1987) is undoubtedly due to the high standing stock of phytoplankton (i.e. 5.14±2.71 mg chl a/l) and bacterial biomass (i.e. 52% of living biomass). These high living biomass is due to the continuous supply of nutrients (allochthonous source) in the harbor, i.e. 420 tons N/yr (EL-NADY *et al.*, 1990) and 1.094 tons P/l (DOWIDAR *et al.*, 1990).

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