Phosphorus fluxes in the Southeastern Mediterranean waters

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The consideration of phosphorus in the marine environment is due to its double existence sometimes as a pollutant and others as an important nutrient element. Elevated phosphorus concentrations cause eutrophication problems while phosphorus absence may be in most cases a limiting factor for biological production.

In the post High Dam period, the biological productivity of the S.E. Mediterranean has greatly declined due to the cessation of the Nile flood and the subsequent drop in the nutrients levels, especially phosphorus. The N:P ratio in the area is always over 20:1 indicating that phosphorus is a limiting nutrient in this basin. This peculiarity must be linked with physical and biological processes in the S.E. Levantine Basin. Direct current measurements are scarce and their use for water exchange is a complicated task due to existance of inshore counter currents and high variability due to wind. However, water circulation is a principal factor affecting the phosphorus cycle in the basin. Several biological and chemical transformations took place in the surface layer, while phosphorus is supposed to be more conservative in the intermediate and deep waters.

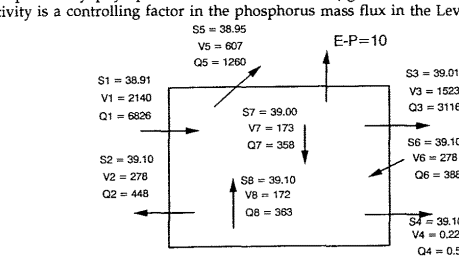
The present study is an attempt to compute the balance of phosphorus in the S.E. Mediterranean Basin based on the study of the movement of major water masses in the area. Data used in this study are a result of 10 oceanographic seasonal cruises carried out in the S.E. Mediterranean Basin during 1982/86, covering the area between longitudes 29°45' E & 32°40' E and extending over the continental shelf off the Egyptian coast. The geographical variations of salinity and temperature in this area were previously published by ABDEL-MOATI and SAID (1987). On the basis of water and salt budgets and in condition that there is no eustatic changes of bottom configuration, no fluctuations in sea level and that the bottom water layer has a more or less uniform thickness and depth, it is possible to write the mass balance equations:

$$V1+V6=V3+V4+V2+V5+(E-P);\ V2+V4-V6=V7+V8;\ \rho 2S2V2+\rho 4S4V4=\rho 6S6V6 \text{ and}$$

$$\rho 6S6V6-\rho 2S2V2-\rho 4S4V4=\rho 8S8V8-\rho 7S7V7 \text{ where } (E-P)= 10 \times 10^9 m^3 y^{-1} \text{ (see diagram).}$$

The coastal waters of the area receives about $16.1 \times 10^9 m^3/y$ of fresh and brackish water from the different landbased sources. About 20% of this amount is discharged from the River Nile while the rest is being discharged through the Nile delta lakes. Through this route about 1371 T of phosphorus are conveyed yearly to the S.E. Mediterranean waters. About 32% of this amount is discharged from Lake Manzalah, the largest Nile delta lake, while about 26% is conveyed through the functioning branch of the Nile. Upon mixing with sea water, huge amounts of this discharge are lost through sedimentation in the coastal waters. This is evidenced from the remarkably low phosphorus concentrations (average 0.088 µM) observed at points located about 8 Km opposite to the major sources compared with 6 µM levels recorded near the hot discharge points. The contribution of rain water ($3.4 \times 10^9 m^3/y$) to the phosphorus balance is considered insignificant (about 4.2 T/y) compared to that discharged by landbased sources.

Phosphorus input and output fluxes due to water exchange, were calculated assuming that the phosphorus concentration observed in the western boundary is typical for the inflowing current while that of the eastern was characteristic for the outflowing current. The total phosphorus input to the S.E. Mediterranean Basin is 8589 T/y while the output reaches 4824 T/y, leading to a net gain of 3765 T/y. On the other hand, the standing stock of phosphorus in the basin is 3307 T. Of this amount 6% are present in the inshore waters (<20 m) while 44% and 50%, respectively, are present in the middle (20-100 m) and offshore waters (100-200 m). Between the input/output and the amount actually present, there is a surplus of 458 T of phosphorus. The difference between the calculated transport rates indicates a net loss from the water column. Comparing the estimated phosphorus recycled annually with the standing stock, it appears that the residence time of phosphorus is 0.4±0.1 y. Incorporation with biological cycles and/or further sedimentation could explain this imbalance. Vertical water movements create an important role in phosphorus cycling in the S.E. Mediterranean Basin. Differences in concentrations between surface and bottom layers leads to a net phosphorus transport of about 5 T through the thermocline layer by down and upward fluxes. The upward flux is nearly negligible during summer time due to the trapping of regenerated phosphorus in the bottom water below the picnocline. Using the formula of Hamilton-Taylor 1979) and an average sedimentation rate of 0.037 cm y^{-1} (ROSS & UCHUPI, 1977), the phosphorus sedimentary flux should be 61 T/y. The degree of accuracy of phosphorus loss depends on factors such as no organic phosphorus measurements were performed, particulate phosphorus data were not collected in continuous series and water circulation other than geostrophic were not considered. Based on insitu productivity measurements using labeled carbon-14 (DOWIDAR, 1984) the annual average primary production of the area was 55.5 g C $m^{-2}y^{-1}$ corresponding to 527 µg at C $m^{-2}h^{-1}$. Using Redfield ratio, the demand for phosphorus by phytoplankton amounted to 4.97 µg at P $m^{-2}h^{-1}$ indicating that biological activity is a controlling factor in the phosphorus mass flux in the Levantine Basin.



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* V1 TO V8 in $10^9 m^3/y$ while Q1 TO Q8 in T/y

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