SEDIMENTATION IN A DEEP LAKE: ROLE OF PHYSICAL PROCESSES AND ADAPTATION OF PHYTOPLANKTON

I. Ostrovsky

Israel Oceanographic and Limnological Research, Yigal Allon Kinneret Limnological Laboratory, Migdal 1485000, Israel, ostrovsky@ocean.org.il

Sedimentation is a major process for removal of particulate material and important determinant accounting for the stability of aquatic ecosystems. The fluxes of particulate material are affected by numerous physical, chemical, and biological processes. The resulting patterns of particle deposition to bottom sediments depend on lake thermal and chemical structure, and the hydrological regime.

Gross sedimentation rates (GSR) in Lake Kinneret (Israel), regularly monitored from 1999 up-to-date with sedimentation traps, showed noticeable temporal and spatial variability. In the lake center, the annual mean GSR ranged from 1.9 to 6.0 g $m^{-2} \cdot d^{-1}$. The accumulation rate of sediments at the lake centrum during the study averaged from 2.6 to 4.3 $mm \cdot yr^{-1}$, in agreement with values obtained by sediment core dating. Organic matter content comprised 33-42 % of the sinking particulate matter in sediment traps located in the lake center and it was 1.5–2 folds lesser in peripheral stations.

Between 2003 and 2010 the annual GSR decreased about 3–4 fold at the lake center (Sta. A, 40 m). The decrease in GSR reflects changes in the rate of particulate organic matter (POM) export from the epilimnion downwards. The strong positive correlation between GSR and the annual water inflow ($r=0.75$, $P<0.01$) implies that the allochthonous material exported from the watershed affect the sedimentological processes. The organic matter sedimentation rate (OMSR) measured in the middle of the quiescent hypolimnion provides the reliable assessment of POM flux from the upper productive layer (Ostrovsky and Yacobi, 2010). The POM sedimentation declines from February until October and the ratio of this flux to primary production is the export ratio (ER) showing the proportion of primary production settled from the upper productive layer. Changes in the ER are related with the composition of phytoplankton and physical regime in the lake. During January–March (holomixis), large celled algae *Aulacoseira granulate* (Ehrenberg) Simonsen dominate the phytoplankton and are hardly consumed by zooplankton. The high sinking velocity of *A. granulata* is a reason why high proportion of the phytoplankton reaches the lake bottom in still warm winter days when turbulent mixing is restrained. Increased turbulence that prevails throughout the well-mixed water column circulates the algal cells between the euphotic zone and the trap locations. The latter is the reason for the overestimation of sedimentation flux of the negatively buoyant *A. granulata* cells in the non-stratified water column (Yacobi and Ostrovsky, 2012). This accounts for the enlarged ER ratio during holomixis.

A drop in ER occurs promptly after thermal stratification has established and the lower part of the water column became physically separated from the upper productive layer. The ER decline is explained by a shift in dominance in algal community from large *A. granulata* to buoyant Microcystis sp., motile *Peridinium gatunense* Nygaard, and then to small slow-sinking phytoplankton throughout thermal stratification (Ostrovsky et al., 2014). High turnover rates characteristic of small algal species enhance nutrient recycling within the euphotic zone and may be the reason for the lowest rate of phosphorous loss from the epilimnion in July-November (Ostrovsky and Yacobi, 2010). The seasonal timing of minimal ER and the greatest retention of limiting nutrients in the epilimnion is an outcome of adaptation of planktonic communities to stratification, when nutrient losses from the upper productive stratum cannot be replenished.

The fate of algal material was traced by the examination of photosynthetic pigments in particles prevailing in water and traps. Chlorophyll *a* (Chl *a*) is universally found pigment in all oxygenic photosynthesizers (algae and cyanobacteria). Upon degradation Chl *a* yields an array of degradation products, which reflect diagenetic processing of phytoplankton. Analysis of the seasonal variation of the ratio between Chl *a* -degraded products and intact Chl *a* in sediment traps helps to elucidate the trophic efficiency by which algal material in the water column is utilized (Ostrovsky and Yacobi, 2010). This ratio displayed maximum values of 0.4–0.6 during holomixis and nearly zero values in August–October, when algal community consisted of small species that possess low settling velocity, are easily consumed by zooplankton, and thus can be readily recycled within the epilimnion (cf. low ER). The maximum values of the ratio during the holomixis are related with dominance of the large algae that populate the entire water column, such that a high proportion of their fragments may be maintained in the well-mixed turbulent water for a long time. Moreover, large individual cells may have better ability to survive in the deep non-stratified water column with limited light. In contrast, the ability to retain and recycle in the upper euphotic layer under nutrient limitation may confer special evolutionary advantage to buoyant, motile, or small algal populations in stratified water bodies.

Ostrovsky, I., Yacobi, Y.Z. (2010), Sedimentation flux in a large subtropical lake: Spatiotemporal variations and relation to primary productivity, Limnol. Oceanogr. **55:** 1918–1931.

Ostrovsky, I., Yacobi, Y.Z., Koren, N. (2014). Chapter 27. Sedimentation processes. In Lake Kinneret: Ecology and Management (Eds T. Zohari, A. Sukenik, T. Berman, A. Nishri). pp. 485–497. Springer, Dordrecht.

Yacobi, Y.Z., Ostrovsky, I. (2012). Sedimentation of phytoplankton: role of ambient conditions and life strategies of algae, Hydrobiologia **698**: 111–120.