Long-term impacts of human-induced eutrophication on the chemical properties of Black Sea oxic and suboxic water layers

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Abstract
The Black Sea, a typical enclosed ecosystem fed with river discharges, has been subject to anthropogenic pressures since the 1960's. Before the 1960's, the less- contaminated, P-depleted major rivers were rich in nitrate and reactive silicate, leading to high N/P ratio > 25 but low N/Si (<1) as the wet deposition were rich in DIN, but depleted in reactive Si and phosphorus. At this time, the Black Sea surface waters had very high silicate (30-70 μM) but low concentrations of phosphate (0.1-0.3 μM) and nitrate (< 0.1 μM), leading to very high Si/DIN ratios (>>100) but low N/P (<5), indicating N-limited primary productivity in the coastal and open sea (salinity >17.5). After the mid 1970's, the increased nutrient (N, P) inputs by mainly the Danube River with modified N/P/Si molar (increased N/Si) ratios have drastically enhanced eutrophication and influenced bio-chemical properties of the whole Black Sea. Excess production of particulate organic matter (POM) in the surface waters and export below the euphotic zone (EZ) has altered bio-chemical properties of the upper layer waters in the Black Sea, leading to long-term (decadal) changes in the vertical chemical features formed in the oxic-suboxic water column and the boundaries of the oxic/suboxic/anoxic interfaces formed within the permanent halocline of the deep Basin. Briefly, the enhanced eutrophication has reduced thickness of the oxic water layer, leading to the enlargement of the suboxic water layer (O_2<30 μM) after the 1970's. The enhanced eutrophication and its indirect impacts on the ecosystem have altered plankton composition, vertical migrations of zoo-plankton in the deep basin and increased competition among pelagic fishes, leading to drastic decreases in the upper–trophic level fish stocks in recent decades.

Keywords: Black Sea, eutrophication, nutrients, particulate organic matter, dissolved oxygen