Biogeochemical assessment of shallow sea environments (White Sea, Russian Arctic)

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Shallow sea areas and enclosed estuarine systems are characterized by extreme diversity of biological communities as well as very active fronts and biogeochemical barriers creating small-scale variability in hydrodynamic, lithological and geochemical patterns. Therefore, the problem of separating hazardous anthropogenic loads from geochemical baseline, crucial for analysis of data on vulnerability of various environments, needs special attention.

The present study attempts to develop environmental monitoring parameters and objective criteria for environmental assessment using Kandalaksha Bay of the White Sea (Russian Arctic) as a case study. The approach involving both geochemical and biochemical parameters was exercised. In particular, element composition of the grounds studied served as a parameter reflecting global geochemical composition, hydrolytic enzymatic activities were employed as a dynamic index of organic matter decomposition rate and enzymatic test-systems were utilized as an indicator of contamination. In the framework of the above-mentioned study, surface sediment and adjacent shore soil samples were collected in June 2000 in six small bays along the Karelian shore of Kandalaksha Bay. These include Ermolinskaya, Chernorechenskaya, Rugoziorskaya, Griaznaya bays, Poyakonda and Podvolochie. In the samples major (C, N, S, P, Al, Fe) and trace (Mn, Co, Cu, Ni, Cr, Cd, Li, Zn, Pb) element contents and enzymatic activity parameters were determined.

For all estuarine systems investigated terrigenous inflow seems to be a minor factor in shaping geochemical composition of the sediments. Nevertheless, small-scale hydrodynamic processes specific for each particular area affect natural material fractionation and further determine sediment formation of the restricted exchange environments. The most vivid example is Ermolinskaya Bay where the fine-grained sediments enriched in organic matter and thus in nutrients and metals are formed due to pronounced trapping effect of the separating process.

The found geochemical composition of marine sediments at studied bays corresponded to that of unpolluted Arctic coastal environments. The distribution of azocasein turn-over period in azocasein-trypsin test showed no significant contamination of examined sediments. Therefore, the values of trace heavy metals obtained in this study can be perceived as a natural background, with Cu, Ni, Li and Pb contents lower and Zn and Cr higher than in other parts of the White sea. This conclusion is also supported by the fact that the grain size was the main determinant in geochemical composition and enzymatic activities patterns among sites studied.

The comparative study of the pristine (Ermolinskaya Bay) and man-affected (settlement Poyakonda) soils revealed significant enrichment of Poyakonda soil in organic carbon, organic nitrogen, Fe, Mn, Cr and Zn. In Poyakonda soil enzymatic activities were strongly depressed thus indicating the low self-purification capacity of the environment in response to an increasing load of organic matter. Results obtained from applying of enzymatic test-systems show low-level and no contamination in Poyakonda and Ermolinskaya soils, respectively.

The present study has shown that the local hydrodynamic situation predisposes geochemical and biological patterns of the environment and thus possesses considerable ecological relevance. Comprehensive biogeochemical approach exercised in the current research provides valuable information on grounds state of health and can thus serve as a basis of objective environmental assessment of a region.