Radionuclides and the mass balance of the Baltic Sea

Extended abstract

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An important use of radionuclides in Baltic Sea research has been the evaluation of sedimentation rates. These results have been further used in studying the mass balances of different chemical substances in this region.

Despite the shallowness of the Baltic Sea there are several basins with the depth of between 100 and 450 m where continuous and regular deposition takes place. Palebiological investigations and other studies of these basins have shown that the various evolutional phases since the last (Weichselian) glaciation are often reflected in the different sediment layers. With appropriate training, the interfaces between the various layers can even be identified by means of a good echosounder.

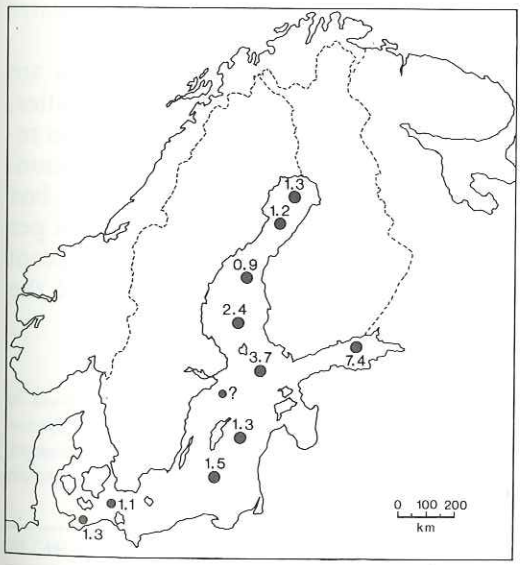

Fig. 1. The rates of sedimentation (mm/a) in the basins of the Baltic Sea, obtained with polonium-210 datings.

The layer representing the Litorina phase (7000 years) can be as thick as 7 m, representing a sedimentation rate of 1 mm/a. This information together with direct datings with radionuclides, especially polonium-210 (Niemistö and Voipio 1981), show that the rate of sedimentation in the various basins can be as high as a few millimeters per year (cf. Fig. 1).

All the sedimentation rates given in Figure 1 represent areas with a relatively rapid sedimentation, also when comparing the localities inside the various basins, and therefore they evidently give too high a value for the mean rate of sedimentation. About half of the area of the Baltic Sea is composed of soft bottoms with a contemporary sedimentation. For these reasons Niemistö and Voipio have estimated that the mean sedimentation rate for the whole

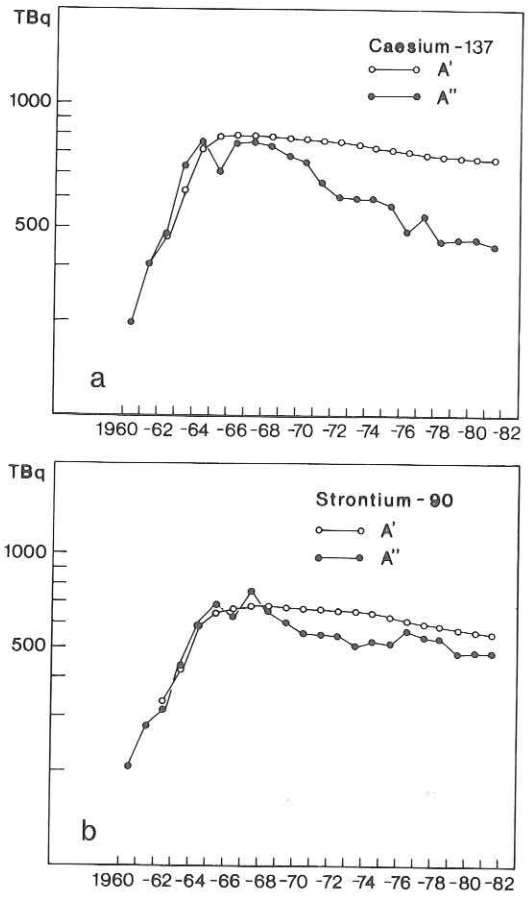

Fig. 2. The inventories of caesium-137 (a) and strontium-90 (b) in the Baltic Sea calculated from sea water analyses (A'') and from the annual changes in the balance terms added to the 1961 inventory (A').

Baltic Sea is of the order of 0.1 mm/a. About the same estimate was given by Pustelnikov (1976), while Larssen (1979) gave a slightly higher sedimentation rate for the southwestern part of the Baltic Sea. Owing to the mosaic structure of the bottom configuration and sediment beds in the Baltic Sea, it seems to be practically impossible to obtain, with a reasonable number of samples, a more reliable value for the mean sedimentation rate.

Despite the fact that the mean sedimentation rate is only a rough estimate, it is the only available way of estimating the mass balances of substances which are not totally conservative.

There is quite a lot of information available about the concentration of artificial radionuclides in various compartments related to the water balance of the Baltic Sea. Thus we know the amount of direct deposition on the sea surface, the river input and the amounts transported with the inflowing and outflowing water. Salo and Voipio (1981) have mainly considered the differences between the annually estimated inventories (storages) based on measurements of radionuclide concentrations in sea water samples, and the "calculated values" based on summing up the estimates for various water balance terms — taking into account the decrease in radioactivity due to decay.

The difference between the "calculated" and "measured" inventories (quantities A' and A'', see Table 1) has apart from one or two years remained positive (Fig. 2). This indicates that there is some mechanism removing nuclides from the water phase in addition to those included in the estimates of the input/output related to water transport.

As the amounts bound to the biota are small in comparison to the other quantities, the main additional removal mechanism referred to above is evidently sedimentation. The amounts found on the basis of box corer samples yielding the total content per unit area since the beginning of significant nuclear weapons tests in 1955 are of the

TABLE 1

The comparison of the radionuclide amounts found in sediments and the differences between the values for sea water samples, obtained by summing up of the estimates for the balance terms (A'), and the measured inventories (A''), given in terabequerels (TBq).

	Cs-137/TBq	*Sr-90/TBq*
A' –A''	323	77
Found in sediments	277	12

same order of magnitude as the differences A' –A" in Table 1 (Salo et al., in press). This result is also consistent with a mean sedimentation rate between 0.1 and 1 mm/a.

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