
GEOGRAPHY

Accumulation Peculiarities of Artificial Radionuclides in the Elements of Coastal Ecosystems on the Kola Peninsula

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Since 1991, the Murmansk Marine Biological Institute has carried out comprehensive investigations of radioactivity of Arctic and subarctic marine ecosystems, which are based on extensive documentary, geographic, and taxonomic materials. Long-term monitoring of artificial nuclides was focused on ecosystems of the Barents and White seas. Interest in this region stemmed from the availability of potential regional and local sources of radionuclide emission: atomic fleet bases, nuclear test sites on the Novaya Zemlya Archipelago, and radwaste burial sites on the shelf. Special attention was concentrated on study of the content and distribution of radioisotopes in ecosystems of numerous gulfs in the Kola Peninsula [1, 2], since the possible emission of radionuclides to offshore zones of the Barents and White seas from objects of the atomic industry located on their coasts remains a pressing issue. In this respect, the necessity arises for carrying out further investigations of the state of the artificial radionuclide background in coastal ecosystems of the Kola Peninsula, which are most exposed to anthropogenic impact.

The purpose of this work was the assessment of the current radioecological situation in ecosystems of bays and gulfs of the Kola Peninsula.

Radioecological conditions of the regions under study were assessed by the content of artificial radionuclides ^{137}Cs and ^{90}Sr in the environment and biota samples.

Samples were collected during coastal expeditions in the White and Bering seas in 2004–2005. Pechenga, Ura, Saida, Dalnie Zelenetsy, Teriberka, and Kola (middle and southern bays) were inspected for radioactive pollution in the Barents Sea, as well as Palkina Bay and the region of the Kandalaksha Coast in the White Sea. Sampling sites are represented in Fig. 1.

CANBERRA γ -spectrometer was used for measuring ^{137}Cs contents in samples; α - β scintillation counter LS 6500 BEKMAN, for measuring the ^{90}Sr content in accordance with certified procedures.

Cesium radionuclides were sorbed from seawater using an ANFEZs sorbent, which is most reliable in the mass radiochemical analysis of flow media with low activity. The volume of the analyzed seawater sample was 100 l.

To establish the specific activity of ^{137}Cs , bottom sediments, macrophytes, and mussels were dried at 105°C and homogenized. Then the samples were subjected to radiochemical treatment for determining the ^{90}Sr content.

The γ -spectrometric analysis of elements of coastal ecosystems on the Kola Peninsula yielded certain variations in the specific activity of ^{137}Cs in samples from different regions (Fig. 2).

The average specific activity of ^{137}Cs in water of the coastal zone of the Kola Peninsula was 2.7 Bq/m³. The maximum specific activity of ^{137}Cs (4.9 Bq/m³) was established in coastal water of the White Sea; the minimum values (1.1 Bq/m³), in the Kola Bay water. The relatively high ^{137}Cs content in essentially desalinated surface water of the White Sea might be related to the salt composition of water and, probably, the effect of local sources of radioactive pollution.

The specific activity of ^{137}Cs in bottom sediments of the studied bays of the Barents Sea and Kola Bay varied from 0.5 to 9.3 Bq/kg dry weight (hereafter, d.w.). The maximum value (9.3 Bq/kg d.w.) was recorded in the southern bend of Kola Bay (the Tuloma River mouth). Bottom sediments of the Kandalaksha Coast of the White Sea yielded about 5 Bq/kg d.w. The specific activity of this radionuclide in sediments of the Kandalaksha Gulf (Palkina Bay) did not exceed 0.3 Bq/kg d.w.

The study of the specific activity of ^{90}Sr in bottom sediments showed its maximum content in Saida Bay

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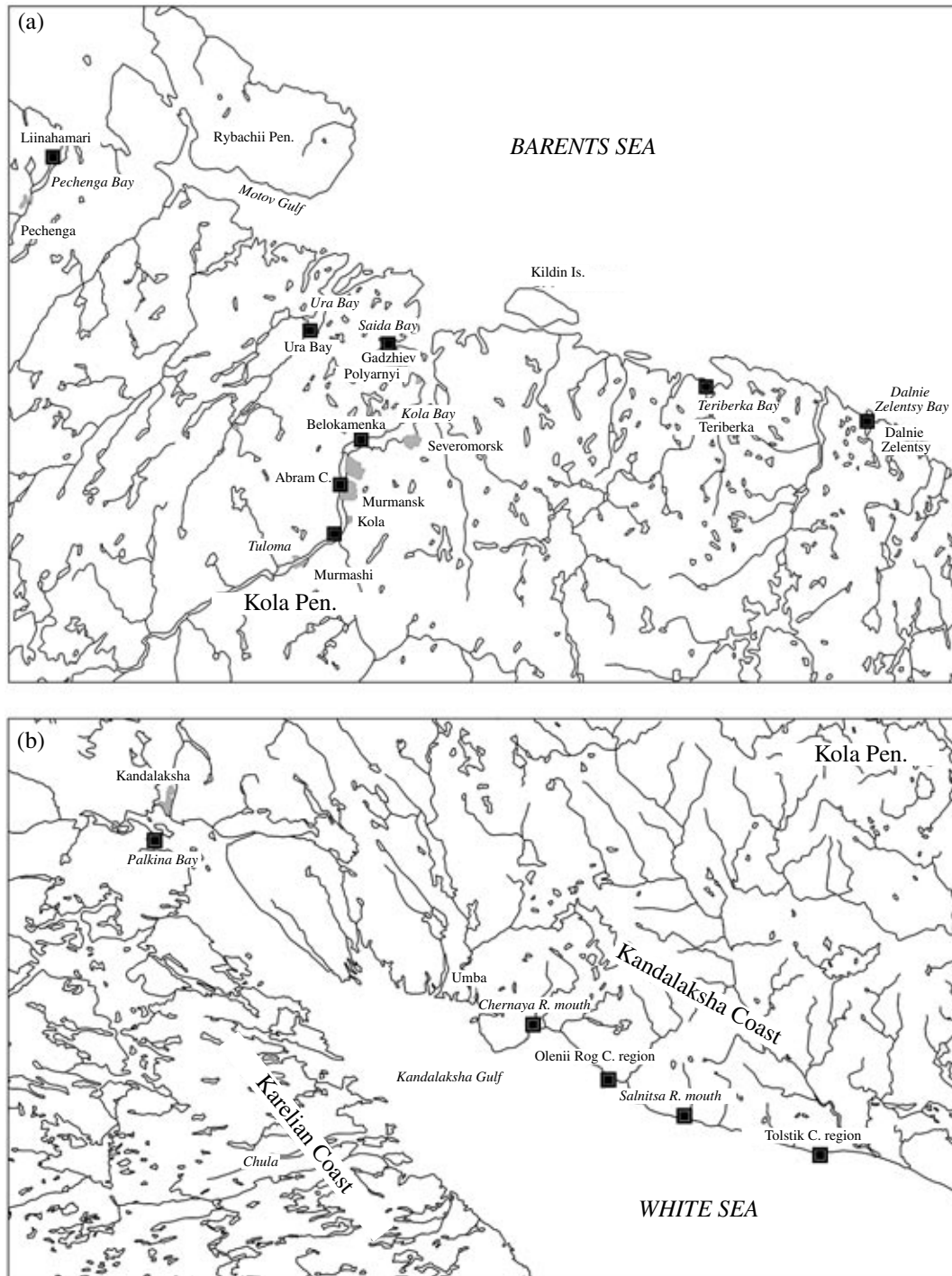


Fig. 1. Schematic map of sampling sites for water, bottom sediments, and hydrobionts in bays and gulfs of Kola Peninsula (2004–2005). (a) Barents Sea; (b) White Sea.

of the Barents Sea (1.8 Bq/kg d.w.) and in the Korabl Cape area of the White Sea (1.7 Bq/kg d.w.).

The grain size and lithological compositions of sediments, as well as seawater salinity, are the most significant factors determining the radionuclide activity in bottom sediments. Samples of bottom sediments were taken in the littoral zone, where sediments are repre-

sented by sand-sized particles with low sorption capacity. The principal rock-forming mineral of terrigenous bottom sediments in the shelf zone of the western sector of the Russian Arctic region is quartz, which exhibits a low sorption capacity [3]. Correlation of data obtained on the ^{137}Cs content in the surface layer of bottom sediments in coastal and offshore waters showed a typical

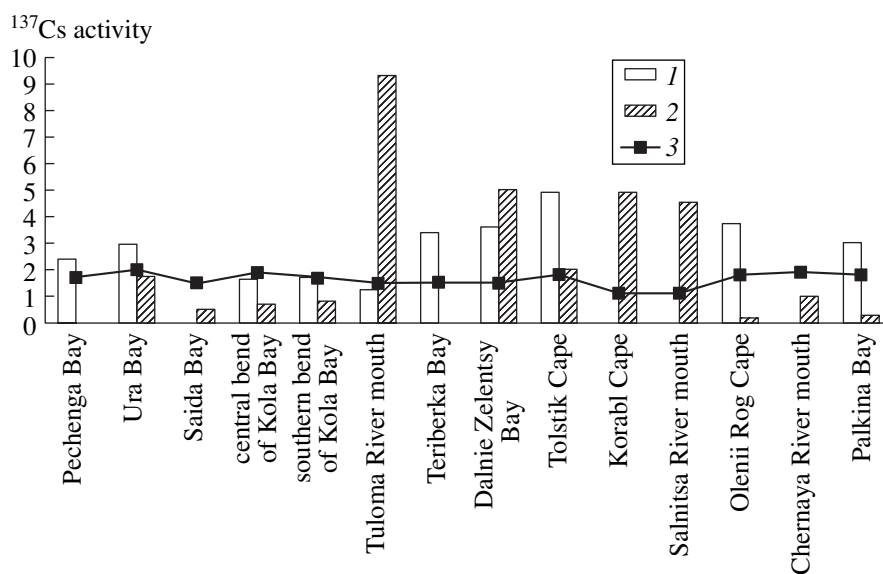


Fig. 2. Specific activity of ¹³⁷Cs in elements of coastal ecosystems of the Barents and White seas. (1) Water, Bq/m³; (2) bottom sediments, Bq/kg d.w.; (3) macrophytes, Bq/kg d.w.

uniform distribution of the radionuclide in the Barents Sea. In the White Sea, bottom sediments are less contaminated by ¹³⁷Cs in the coastal zone compared to its central part, where the specific activity of ¹³⁷Cs was 20–30 Bq/kg d.w., as suggested by the results of investigations carried out in 2003 [4].

We used as markers of radioactive pollution the most abundant species of organisms inhabiting the littoral zone of the Barents and White seas: macrophytes *Fucus vesiculosus* and mussels *Mytilus edulis*. These organisms can accumulate pollutants and retain the main vital functions and genetic stability at relatively high concentrations in the medium. They are easy to observe and long-lived for radioactive pollution monitoring.

The results of γ -spectrometric analysis of *Fucus vesiculosus* revealed no reliable variations in ¹³⁷Cs accumulation between algae of the Barents and White marine basins. The average specific activity of ¹³⁷Cs in all the studied samples was 1.7 Bq/kg d.w. Accumulation of this radionuclide has not changed since the 1990s, when the specific activity of ¹³⁷Cs did not exceed 2.3 Bq/kg d.w. [2].

Strontium, as a calcium analog, actively participates in the metabolism of macrophytes. Therefore, the specific activity of ⁹⁰Sr in vegetative parts of algae reliably reflects its concentration in water. The ⁹⁰Sr content in macrophytes varies within 0.3–4.0 Bq/kg d.w. Judging from the low contents of ¹³⁷Cs and ⁹⁰Sr in recent macrophytes from the early 1990s to the present, no additional emission of artificial radionuclides to the Barents and White seas has been registered.

Mussels collected in different regions of the Kola Peninsula coast were subdivided into groups depending on shell sizes according to the classification suggested

by Fedorov [5]. Medium-sized young mussels attached on collectors for a two-year living period in seawater are arbitrarily subdivided into three generations: (mussels with shell sizes of 10–15 mm) yearlings of autumn settling; (16–32 mm) yearlings of early summer settling; and (33–50 mm) 2-yr-old species. Found in the studied regions were mainly yearlings of the early summer settling and 2-yr-old species. The number of the studied individuals, the average size of shells, and the values of the specific activity of ¹³⁷Cs in soft tissues and shell of mussels are shown in the table. The absolute error in the measurements of the specific activity of ¹³⁷Cs did not exceed 50%.

The analysis of ¹³⁷Cs accumulation by mussels from different regions of the coastal zone of the Kola Peninsula showed that the specific activity of this radionuclide did not exceed 1.7 Bq/kg wet weight (hereafter, w.w.) in shells of different-sized individuals and 3.2 Bq/kg w.w. in soft tissues. No relationship between shell sizes and ¹³⁷Cs contents in shells and soft tissues of mussels has been established. Measurements of the ⁹⁰Sr content revealed slight variations in the specific activity of this radionuclide in mussel shells from different regions of the Kola Peninsula coast. The maximum ⁹⁰Sr content was established in shells of individuals collected in Ura Bay (2.5 ± 0.75 Bq/kg); the minimum content (0.64 ± 0.32 Bq/kg), in the central bend of Kola Bay.

Hence, the values of the specific activity of ¹³⁷Cs and ⁹⁰Sr in the principal elements of ecosystems—water, bottom deposits, macrophytes, and mussels—showed that no additional emission of artificial radionuclides into waters of the Barents and White seas had been established. This fact allows us to conclude that radioecological conditions in the study region are

Table

Sampling site	Number of specimens	Size, mm	Specific activity of ^{137}Cs , Bq/kg w.w.	
			in shells	in soft tissues
Barents Sea				
Central bend of Kola Bay (near Belokamenka Settlement)	147	34.0 ± 4.7	0.9	2.2
	50	44.4 ± 3.8	0.9	1.3
Southern bend of Kola Bay (near Abram-Mys Settlement)	54	35.0 ± 3.1	1.1	2.1
	24	42.3 ± 2.0	1.2	1.8
Kola Bay inlet (Tuloma River mouth)	33	25.3 ± 2.7	1.7	2.5
	58	36.3 ± 7.6	1.0	1.9
Ura Bay	207	32.0 ± 2.9	1.0	1.2
	70	44.8 ± 4.0	1.5	3.2
Pechenga Bay	264	30.6 ± 4.4	0.9	2.3
	38	47.2 ± 3.8	0.9	1.9
Dalnie Zelentsy Bay	155	25.7 ± 2.5	1.9	2.1
	60	32.3 ± 2.6	0.9	2.2
White Sea				
Palkina Bay	80	15.2 ± 3.5	0.5	1.9

favorable and to believe that the specific activity of ^{137}Cs and ^{90}Sr in the medium and biota correspond to background values.

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