Artificial radionuclides in the tissues of the Barents Sea commercial fish species

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INTRODUCTION

It is beyond any doubt nowadays that radioactivity, because of its general spread in the biosphere and highly effective impact on living organisms, is a rather important factor of the environment. Even after the cease of the nuclear weapon testing, the process of fall-out of fission radioactive products onto the earth surface will continue for many years due to the presence of stratospheric reservoir that contains long-living $^{137}\text{Cs}$ and $^{90}\text{Sr}$ (Polikarpov, 1964). This gives the reason for a comprehensive study of the peculiarities of accumulation, distribution and migration of artificial radionuclides in the environment and living organisms, both from the qualitative and quantitative sides.

Scientific interest and practical importance of the Barents Sea ichthyofauna radio-ecological researches are linked with the presence of background concentrations of radionuclides in the surface waters of the area conditioned by their transport by sea currents from radio-chemical plants in Western Europe (Sellafield, La-Hug and Dundrey), burial of liquid and solid radioactive wastes in the area of the Novaya Zemlya Archipelago, partly with location of radiation-danger objects of civil and military purpose in the coastal zone of the Kola Peninsula and atmospheric fall-outs after the accident at the Chernobyl NPS (Matishov, Matishov, 2004). Thus, the importance of information about the state of radioactive contamination of the environment and commercial hydrobionts of this water body, as an index of raw material base’s quality, becomes obvious.

An assessment of contemporary levels of $^{137}\text{Cs}$ and $^{90}\text{Sr}$ content in the tissues of some commercial fish species of the Barents Sea has been carried out in the present research being compared to the dynamics of their changes during a long-term period; regularities of these radionuclides’ accumulation have been studied depending on biological indices of fishes (sex, age, feeding character/regime), as well as annual radiation effective dose, got by the population of the Murmansk Region in 2006 from $^{137}\text{Cs}$ and $^{90}\text{Sr}$ when consuming fish, has been calculated.

MATERIALS AND METHODS

Ichthyologic samples were taken during an expedition to the Barents Sea in 2006. 5 fish species were analyzed: cod ($\text{Gadus morhua morhua}$ L.), haddock ($\text{Melanogrammus aeglefinus}$ L.), ocean perch ($\text{Sebastes marinus}$ L.), Atlantic wolffish ($\text{Anarhichas lupus}$ L.) and Canadian plaice ($\text{Hippoglossoides platessoides limandoides}$ (Bloch)). The ichthyology sampling areas are presented in Table.
Table  Ichthyology sampling areas

<table>
<thead>
<tr>
<th>Date</th>
<th>Fishery Area</th>
<th>Sampled fish species</th>
<th>Trawling Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beginning</td>
</tr>
<tr>
<td>17.08.06.</td>
<td>North Kanin ground</td>
<td>cod, haddock</td>
<td>70°46.600 N</td>
</tr>
<tr>
<td>31.08.06</td>
<td>Rybachyi ground</td>
<td>cod, haddock</td>
<td>69°58.142 N</td>
</tr>
<tr>
<td>21.09.06.</td>
<td>Central trough</td>
<td>Canadian plaice</td>
<td>72°52.024 N</td>
</tr>
<tr>
<td>29.09.06.</td>
<td>Northwestern slope of the Murmansk ground</td>
<td>haddock</td>
<td>70°55.588 N</td>
</tr>
<tr>
<td>01.10.06.</td>
<td>Kildin ground</td>
<td>Atlantic wolffish</td>
<td>69°53.553 N</td>
</tr>
<tr>
<td>10.06.06</td>
<td>Ura-Guba/Ura Bay</td>
<td>cod</td>
<td>69°18.126 N</td>
</tr>
</tbody>
</table>

For spectrometric analysis fish muscles were taken (300 - 500 g.). The samples were dried in the drying ovens at a temperature of 100 ± 5° С for 3-4 hours, then homogenized. Determination of $^{137}$Cs specific activity was by applying a spectrometric complex: gamma-spectrometer «Canberra» (USA) with a detector of especially pure germanium with multi-channel analyzer InSpector–2000. Processing of spectra was at PC with the help of «Genie–2000» software. $^{137}$Cs specific activity was calculated in Bq/kg dry mass of fish muscles.

$^{90}$Sr specific activity in a sample was determined by radio-chemical concentration from fish bone tissue with the further determination of β-radiation of daughter $^{90}$Y according to Cherenkov at α-β-liquid scintillation meter LS 6500 by Beckman Coulter (USA);

Traditional ichthyologic methods were applied when carrying out the activities. Biological analysis of fish species was according to generally accepted methods (Instructions…, 2001; Pryakhin, 2006):

To get qualitative characteristics of feeding of the studied fish species, every specimen was analyzed for the content of gastro-intestinal canal (by occurrence frequency), all feed components were determined to family (in some cases to species). Fish age studies by scales were based on the methods by N.N. Chugunova, 1959, and Yu.Yu. Dgebuadze, 2001.

Calculation of annual effective dose got by population from $^{137}$Cs and $^{90}$Sr was by formula (International…, 1996):

$$D_i = C_i \times DCF_i \times P$$ (microSv/year),

with $C_i$ – concentration of radionuclide in fish, Bq/kg;

$DCF_i$ – coefficient of dose transformation for $^{137}$Cs and $^{90}$Sr, Sv/Bq;

$P$ – volume of consumed fish per year, kg/year (For the population of the Murmansk Region $P=20$kg/year according to data (Basic…., 2006).

**RESULTS AND CONCLUSIONS**

General artificial radioactivity of fish species is determined, mainly, by $^{137}$Cs. This nuclide is accumulated, first of all, in soft tissues. The maximum accumulation levels of radioactive Cesium were registered in the muscles of specimens of ocean perch, minimal – in the muscles of cod and haddock. The content of $^{137}$Cs in the muscles of the studied fish species decreased successively, Bq/kg dry mass: ocean perch (0.9) > Canadian plaice (0.7)> Atlantic wolffish (0.5)> cod (0.4)> haddock (0.4). Short-term $^{134}$Cs in the muscles of the studied fish species was not detected thus proving the absence of fresh fall-outs of artificial radionuclides over the Barents Sea water area.
The highest specific activity of $^{90}$Sr was registered in the bone tissue of cod, the lowest – in wolffish. The content of $^{90}$Sr in the bone tissue of the studied fish species decreased successively: cod (0.6) > haddock (0.5) > Canadian plaice (0.3) > ocean perch (0.2) > Atlantic wolffish (0.1).

The results obtained correlate with the data got by Saetre et al. in 1992 during special researches of cod, haddock and ocean perch samples, linked with the possibility of radioactive contamination of fish population of the Barents Sea as a result of radionuclides discharges in the water area, as well as an accident to the nuclear submarine «Komsomolets». It was determined that mean concentration of $^{137}$Cs in fish varied from 0.3 to 1.0 Bq/kg dry mass, maximal value of specific activity did not exceed 2.5 Bq/kg, correlation of $^{134}$Cs concentration with $^{137}$Cs – 3 %.

As a result of joint activities of Murmansk Marine Biological Institute and Radiation and Nuclear Safety Authority (STUK) (Rovaniemi, Finland) in 1993—1994, the like mean values of specific activity of $^{137}$Cs and $^{90}$Sr in the Barents Sea cod were registered, which were of 0.7 and 0.1 Bq/kg dry mass correspondingly (Matishov, Matishov, 2004). Comparing these results with the data obtained, one may ascertain that the tendency towards the decrease of the Barents Sea cod $^{137}$Cs contamination level that started in 1982—1983 remains and is registered nowadays as well.

The regularities of the long-term dynamics of $^{90}$Sr accumulation in the hydrobionts’ organisms may be traced by, for example, cod. This species is characterized by increased, in comparison to the other fish species, concentrations of Strontium. Variability of $^{90}$Sr content in the bone tissues of cod is well approximated by an exponential equation. The period of half-decrease of $^{90}$Sr concentration in the Barents Sea cod is 7 years, thus correlating with the MMBI observations data.

During the last decade, the $^{137}$Cs contamination levels of muscles tissues and $^{90}$Sr of bone tissue in the Barents Sea commercial fishes remain at the same permanent level and by two orders are lower than the allowable in the Russian Federation values of content of these radionuclides in fish species, which are for $^{137}$Cs – 130 Bq/kg dry mass, for $^{90}$Sr – 100 Bq/kg dry mass (Hygienic..., 1997). The obtained concentrations of radionuclides are correlated to the results of contemporary researches by the Norwegian scientists, who registered approximately 1 Bq/kg $^{137}$Cs in fish from various regions of Norway (Norway’s..., 2006).

Correlation of values of radionuclides’ specific activity in the tissues of sea fishes with their biological peculiarities showed that the content of $^{137}$Cs and $^{90}$Sr does not depend on sex, age and the character of feeding of the species studied. Considerable differences in nuclides’ concentrations in cod and haddock caught in various areas of the Barents Sea were not registered as well.

On the basis of implemented researches, a radiation dose that a human being could get via the water–fish–human being food chain was assessed. In 2006 the total annual radiation effective dose, got by the population of the Murmansk Region from $^{137}$Cs and $^{90}$Sr in the Barents Sea commercial fish species, was 0.3 microSv/year. In 1993, the similar result was obtained when calculating an annual radiation effective dose (0.1-7 microSv/year) for population consuming fish from the Barents and Kara Seas (Foyn, Semenov, 1993).
This gives ground to assume that during the period from 1993 to 2006, radiation dose from $^{137}\text{Cs}$ and $^{90}\text{Sr}$, that could be got by a human being consuming the Barents Sea commercial fish species, remained at the permanently low level and did not exceed 1 % of the safe dose loads level laid down in the Russian Federation, got by the population from natural and artificial radiation sources at 1 mSv/year.

REFERENCES


2001. Instructions on and methods recommendations for collecting and processing of biological information in the PINRO research areas. PINRO Publishing, Murmansk. (in Russian)


