Journal of Environmental Radioactivity 125 (2013) 27–35

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Distribution and migration of ^{90}Sr in components of the Dnieper River basin and the Black Sea ecosystems after the Chernobyl NPP accident

N.Yu. Mirzoyeva*, V.N. Egorov, G.G. Polikarpov†

The A.O. Kovalevsky Institute of Biology of the Southern Seas, National Academy of Sciences of Ukraine (IBSS NAS of Ukraine), Department of Radiation and Chemical Biology, 2 Nakhimov Avenue, Sevastopol 99011, Crimea Region, Ukraine

ARTICLE INFO

Article history:
Received 30 January 2013
Accepted 18 February 2013
Available online 21 March 2013

Keywords:
Chernobyl accident
The Dnieper River basin
The Black Sea
^{90}Sr
Redistribution
Forecast
Dose assessment

ABSTRACT

The change in ^{90}Sr concentrations in hydrobionts, water and bottom sediments of the Chernobyl NPP pond-cooler, the Kievskoe and Kakhovskoe reservoirs, the Northern-Crimean canal and the Black Sea after the Chernobyl NPP accident was studied. The environmental half-times for the decrease of ^{90}Sr concentrations were determined: in water – 4.1–24.3 years; algae and flowering water plants – 3.6–7.7 years, in molluscs – 2.4–6.7 years, and in fish – 7.8–12.9 years. The time for ^{90}Sr concentrations to decrease to pre-accident levels were estimated: in freshwater reservoirs and the northwest part of the Black Sea this was 32–44 years, and in freshwater hydrobionts this was 25–73 years. The contribution of dose from ^{90}Sr to the hydrobionts, sampled from the Kakhovskoe reservoir, the Northern-Crimean canal and the Black Sea, has not reached values which could impact them during the entire post-accident period. This complex of comparative studies was carried out for the first time.

1. Introduction

The Black Sea catchment basin, due to its geographical position, is one of the natural water basins most contaminated by artificial radioactivity. Anthropogenic radionuclides in the Black Sea region primarily originated from the large-scale nuclear weapon tests, which were carried out between 1954–1958 and 1961–1962 before the 1963 test-ban treaty, and from the Chernobyl nuclear power plant (Chernobyl NPP) accident (Buesseler and Livingston, 1996). On the 26th April 1986, the largest nuclear accident of the 20th century occurred at the Chernobyl NPP in the Ukraine (Israel et al., 1987; Israel, 1990; Appleby et al., 1999). Hydrological, hydrochemical, hydrobiological and radioecological studies began immediately in the water reservoirs, in the zones remote from the Chernobyl NPP, in the reservoirs of the Dnieper River (top and bottom water reservoirs) (Romanenko et al., 1992; Yevtushenko et al., 1992; Voitsekhovitch et al., 1997, 2001; Kaglyan, 2003; Gudkov, 2006), in the Northern-Crimean canal (Kulebakina, 1991), as well as in the seas of the Mediterranean basin and, primarily, in the Black Sea (Polikarpov, 1987; Eremeev et al., 1993). The priorities included the study of the long-lived isotope ^{90}Sr which is radiologically important and ecologically dangerous. The main feature of the Chernobyl NPP accident was that the radioactive pollution of the environment was rapid, virtually a pulse input, compared to the typical longer time scales that occur for natural biogeochemical processes. Therefore, as a radiotracer, ^{90}Sr, is useful to characterize the rate of the hydrological and biogeochemical processes.

The Chernobyl NPP accident released about 1300–8100 TBq of ^{90}Sr to the environment (Israel et al., 1987; Gudiksen et al., 1989; Israel, 1990; Appleby et al., 1999). In May 1986, the atmospheric fallout of ^{90}Sr over the Black Sea was 100–300 TBq (Livingston et al., 1986; Eremeev et al., 1993; Gulin et al., 1997). As well as receiving direct atmospheric fallout, the Black Sea also receives additional secondary contamination by post-Chernobyl radionuclides via river discharge, particularly at the north-western area from the Danube and the Dnieper rivers (Livingston, 1988; Polikarpov et al., 1992). The ^{90}Sr input from the Dnieper River was 85 ± 10 TBq and the Danube River 75 ± 18 TBq during the period 1986–2000 (Egorov et al., 1999; Voitsekhovitch et al., 2004).

The purpose of our studies (during 1986–2011), carried out with significant international support and under the sponsorship of the IAEA, was to determine the distribution and migration of ^{90}Sr after the Chernobyl NPP accident in the biotic and abiotic components of the water ecosystems of the Chernobyl NPP pond-cooler, the Kievskoe and the Kakhovskoe reservoirs, the Northern-Crimean

* Corresponding author. Tel.: +380 692 450380; fax: +380 692 557813.
E-mail addresses: natmirz@mail.ru, Safar.Shovgi@mail.ru (N.Yu. Mirzoyeva).
† Deceased.

0265-931X/$ – see front matter
http://dx.doi.org/10.1016/j.jenvrad.2013.02.011

canal (NCC) and the water area of the Black Sea. In addition the time for ^{90}Sr concentrations to reach pre-accident levels was also estimated in the biotic and abiotic components of the researched reservoirs.

Scientific novelty of these researches consists in that on the basis of comparative long-term (1986–2011) study of the freshwater and seawater reservoirs in the Ukraine for the first time: the dynamics and migration of ^{90}Sr concentration in the components of the aquatic ecosystems, its stock and the degree of purification of water of the reservoirs, the forecast of the time scales of ^{90}Sr concentration reduction to pre-accident levels in water and hydrobionts were determined; the use of ^{90}Sr as a radiotracer for geochronology of the Black Sea bottom sediments was analysed and assessed; the exposure doses received by various ecological groups of hydrobionts from the ionizing radiation of ^{90}Sr and its daughter product ^{90}Y in the post-accident period were calculated.

2. Materials and methods

2.1. Sampling sites and samples taken

Historic data are available from the database of the Department of Radiation and Chemical Biology of the Institute of Biology of the Southern Seas (IBSS) and from other literature sources for ^{90}Sr concentrations in components of the ecosystems of the Black Sea for 1986–1994. Sampling in the Chernobyl NPP pond-cooler and the Kievskoe reservoir was carried out by IBSS during 1990–1992, and in the Kakhovskoe reservoir and the Northern-Crimean canal

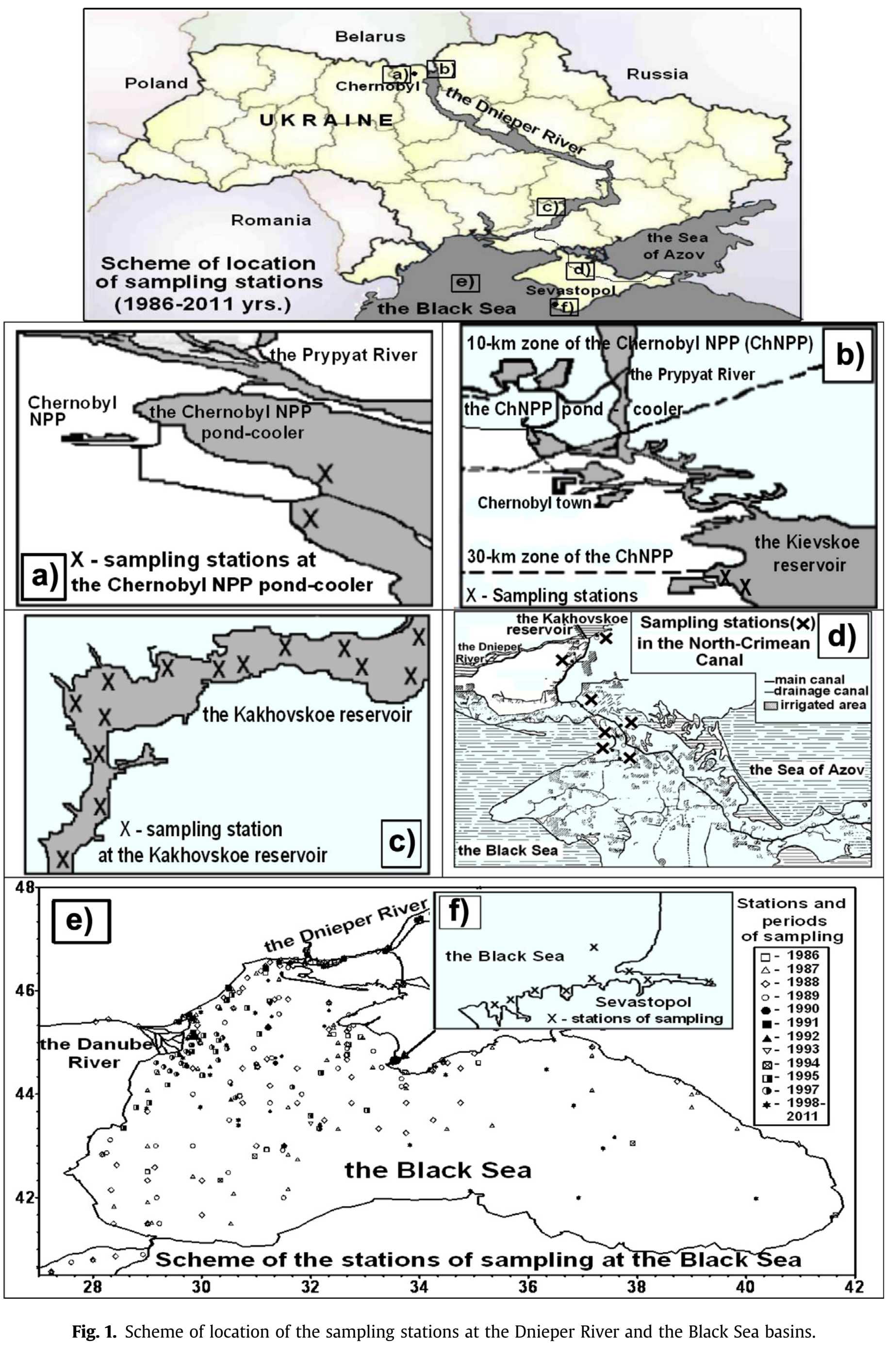

Fig. 1. Scheme of location of the sampling stations at the Dnieper River and the Black Sea basins.