Journal of Environmental Radioactivity 116 (2013) 84–92

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Radioactivity

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

Database of meteorological and radiation measurements made in Belarus during the first three months following the Chernobyl accident

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ARTICLE INFO

Article history:
Received 24 February 2012
Received in revised form
20 September 2012
Accepted 24 September 2012
Available online 24 October 2012

Keywords:
Chernobyl
Meteorological
Radiation
Measurement
Database

ABSTRACT

Results of all available meteorological and radiation measurements that were performed in Belarus during the first three months after the Chernobyl accident were collected from various sources and incorporated into a single database. Meteorological information such as precipitation, wind speed and direction, and temperature in localities were obtained from meteorological station facilities. Radiation measurements include gamma-exposure rate in air, daily fallout, concentration of different radionuclides in soil, grass, cow's milk and water as well as total beta-activity in cow's milk. Considerable efforts were made to evaluate the reliability of the measurements that were collected. The electronic database can be searched according to type of measurement, date, and location. The main purpose of the database is to provide reliable data that can be used in the reconstruction of thyroid doses resulting from the Chernobyl accident.

1. Introduction

As a result of the Chernobyl accident in north-western Ukraine on 26 April 1986, large amounts of radionuclides (fission products, activation products, and fuel material) were released into the atmosphere and caused serious contamination in Belarus, Ukraine, and Russia (UNSCEAR, 2000). Large-scale investigations of the environmental contamination by radioactive materials have been conducted by international organizations since the time of the accident (EC, 1998; IAEA, 2006a, 2006b). The contamination of air, soil, surface water and ground water with long-lived radionuclides (^{137}Cs, ^{90}Sr, and ^{238,239,240}Pu) was analyzed in those studies. At the national scale, the contamination of the Belarusian territory with long-lived radionuclides has been also investigated thoroughly (CHB, 1996). Fig. 1 illustrates the ^{137}Cs deposition density in Belarus (CHB, 2001). The collected and analyzed measurements of long-lived radionuclides also form the basis for the prediction of the environmental contamination with these radionuclides of Chernobyl origin in subsequent years (UNSCEAR, 2011).

Analysis of the environmental contamination with short-lived radionuclides during the first few months after the accident has received less attention, although most of the exposure to population was due to radioiodines, and resulted mainly from the consumption of milk contaminated with ^{131}I. It is estimated that several thousand Belarusian children and adolescents received thyroid doses from ^{131}I of 2 Gy or more (UNSCEAR, 2000) and that the thyroid doses exceeded 10 Gy for a few hundreds of them (Shinkarev et al., 2008). The substantial increase of thyroid cancer beginning in 1990 among children who resided in areas contaminated with ^{131}I in fallout from

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0265-931X/$ – see front matter © 2012 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.jenvrad.2012.09.010

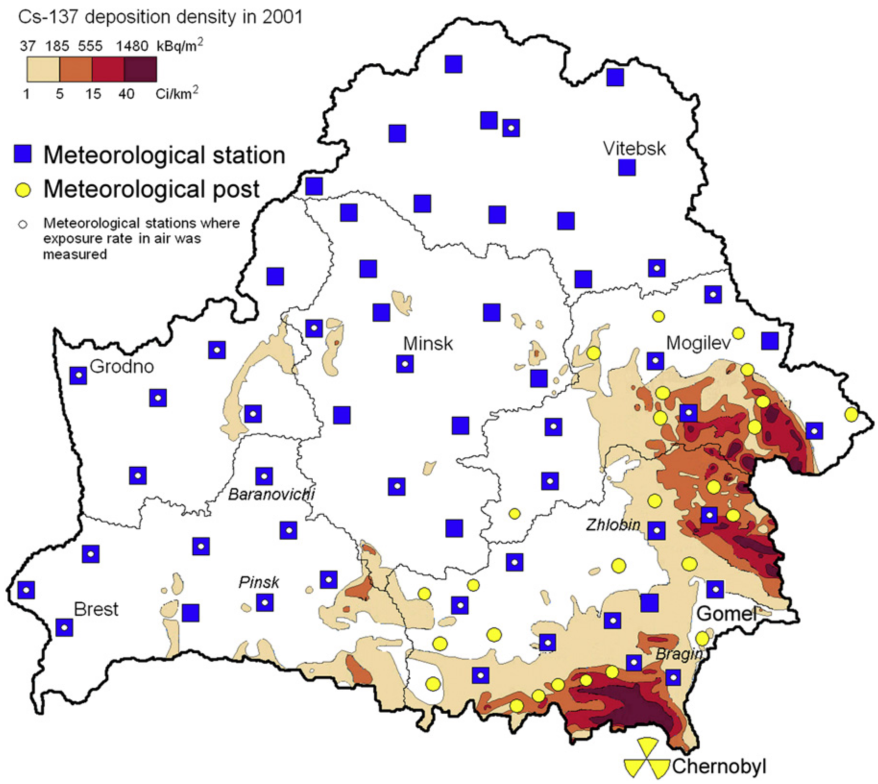

Fig. 1. Location of 56 meteorological stations in entire country and 26 meteorological posts in the most contaminated Gomel and Mogilev oblasts. ^{137}Cs contamination of the country is also illustrated.

the Chernobyl accident seems to be the major health effect resulting from the accident (WHO, 2006).

The estimation of the thyroid doses from intakes of ^{131}I is largely based on measurements of exposure rate against their neck (called “direct thyroid measurements”) that were performed on large numbers of people within a few weeks after the accident; the methodology used does not make it necessary to know the absolute concentrations of ^{131}I in milk or in other foodstuffs (Likhtarev et al., 2006). There are, however, major uncertainties in this type of dose assessment. In the framework of a long-term epidemiological study of thyroid cancer and other thyroid disease in Belarus following the Chernobyl accident conducted jointly by the Ministry of Health of Belarus and the U.S. National Cancer Institute (Stezhko et al., 2004), it has been found desirable to use an independent approach, called the “environmental transfer approach”, in order to evaluate and confirm the validity of the thyroid dose estimates derived from direct thyroid measurements. In this “environmental transfer approach”, the transfer of ^{131}I to man, and, consequently, the thyroid dose, is modeled using as a starting point the ^{131}I concentrations in air and soil, and making use also of other parameters, such as exposure rates, ^{131}I concentration in pasture grass, in cow’s milk, and/or in leafy vegetables (Bouville, 1999). The valid implementation of the “environmental transfer approach” required calibration of this method with measurements of ^{131}I activity in environmental samples.

In addition, other contributions to the thyroid dose (e.g. inhalation and ingestion of short-lived radioiodines and radiotelluriums, external exposure from radionuclides deposited on the ground, and ingestion of cesium isotopes), which were minor compared to ^{131}I intakes, are being estimated (Gavrilin et al., 2004; Minenko et al., 2006; Drozdovitch et al., 2010). External exposure to the thyroid resulted from the ground deposits of gamma-emitted radionuclides: short-lived radionuclides with half-lives of less than 10 d (^{99}Mo, ^{132}Te, ^{131}I, ^{132}I, ^{133}I), medium-lived radionuclides with half-lives of 10–100 d (^{95}Zr, ^{95}Nb, ^{103}Ru, ^{136}Cs, ^{140}Ba + ^{140}La, ^{141}Ce), and long-lived radionuclides with half-lives of more than 100 d (^{106}Ru, ^{134}Cs, ^{137}Cs, ^{144}Ce). Internal whole-body exposure to the population was caused mainly by ingestion of ^{134}Cs and ^{137}Cs. Reconstruction of radiation doses from these pathways requires the knowledge of the mixture of radionuclides at the time of their ground deposition in various locations of Belarus.

Fortunately, a large number of radiation measurements of short- and medium-lived radionuclides in air, soil, grass, cow’s milk, and water were performed in Belarus during the first few months after the accident. To keep these measurements and make them available for the purposes of the reconstruction of thyroid doses at the present time and in the future, it was decided to create a database of meteorological and radiation measurements performed shortly after the Chernobyl accident. This paper describes those radiation measurements, which have been collected, entered, validated and stored in an electronic database.

In addition, it was found important to collect and include in the electronic database the meteorological measurements, because of their direct influence in the timing, location, and magnitude of the activities deposited on the ground after the accident. The meteorological and the radiation measurements will be presented and discussed in turn.

2. Meteorological measurements

Meteorological data were collected at a number of locations in Belarus. The network of the State Committee for Hydrometeorology for the entire country includes 56 meteorological stations, 82 stationary meteorological posts, 47 hydrological posts, and 88 so-called “expedition” posts. The locations of the 56 meteorological